POLLEN PROFILES FROM SOUTHEASTERN ALASKA

by

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A THESIS

submitted to

OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

DOCTOR OF PHILOSOPHY

June 1952

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Date thesis is presented January 31, 1952

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ACKNOWLEDGEMENTS

This thesis has been made possible through the assistance of many people and organizations. The American Geographical Society of New York has afforded the opportunity to travel and work in Southeastern Alaska through its Juneau Ice Field Research Project. Under its auspices during 1950 and 1951, this work was done. It is a pleasure to acknowledge the interest of Mr. Maynard M. Miller, Field Director of the Juneau Ice Field Research Project, and Mr. William O. Field, Jr., Head of the Field Research Section of the American Geographical Society. The support of the Office of Naval Research, the U. S. Forest Service, the U. S. Navy, and the Air Force 10th Rescue Squadron is greatly appreciated. I should like to thank Dr. Donald B. Lawrence, of the University of Minnesota, for his many courtesies during the first field season.

Mr. Alva W. Blackerby, Forester in the Tongass National Forest, is especially thanked for arranging transportation into the field at Ketchikan, Petersburg, and Juneau. Mr. C. M. Archbold and Mr. Harold Anderson, District Supervisors at Ketchikan and Petersburg, respectively, were also helpful in facilitating the obtainment of peat samples. The assistance of Mr. Ernest Ely, of the Portland Medical School, made possible the procurement of the peat section from Upper Montana Creek near Juneau.

Financial support of a Sigma Xi-Resa Grant-in-Aid enabled the work at Sitka and defrayed expenses connected with the drafting of the thesis. Dean Henry P. Hansen of the Graduate School of Oregon State College, who acted as major professor during this tenure, is deserving of my sincere thanks. His suggestions and critique greatly aided the final documentation of this thesis, while his many generosities, above all, rendered a more expeditious attainment of these data.

My best thoughts of gratitude go to my wife, Grace Harrington Heusser, for her unselfish encouragement and enthusiastic interest.

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POLLEN PROFILES FROM SOUTHEASTERN ALASKA

INTRODUCTION

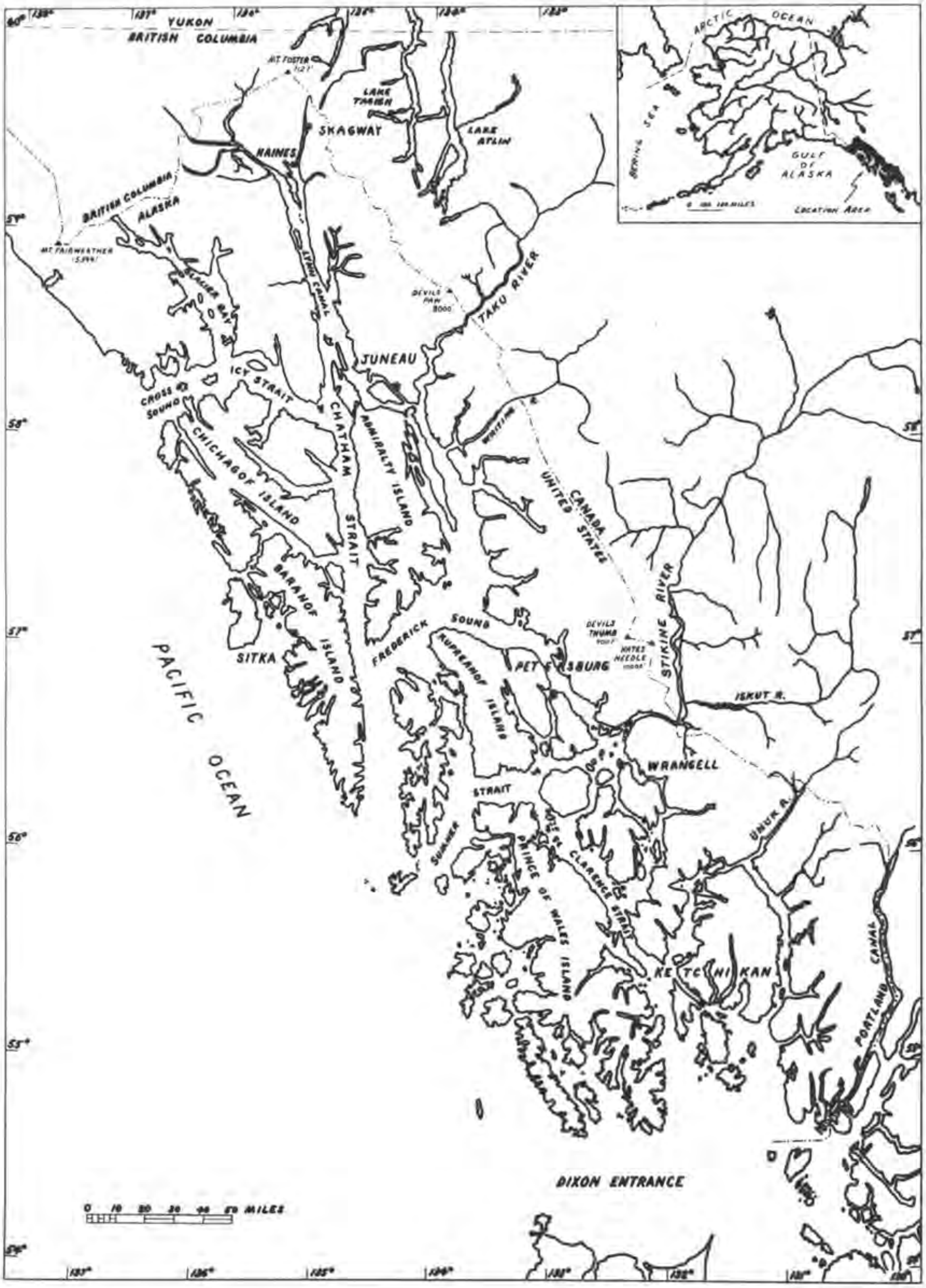
The science of pollen analysis on the North American continent has progressed rapidly since its beginning about 25 years ago. This paleo-ecological research technique had been used to unravel the history of postglacial vegetation and climate in Europe for some time before, although its present degree of refinement was developed by von Post in 1916. Fuller (30, pp. 323-325) has discussed the early workers, and Cain (9, pp. 627-628) has reviewed the later work done in the field. In retrospect, the work of Auer in 1927 marks the first pollen study on this continent in the peat of southeastern Canada. Voss, Potzger, Sears, and others followed in the East and Middle West, and Deevey (20, pp. 717-752) has, of late, applied the method in New England. The most integrated regional studies have been made by Hansen in the Pacific Northwest (36, pp. 1-130) and more recently in western Canada (39) and (37, pp. 411-421) and Alaska.

Peat sections from the North Pacific coastal region of Alaska have not been pollen analytically investigated, except for studies at scattered stations at Anchorage (Hansen, personal communication), Kodiak

(6, pp. 97-100), and Adak in the Aleutian Islands (47, pp. 380-381). In coastal British Columbia, the northernmost study has been on Vancouver Island (38, pp. 270-276). Thus, the Southeastern Alaska region is situated 400 to 500 miles from the nearest area whose postglacial forest history has been interpreted from pollen profiles. It is significant, therefore, that pollen profiles of this study from Southeastern Alaska lessen the gap in our knowledge of the postglacial phytogeography and climate of the Coast Forest Formation.

Peat deposits in Southeastern Alaska are well distributed and abundant, due to the prevailing wet climate and the numerous depressions and lowlands created by Pleistocene glaciation. During the summers of 1950 and 1951, peat sections were obtained from seventeen sites located at Ketchikan, Wrangell, Petersburg, Sitka, and Juneau in an area approximately 250 by 100 miles (Figs. 1, 2, and 3). The field work was greatly facilitated by means of air travel in this vast regional labyrinth of waterways and islands. In addition to the record of postglacial forest succession and climate, the pollen profiles disclose evidence for the post-Wisconsin vulcanism, change in sea level, and the advance and retreat of the glaciers in the Coast Range and in the Alexander Archipelago.

Fig. 1. Map of Southeastern Alaska showing the location of sampling districts of Ketchikan, Wrangell, Petersburg, Sitka, and Juneau; insert map relates the location of regional study with respect to Alaska as a whole.


YUKON
BRITISH COLUMBIA
LAKE TAGISH
SKAGWAY
LAKE ATLIN
HAINES
BRITISH COLUMBIA
ALASKA
GLACIER BAY
LYNN CANAL
TAKU RIVER
JUNEAU
ICY STRAIT
CROSS SOUND
CHATHAM
STRAIT
ADMIRALTY ISLAND
CHICHAGOF ISLAND
CANADA
UNITED STATES
BARANOF
ISLAND
FREDERICK
SOUND
KUPREANOF ISLAND
STIKINE RIVER
SITKA
PACIFIC
OCEAN
ISKUT R.
WRANGELL
SUMNER
STRAIT
PRINCE OF WALES ISLAND
CLARENCE STRAIT
UNUK R.
KETCHIKAN
PORTLAND CANAL
DIXON ENTRANCE
0 10 20 30 40 50 MILES
ARCTIC OCEAN
BERING SEA
GULF OF ALASKA
LOCATION AREA

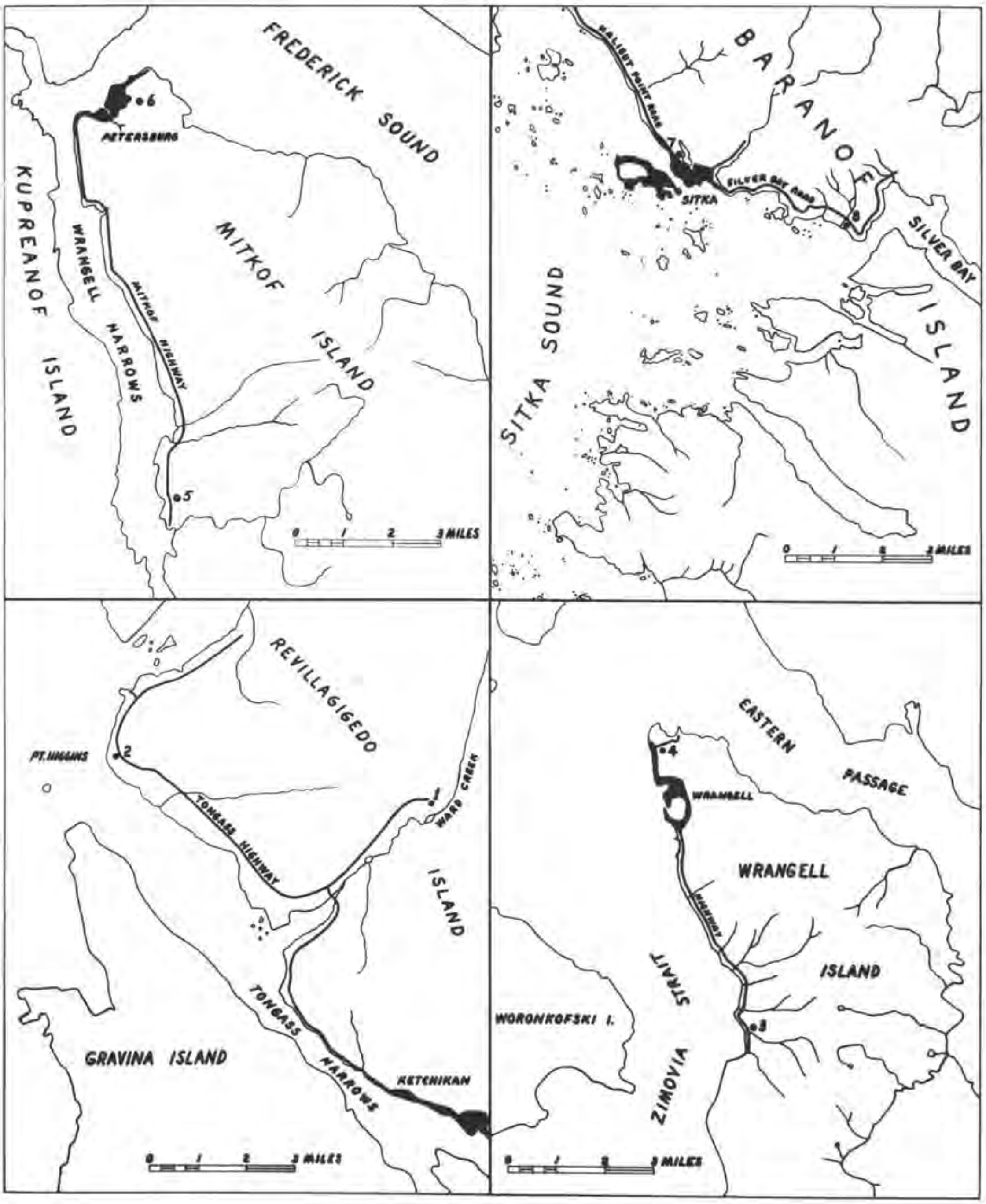


Fig. 2. Maps of sampling districts of Ketchikan (lower left), Wrangell (lower right), Petersburg (upper left), and Sitka (upper right); sampling locations are shown by number.

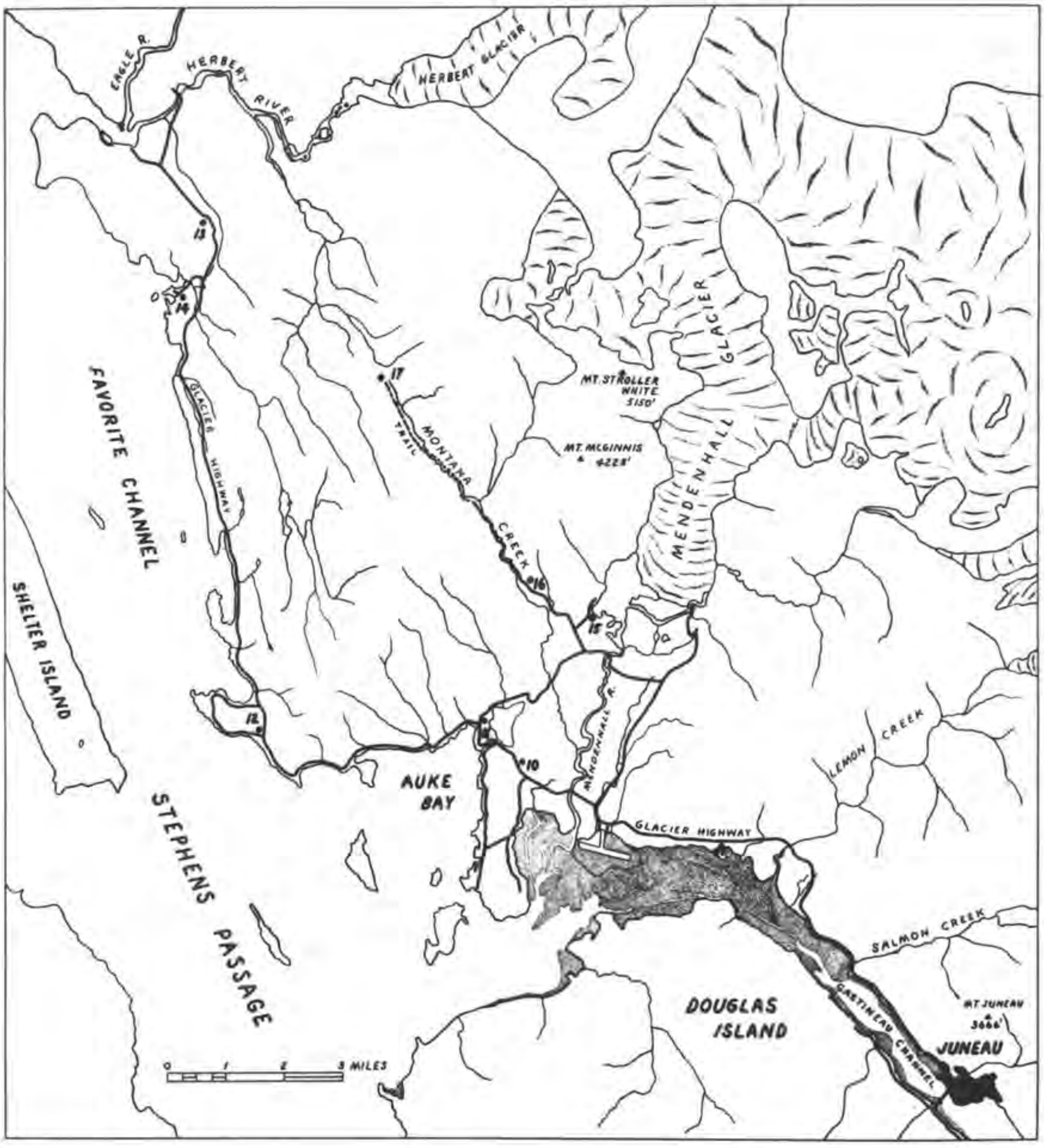


Fig. 3. Map of the Juneau District, Southeastern Alaska, showing the location of sampling stations by number.

PHYSIOGRAPHY

Physiographic provinces have not been clearly delineated in Southeastern Alaska, although the work of Bostock in British Columbia (5, pp. 80-88) and of Buddington and Chapin in Alaska (8, pp. 18-19) has, in general, outlined the extent and relation of the geomorphic units. The scheme followed is that of Bostock applied to Southeastern Alaska. He recognizes three major subdivisions of the Western System of the Canadian Cordillera: the Coast Mountains, the Coastal Trough, and the Outer Mountains. The first of these is the best defined in this area of Alaska.

The northern member of the Coast Mountains in Southeastern Alaska is known as the Boundary Ranges. This unit is bordered at the Skeena River Valley by the Pacific Ranges, a southern component of the Coast Mountains. On the east, the Interior System of the Cordillera bounds the province, while on the west boundaries are made with the Coastal Trough and the Outer Mountains. Northward the ranges descend into the Kluane Plateau in the Yukon Territory.

The Boundary Ranges constitute a broad uplift that has been deeply dissected by streams and modified by glaciation. In Alaska, as well as in British Columbia, these ranges are exceptionally rugged and continuous except where such rivers as the Taku and Stikine cut through. Elevations are highest in the vicinity of the Stikine River, as represented by such peaks as Kates Needle (10,002 feet) and Devils Thumb (9,077 feet) (Fig. 1). Kates Needle is the highest peak of the Boundary Ranges in Alaska, although the nearby British Columbia peak, Mt. Ratz (10,290 feet) is higher. North of the Taku River, Devils Paw (8,584 feet) marks the highest promontory in this sector (Fig. 4). Elevations to the north of this peak are generally in the neighborhood of 7,200 feet (Fig. 5). South of Devils Paw, elevations decrease to approximately 6,000 feet before rising to a maximum north of the Stikine River. South of the Stikine River, the altitude of the land is close to 6,500 feet and continues so to Portland Canal on the southeast International Boundary. Thus, at the southern end of these ranges in Alaska, elevations are lower than those at the north beyond Devils Paw. Extensive ice fields are found along the entire upland of the ranges. The largest of these is the Juneau Ice Field of approximately 700 square miles, continuous with smaller ice fields for about 80 miles to the northwest (26, p. 180) (Fig. 6).

Boundary Ranges are comprised for the most part by the Coast Range batholith which has aptly been called the

Fig. 4. Devils Paw (8,584 feet) on the northeast flank of the Juneau Ice Field, Southeastern Alaska; Michaels Sword is shown on the left of Devils Paw; in the foreground the névé surface of a portion of this ice field.

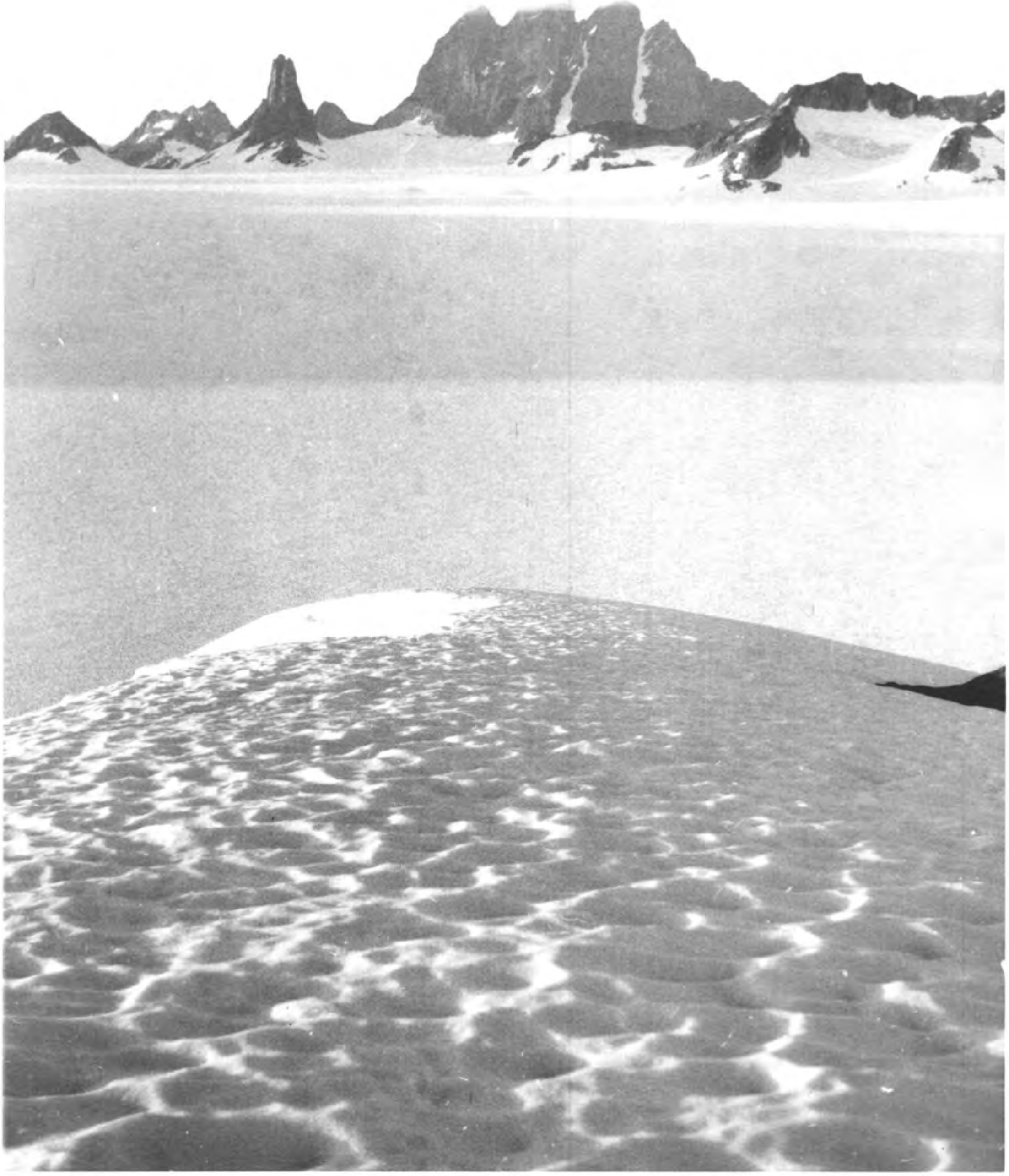


Fig. 5. Steep-walled, U-shaped valley on the northwest side of the Juneau Ice Field, Southeastern Alaska, which has recently been deglaciated since approximately 1750; such fretted upland with arêtes, ice aprons, and other features of alpine glaciation is typical of the northern Coast Range.

Fig. 6. View of the Juneau Ice Field, Southeastern Alaska, from the summit of Exploration Peak (5,907 feet); vantage is south-southwest toward Juneau, showing the upper Taku Glacier névé; firn line of Taku Glacier is seen on the left.

backbone of the Alaska "panhandle". This intrusion is a portion of an extensive, composite batholith extending from the Fraser River in southwestern British Columbia for a distance of 1,100 miles into the Yukon Territory (8, p. 173). Kerr (51, p. 141) states that the batholith represents a geanticline consisting of a granitic core which generally consists of three belts: a western of quartz diorite, a central of granodiorite, and an eastern of quartz monzonite. Underlying Paleozoic rocks are exposed in some places, as well as Mesozoic volcanics. The area of the Boundary Ranges constituted a geosyncline prior to intrusion and was subject to periodic downwarping accompanied by the accumulation of sediments and volcanics (51, p. 148). A fringe of metamorphics produced at the time of intrusion, occurs along the western margin of the batholith from Revillagigedo Island in the south to the proximity of Juneau in the north (8, pp. 292-293).

A Middle Cretaceous revolution appears to have taken place following the batholithic intrusion of Upper Jurassic or Lower Cretaceous time (51, pp. 148-154). This is implied from the Stikine and Taku river districts where Upper Cretaceous strata rest unconformably on much older formations. Post-Cretaceous uplift has been inferred by the gentle dip of Upper Cretaceous strata from the Boundary Ranges to the interior. Stream valleys crossing the ranges appear to have begun in late Mesozoic or early Tertiary time and have since been antecedent with respect to subsequent uplifts (74, p. 126). A succession of uplifts occurred later in the Tertiary: the first, apparently prior to the Pliocene, was more extensive than any previous; the second, following a long period of erosion, probably took place in the Pliocene with extensive block faulting; and the third, probably in late Pliocene, brought about the entrenchment of the streams in their valleys.

These ranges at the advent of the Quaternary were greatly altered by alpine and continental glaciation. Peaks covered by the Cordilleran ice sheet were rounded and smoothed, while those that were protruded as nunataks became serrated or sharpened by nivation in cirques. The valleys were widened and deepened by ice corrasion with the result that broad fiords were formed as the sea invaded in postglacial time. Vulcanism was also prevalent in these ranges during the Pleistocene, as in the vicinity of the Iskut and Unuk rivers (51, p. 153).

Juxtaposed between the Boundary Ranges on the east and the Outer Mountains on the west, there is a downwarped area known as the Coastal Trough (5, p. 78). This province in Southeastern Alaska forms an integral member of the Pacific Coast downfold which begins in the Gulf of California (12, p. 23). Peacock (69, p. 650) calls the entire downfold the Intermont Valley Belt and in Southeastern Alaska, the Alexander Basin.

Included in the region of the Coastal Trough are the islands and waterways which form a narrow wedge situated along the axis of Clarence Strait (Fig. 1). The trough appears to extend as far as Admiralty Island in the region of Chatham Strait, but becomes overlain by Tertiary rocks (8, p. 19). It is here that the province merges with the Coast Mountains and Outer Mountains. Its present configuration is due to a series of anticlinoria and synclinoria which strike northwest-southeast. The structural alignment was formerly northeast-southwest up to the close of the Paleozoic, but at some time after this and before the batholithic intrusion, the present system of folding was produced (85, p. 39). Peacock finds these systems more widespread in Southeastern Alaska, although the younger is more obvious. Accordingly, he has shown the coastal fiords to be oriented on the basis of a "concordant" and "discordant" structural system (69, pp. 655-660).

The relief of the land is not great, as only the low margins of the bordering islands make up the elevated portion of the submerged trough. The topography was undoubtedly changed from its pre-Pleistocene pattern, since during the Pleistocene, a network of glaciers flowed in great chains southward through Clarence Strait and on into the Pacific Ocean via Dixon Entrance. As a result, the trough was widened and deepened with the subsequent formation of the fiord that now occupies Clarence Strait to depths of 1,000 to 2,000 feet (28).

The Outer Mountains are situated as the outermost province bordering the Pacific Ocean and include the ranges of the islands west of the Coastal Trough and the St. Elias Mountains with the neighboring Fairweather and Chilkat ranges northwest of Lynn Canal. The province is represented by a discontinuous mass as far south as Vancouver Island, British Columbia (74, p. 119), and structurally, it is considered to be in the form of an anticlinorium.

The mountains of Prince of Wales, Baranof, and Chichagof islands of the Alexander Archipelago, for the most part, rise rather steeply from sea level and are typically rugged and uneven at an altitude of 3,000 to 4,000 feet. Many of the peaks are rounded on top giving testimony of having been covered by an ice sheet, while others with horned summits appear to have projected above the ice mass. Cirques, broad glacial valleys, and other glacial features are prevalent, and on Baranof and Chichagof islands, numerous glaciers are found at higher elevations.

Paleozoic and Mesozoic sediments and volcanics form the bulk of the country rock in the province, and over much of the area, the Coast Range batholith has intruded. On Kruzof Island, almost contiguous on the east with Baranof Island near Sitka, nearly half of its area has been covered by lava and ash from the postglacial eruption of Mount Edgecumbe (56, p. 20).

The St. Elias Range at the north end of the Outer Mountains is divided southward by Glacier Bay into the Fairweather Range on the west and the Chilkat Range to the east. The Chilkat Range is low, by comparison, while the St. Elias and Fairweather ranges include a composite of the largest group of high peaks in North America (5, p. 92). The highest of these in Southeastern Alaska are Mt. St. Elias (18,008 feet) and Mt. Fairweather (15,300 feet).

QUATERNARY DYNAMICS

Inasmuch as postglacial forest succession, as indicated by the pollen profiles of this study, is directly related to Pleistocene glaciation, a thorough discussion of the dynamics of the Quaternary period is most pertinent. Environmental conditions have been tempered on a large scale by the changes imposed during this interim, and plants have been prone to disperse and develop accordingly.

Southeastern Alaska is today a region in which the effects of the great cataclysm of ice are widely evident. The quantity and extent of outwash, the depth and breadth of the fiord waterways, and the numerous other glacial features bear witness to the intensive action of this ice. There are few areas in the world that can be compared. A similar, intense glaciation has been active on the southern coast of Chile in the Southern Hemisphere. Coastal Norway has likewise been greatly modified. On the North American continent, ice action is nowhere more evident than in Southeastern Alaska.

Four developmental ice stages have been recognized in northern British Columbia which are applicable to Southeastern Alaska (49, p. 17). These are comparable to the four phases recognized in southwestern British Columbia (19, p. 404). These stages are alpine, intense alpine, mountain ice sheet, and continental ice sheet. The alpine stage was evident in the beginning, and glaciers were restricted to the higher elevations, but flowed downward into the valleys. An intense alpine stage followed, during which glaciers occupied the valley systems traversing the ranges. When such valleys as the Stikine and the Taku were filled with ice, this stage was prominent. As the magnitude of the ice increased, the succeeding mountain ice sheet stage was apparent along the axis of the ranges, and flow took place to either side, especially westward over Southeastern Alaska. During these three preceding stages, topography influenced the direction and movement of the ice, while in the ultimate continental ice sheet stage, further development was controlled by climate, and there was little movement (19, p. 410).

The Cordilleran ice sheet is thought to have developed in this manner, and during its maximum, it reached to the Pacific Ocean and covered the Coast Range and the adjacent islands. The nature of the present topography of Prince of Wales, Baranof, and Chichagof islands strongly indicates that in Southeastern Alaska there were several centers of glaciation. The well developed mountain chains on these islands were at least centers of valley glaciers. The extent to which these centers grew and glaciers flowed outward was controlled by the preglacial topography. Whether these glaciers coalesced and attained ice sheet proportions is unknown. It would appear, however, that the glaciers on these islands became incorporated with the Cordilleran ice sheet. The marked development of fiords along the margins of the islands suggests such a regimen. The orographic effect caused a greater amount of snowfall on the windward sides. This is evident from the greater length and number of the fiords on the west.

It is not known whether the Cordilleran ice covered all of the higher promontories. There has been much speculation along this line, although the final solution may never be had. In much of the region, the higher peaks have been so badly shattered by weathering and frost action, that evidence of overriding, such as striae and percussion marks, have been completely obliterated (50, p. 681). Horned peaks, which are commonly thought to have been emerged above the ice sheet, can no longer be considered a sure indication of being emerged. This consideration manifests itself from the fact that alpine glaciation in post-Pleistocene time has been sufficiently intense to have sculptured horns of the domes that may have remained as indicators of overriding (49, pp. 24-25).

The data which have been presented by various workers to indicate the thickness of the ice during continental glaciation, do not necessarily preclude the possibility that ice did extend above the elevations indicated. The information at present reveals ice thicknesses as follows (8, p. 24): at the head of Portland Canal, 6,000 feet; south of Stikine River and east of Wrangell, 5,000 feet; near Thomas Bay north of Petersburg, 5,000 feet; along Whiting River east of Stephens Passage, 4,500 feet; and in the Eagle River region near Juneau, 3,400 feet. The thickness of the ice in the archipelago appears to have been at least 3,500 feet on Etolin Island; on Kupreanof Island, over 3,000 feet; on Kasaan Peninsula on the east side of Prince of Wales Island, over 2,840 feet; on the west side of Chichagof Island, over 2,100 feet and on the east side, over 2,800 feet, although under 4,000 feet; and on Yakobi Island south of Cross Sound, over 2,300 feet. These figures suggest that all of Southeastern Alaska, both the mainland and islands, was ice-covered, except perhaps the highest peaks.

The direction of ice flow was along a number of courses (Fig. 7). Paramount of these are the routes represented today by Lynn Canal-Chatham Strait, Cross Sound-Icy Strait, Stephens Passage-Frederick Sound, and Clarence Strait-Dixon Entrance (28). Flow was predominantly southwesterly with the greatest amount occurring along the line

Fig. 7. Map of Southeastern Alaska showing the distribution of existing ice fields in black areas and Pleistocene glacier flow lines with arrows; data are largely from Flint (28).

of Lynn Canal-Chatham Strait. As a result of the concentrated flow along these alleys, the preglacial drainage was rearranged so that as the ocean invaded along the fronts of receding ice, fiords were formed. The extent to which the ice scoured the land surface is shown by the depths in the fiord formed by Lynn Canal-Chatham Strait. Soundings indicate depths generally over 2,000 feet with an extreme of 2,900 feet off Point Caution on Admiralty Island (62, p. 584). These soundings further reveal that fiords in Southeastern Alaska extend across the continental shelf as at Chatham Strait and Cross Sound (62, p. 585).

The nature of shrinkage of the Cordilleran ice sheet may be likened, in part, to that discussed by Demorest in the deglaciation that has occurred to isolate the present Greenland ice sheet from its former adjuncts (21, p. 395). Under the influence of higher temperatures, loss by ablation increasingly exceeded nourishment. The higher peaks of the Outer Mountains on the islands, as a result, emerged before those of the Coast Range due to thinner ice and a more pronounced ameliorating climate at lower elevations. The rock surfaces thus exposed, became heated, warming the air which in turn increased local ablation. Mathews (65, pp. 374-376) holds that alpine glaciers were relatively shrunken during the wasting stages and offers evidence for this. While nunataks were appearing in both the coastal islands and in the Coast Range, the ice sheet may yet have continued to move forward somewhat because of its mass. Thus, as the ice surface was lowered by ablation induced by increased solar heat, rainfall, and wind sublimation, the mass dwindled and more ridges emerged until local ice was all that remained. These last remnants no doubt retreated in a mode similar to their retreat today in the higher ice fields. The ocean with its tidal effect invaded the depressed land along ice fronts in the fiords and may have accelerated the retreat along these lines of former advance.

As has already been pointed out, weathering has been so severe at higher elevations that the degree of emergence of the higher peaks above the last ice sheet is unknown. The existence of former ice sheets has also been obscured by the destruction of the evidence left by preexisting sheets. Thus, the presence of former Pleistocene ice, other than that correlated as Mankato or Late Wisconsin, is unknown. Capps (10, pp. 7-8) has summarized the evidence at hand. The presence of older, deeply oxidized tills, as well as boulders of glacial origin well beyond the limit of Late Wisconsin ice, has been recognized, but this evidence is inconclusive. Such evidence may point to former substages of the Wisconsin, such as the Cary, Tazewell, or Iowan. Recent work at the Lamont Geological

Observatory (57, p. 568) has dated through the radiocarbon assay technique what may be pre-Mankato peat at 14,300±600 years.

Since the retreat of the Cordilleran ice, uplift has taken place and appears to be going on at present in certain areas (51, p. 154). In the Coast Range, Schofield and Hanson (73, p. 32) have found marine silts elevated to 400 feet in the Salmon River district near Portland Canal in the southeast; Kerr (50, p. 693) likewise has found shell deposits at 400 feet in the Taku Valley; and Knopf (55, p. 33) has noted shells of a cold water fauna in the Juneau region at 200 feet on Douglas Island, at 60 feet on Lemon Creek, and at 30 feet at the mouth of the Eagle River. Such information has been found elsewhere in the Coast Range, as Johnston (45, p. 52) has shown an uplift as high as 650 feet near Vancouver, British Columbia. In the archipelago, glacial gravel containing marine fossils occurs at 80 feet on Gravina Island near Ketchikan, and terraced sand and gravel are elevated 40 feet on Ernest Sound, an arm of Clarence Strait (8, pp. 276-278). Elevated marine fossils have also been found on Baranof Island near Sitka by Nichols and Miller (personal communication).

The greatest amount of uplift is found in the St. Elias Range. Russell (72, pp. 25-26) found 2,000 to

5,000 feet of glacial deposits with marine fossils in the foothills above the Malispina Glacier. Maddren (61, p. 132), working northwest of Mount St. Elias, noted bedded marine shales and sandstones of Pleistocene age uplifted 2,000 to 4,000 feet. These data indicate marine invasion inland as the glaciers retreated. Continued shrinkage of the continental glacier with the consequent decrease in the weight of the ice, permitted the land to rise to its present height.

CLIMATE

Climatic conditions are notably mild and humid over the greater part of Southeastern Alaska, although inland in the Coast Range and at higher elevations in the archipelago, they are more severe. According to the climatic systematics of Köppen (80, pp. 310-313), three types are evident, although the first is by far the most prominent. At lower elevations near sea level, it is warm, temperate, and rainy with no distinct dry season and with cool summers. Higher elevations below timberline throughout the region are characterized by a cold climate with humid winters. There is no dry season and the summers are cool. Some of the greatest snowfall in the world occurs here. A relatively small area of the archipelago has a boreal climate, but above timberline in the Coast Range, there are greater areas subjected to this type. Here are patches of tundra, and the vegetation assumes an arctic-alpine physiognomy.

Temperatures for the five study districts in the coastal area (Table 1) reveal a range for the January average from 27.5° at Juneau to 32.6° at Ketchikan, while the July average ranges from 54.9° at Sitka to 58.2° at Wrangell (54, p. 1211). Inland, on the other hand, temperatures are generally lower and at higher elevations in winter become quite low. On the upper Taku Glacier in the Juneau Ice field (Fig. 6), temperatures were noted as low as -30°F. during the month of February, 1951 (67, p. 2). Temperatures averaged in the forties, by contrast, during the summers of 1950 and 1951, and only at night fell a few degrees below freezing.

The precipitation of the coastal districts investigated ranges between 82.9 inches annual average at Wrangell to 150.9 inches annual average at Ketchikan (Table 1) (54, p. 1211). The greatest precipitation occurs during the months of October and November and the least during the month of June. The climate is humid throughout the year, however, and considerable snow falls in winter at sea level, amounting to an annual average of over 100 inches (54, p. 1215). In the Coast Range and at higher elevations on the islands, snowfall is much greater and nourishes the numerous ice fields. A snowfall of 72 inches during a blizzard period of 10 days during February, 1951 was observed at 3,600 feet in the Juneau Ice Field (67, p. 2). Nourishment of this ice field appears to take place largely during fall, winter, and spring. During the summers of 1950 and 1951, there were only occasional snow flurries, and precipitation was almost entirely in the form of rain. Fog, rain, and drizzle persisted almost continually for three weeks during one particular period in the

District	Temperature °F. January Average	July Average	Maximum	Minimum	Average Precipitation in. January	February	March	April	May	June	July	August	September	October	November	December	Annual Total
Juneau	27.5	56.6	89	-15	7.2	5.6	5.4	5.5	5.2	4.0	5.0	7.3	10.2	11.2	9.1	7.6	83.3
Sitka	32.4	54.9	87	-5	7.8	6.8	6.0	5.6	4.2	3.4	4.3	7.0	10.3	12.6	10.1	9.1	87.1
Petersburg	28.5	55.2	81	-5	8.5	9.9	7.3	6.4	5.8	4.5	5.3	6.9	12.0	15.3	12.8	11.8	106.5
Wrangell	29.0	58.2	92	-6	7.7	7.3	5.4	4.9	4.4	3.6	4.5	5.3	8.4	11.2	11.8	8.6	83.0
Ketchikan	32.6	57.5	96	-8	13.7	11.6	12.2	10.8	8.3	6.6	8.2	11.5	12.1	20.1	19.7	15.9	150.9

Table 1. Climatic Summaries for Districts Studied in Southeastern Alaska.

summer of 1950.

Farther inland on the lee slopes of the Coast Range in British Columbia, precipitation is much less (13, p. 388). The annual precipitation has been recorded as low as 10.9 inches at Atlin on the east shore of Lake Atlin, 65 miles north-northeast of the Juneau Ice Field. Still less is the precipitation at Telegraph Creek on the upper Stikine River, about 140 miles southeast of Atlin. Here the annual precipitation is only 8.2 inches. Telegraph Creek is approximately only 100 miles from Petersburg, where the average is over 106 inches. This great variation reflects the rain shadow effect of the Coast Range. The warm, moist air moving inland from the Pacific Ocean rises upon reaching the mountain barrier and is cooled, eventually reaching the condensation zone and losing much of its moisture. Condensation occurs to the summit of the range, but to the leeward, the descending air is dry and does not lose much more of its moisture. This orographic effect accounts for the great quantities of snow which fall on the upper windward slopes in winter.

The climatic regimen of Southeastern Alaska is controlled largely by the prevailing wind and the Kuro Shio or Japanese current, which through its ability to store heat, causes this high latitude, subarctic region to have a mild climate (76, pp. 274-275). Air masses in winter originating in the Asiatic anticyclone, move across the Gulf of Alaska and are warmed in transit (82, pp. 207-208). On reaching the southeastern coast of the Territory, they give up their heat in the form of warm rains. These air masses, in the nature of cyclonic storms, develop in a trough of low pressure, known as the Aleutian low. The Coast Range, over which they begin their winter continental track, acts as a barrier to their advance inland. These cyclonic disturbances may thus become stagnated in the Gulf of Alaska for long periods, resulting in prolonged inclement weather. At times, however, the arctic high builds up over the continent, and fair weather with cold, northerly winds may prevail for a time. For the most part, winds are southerly in keeping with the low pressure, cyclonic storms (54, p. 1214).

Although the Aleutian low is pronounced in winter, during the summer, it is practically non-existent, and the North Pacific high, moving up from the south, dominates this area. The pressure differential between the cool ocean and the warmer land surfaces, creates a steady southward flow of polar, marine air (82, pp. 211-212). Thus, Southeastern Alaska is favored with more fair weather and northerly winds in summer, but with the return of the Aleutian low in autumn, the heaviest precipitation of the year is experienced.

METHODS

Peat sections were obtained at decimeter intervals from seventeen muskegs in Southeastern Alaska. Two sections each were collected at Ketchikan, Wrangell, Petersburg, and Sitka (Fig. 2) and the remainder at Juneau (Fig. 3). A Hiller borer was used, and a small amount of sediment was removed at each prescribed level from the chamber of the instrument. A number of test borings were made at each station before a section was taken for study. This insured the attainment of maximum depth. In all cases, the inorganic bottom sediments were penetrated, and the macroscopic character of all the samples was recorded. The material was placed in 6 dram vials, treated with alcohol preservative, and corked. The floristic and successional status of each area was noted, and representative plants were collected and identified. The keys of Anderson (2) and Hultén (44) were used.

The sediments were prepared for microscopic study by means of the potassium hydroxide method (36, p. 39). The treatment consisted of boiling a small portion of each sample in approximately 200 ml. of water to which a few drops of saturated KOH solution and gentian violet stain had been added. After boiling, the deflocculated material was strained through a relatively fine wire mesh in order to remove the macroscopic particles. The solution was then centrifuged, and about 0.5 ml. of the residue was mixed with 1-2 ml. of warm glycerine jelly. Two or three drops of this mixture were placed on a clean microscope slide and mounted unter a 7/8 inch cover glass. Pollen identification was made at 100x with the use of a mechanical stage, although critical determinations required a lens combination of 440x. From 100 to 150 pollen grains of lodgepole pine (Pinus contorta)[1], western hemlock (Tsuga heterophylla), mountain hemlock (Tsuga mertensiana), and Sitka spruce (Picea sitchensis) were identified at each level. The percentage representation of each forest tree species was determined from the total number of pollen grains counted. These data provide the basis for the pollen profiles.

Microscopic analysis was made after a thorough study of pollen grains of all species represented in the sediments. The fossil pollen grains of lodgepole pine, western hemlock, mountain hemlock, and Sitka spruce were easily identified. Silver fir (Abies amabilis) and alpine fir (Abies lasiocarpa) require separation on the basis of size-frequency curves (36, p. 45). The inaperturate grains (23, p. 128) of western yew (Taxus brevifolia), juniper (Juniperus communis var. montana), western red cedar

[1]The nomenclature followed is that of Anderson (2).

(*Thuja plicata*), and Alaska yellow cedar (*Chamaecyparis nootkatensis*) are inseparable (84, p. 234) and were designated "conifer complex". As these conifers form only a small proportion of the forest, their exclusion from the percentage calculation does not constitute any serious error. Of the herbs and shrubs, the pollen of the Empetraceae and Ericaceae are also inseparable (22, p. 90).

LOCATION AND CHARACTERISTICS OF THE MUSKEGS

Ketchikan District

The muskegs on Revillagigedo Island were sampled at Upper Ward Creek and at Point Higgins (Fig. 2). The station at Upper Ward Creek (#1) is located at the end of the Ward Creek Road approximately eight miles from Ketchikan and about three miles above Ward Cove. This slope muskeg is inclined at a low angle to the west-northwest. A few terraces are present at intervals at right angles to the slope. These are thought to be due to underlying ridges of intrusives of the Coast Range batholith which are conspicuously outcropped in this area. Many of the smaller raised muskegs appear to have developed in depressions between these outcrops. This may have been the original condition of the muskeg at Upper Ward Creek, as a number of smaller muskegs were probably united by further peat development into the present sloping one. This, of course, does not infer that all slope muskegs have formed in this way.

Scattered lodgepole pines and Alaska yellow cedars are poorly represented, as is a low growth of juniper with some western red cedar. Sedges, occurring in patches, are most abundant in the herb layer and consist of <u>Carex pauciflora</u>, <u>Scirpus caespitosus</u> var. <u>callosus</u>, and

Rynchospora alba. Club moss (*Lycopodium annotinum*), Labrador tea (*Ledum groenlandicum*), crowberry (*Empetrum nigrum*), swamp laurel (*Kalmia polifolia*), and cranberry (*Oxycoccus microcarpus*) are also present with blueberry (*Vaccinium uliginosum*), western tofieldia (*Tofieldia occidentalis*), burnet (*Sanguisorba menziesii*), bunchberry (*Cornus canadensis*), and cloudberry (*Rubus chamaemorus*). Sphagnum moss is not common. The higher plants are included in Table 2.

This muskeg was sampled to a depth of 3.8 meters into gray-green micaceous sand. The peat consists almost entirely of sedge with some moss at the surface (Fig. 17). A number of woody horizons are evident, and at a depth of 0.6 meter, shards of volcanic glass are found. Oxidized peat containing septate hyphae of what appear to be the fungal component of a lichen occurs between 2.6 and 2.9 meters. Near the bottom of the section, decomposed sedge peat grades through fine clastics for 0.3 meter before reaching the underlying sand.

The Point Higgins (#2) station is about six miles west of Upper Ward Creek near the northern end of the Tongass Narrows and is lower in elevation (Fig. 2). It is located on the Tongass Highway near the road leading into the U.S. Coast Guard Radio Station. The muskeg slopes to the north and south and is situated as a broad bench between outcrops of intrusive rock as in the Ward Creek area. Numerous, small depressions devoid of plant cover are exposed on the muskeg. The surface of the peat was cracked in these, as a result of the uncommon dry summer period which had prevailed. During normal times, these pockets are filled with water and are probably related to the development of the muskeg.

Few trees are present except along the margin where the forest has created a tension zone. The trees appear to have been cut on the muskeg to mark the entrance to the radio station. A few, low specimens of lodgepole pine, Alaska yellow cedar, western red cedar, western hemlock, and juniper are found, although the last is by far the most abundant. Salal (Gaultheria shallon) is present in places as is skunk cabbage (Lysichitum americanum); otherwise, the plants are essentially similar to those at Upper Ward Creek (Table 2).

The depth of the muskeg at Point Higgins is 4.3 meters, and below 4.0 meters, decomposed sedge becomes increasingly merged with sand (Fig. 18). Most of the peat is composed of sedge. A prominent interval of woody peat occurs midway in the section. This feature along with the greater depth of moss in the upper layers, causes this muskeg to be different from that at Ward Creek. Volcanic ash is noted at 0.7 meter. Acicular crystals of unknown

Table 2*. Floristics of Sampling Stations in Southeastern Alaska.

	Upper Ward Creek (No. 1)	Point Higgins (No. 2)	Ski Trail (No. 3)	Wrangell (No. 4)	Mitkof Highway (No. 5)	Petersburg (No. 6)	Halibut Point Road (No. 7)	Silver Bay Road (No. 8)	Lemon Creek (No. 9)	Mendenhall River (No. 10)	Auke Bay (No. 11)	Lena Beach (No. 12)	Herbert River Tributary (No. 13)	Eagle Harbor (No. 14)	Mendenhall Lake (No. 15)	Lower Montana Creek (No. 16)	Upper Montana Creek (No. 17)
Blechnum spicant..........................	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equisetum variegatum......................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Lycopodium annotinum......................	x	x	x	x	x	-	-	-	x	-	x	x	-	-	-	x	-
Juniperus communis var. montana...........	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-	-	-
Thuja plicata.............................	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chamaecyparis nootkatensis................	x	x	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-
Pinus contorta............................	x	x	x	x	x	x	x	-	x	x	x	x	-	x	-	x	-
Tsuga heterophylla........................	-	x	x	-	-	-	x	x	x	x	x	x	-	x	-	x	x
Tsuga mertensiana.........................	-	-	x	-	-	-	-	x	x	x	x	-	-	-	-	x	-
Picea sitchensis..........................	-	-	-	-	-	-	x	x	x	x	-	-	x	-	x	x	x
Sparganium hyperboreum....................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Calamagrostis canadensis..................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Calamagrostis canadensis ssp. langsdorfii..	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agrostis scabra var. geminata.............	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Rynchospora alba..........................	x	x	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-
Eleocharis palustris......................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Eriophorum scheuchzeri....................	-	-	-	-	-	-	-	-	-	-	-	-	x	-	x	-	-
Eriophorum chamissonis....................	-	-	-	-	-	-	-	-	x	-	x	-	x	-	x	-	-
Eriophorum angustifolium..................	x	x	x	-	x	x	-	-	x	-	x	x	-	-	-	x	-
Scirpus caespitosus var. calloeus.........	x	x	x	-	x	x	-	-	x	x	-	x	-	-	-	x	x
Carex pauciflora..........................	x	x	x	x	x	x	-	x	x	x	x	x	-	x	-	x	x
Carex hindsii.............................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Carex sitchensis..........................	-	-	-	x	x	-	-	-	x	-	x	-	-	-	-	-	-
Carex limosa..............................	-	x	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-
Carex physocarpa..........................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Lysichitum americanum.....................	-	x	x	-	-	-	x	-	x	x	x	x	x	-	-	x	x
Tofieldia occidentalis....................	x	x	-	x	-	-	x	-	-	-	-	-	-	-	x	-	-
Fritillaria camtchatcensis................	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x
Maianthemum dilitatum.....................	-	-	x	x	-	-	-	-	x	x	x	x	-	-	-	-	x
Iris setosa...............................	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Limnorchis dilitata.......................	x	x	-	-	-	-	-	-	-	x	x	-	x	-	x	-	x
Listera cordata var. nephrophylla.........	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Populus trichocarpa.......................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Geocaulon lividum.........................	-	-	-	-	-	-	-	-	x	-	x	x	-	x	-	x	-
Polygonum bistorta ssp. plumosum..........	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	x
Caltha palustris ssp. asarifolia..........	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Coptis trifoliata.........................	x	x	x	-	-	-	-	x	-	x	x	x	-	-	-	x	-
Drosera rotundifolia......................	x	x	x	x	x	x	x	x	x	x	x	x	x	-	-	x	x
Parnassia palustris.......................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Rubus chamaemorus.........................	x	x	x	x	x	x	x	-	x	x	x	x	-	x	-	x	x
Rubus pedatus.............................	-	-	-	-	-	-	-	-	x	x	x	x	-	-	-	-	-
Rubus stellatus...........................	-	-	-	-	-	-	-	-	x	-	-	-	x	-	-	-	-
Potentilla palustris......................	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Geum calthifolium.........................	x	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-
Sanguisorba menziesii.....................	x	x	x	x	x	x	x	-	-	-	-	-	x	-	-	-	-
Empetrum nigrum...........................	x	x	x	x	x	x	x	x	x	x	x	x	-	x	-	x	x
Hippuris vulgaris.........................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Cornus canadensis.........................	x	x	x	x	x	x	x	-	x	x	x	x	-	-	-	x	x
Ledum groenlandicum.......................	x	x	x	x	x	x	x	-	x	-	x	x	-	x	-	x	x
Menziesia ferruginea......................	-	-	x	-	-	-	-	-	x	-	x	x	-	-	-	x	-
Kalmia polifolia..........................	x	x	x	-	x	x	-	x	x	-	-	x	-	x	-	x	-
Andromeda polifolia.......................	-	-	-	-	-	x	-	-	x	x	-	x	-	x	-	x	x
Gaultheria shallon........................	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium vitis-idea......................	-	-	x	-	-	-	x	-	x	x	x	x	-	x	-	x	-
Vaccinium uliginosum......................	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x
Oxycoccus microcarpus.....................	x	x	x	-	x	x	-	-	x	x	x	x	x	x	-	x	x
Trientalis europea ssp. arctica...........	-	-	x	-	-	-	-	-	x	-	x	x	-	-	x	-	-
Gentiana douglasiana......................	x	-	x	x	x	x	-	-	x	-	-	-	-	-	-	-	-
Menyanthes trifoliata.....................	-	-	-	x	-	x	-	x	-	x	x	-	x	-	-	-	-
Fauria crista-galli.......................	x	x	-	x	x	x	-	x	x	x	x	x	-	-	-	x	x
Pedicularis sudetica......................	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-

*This table does not pretend to represent a complete floristic coverage, but rather includes only the majority of plants present.

composition occur at 0.1 and 0.5 meter and are thought to be of volcanic origin. Examination of this material under the petrographic microscope[2] only revealed that the material is not a glass. This, of course, does not preclude its origin as volcanic, since non-glass ejecta are also discharged during vulcanism. Of interest is the fact that such crystals are also found in névé and firn in the Juneau Ice Field at 3,600 feet (41), as well as in muskegs elsewhere in this study. The stratum from 1.6 to 1.9 meters is badly decomposed, containing black fragments indicative of fire. Septate hyphae are evident from 2.4 to 3.7 meters.

Wrangell District

Muskegs on the north end of Wrangell Island, 85 miles north-northwest of Ketchikan, occupy small areas in the vicinity of the port of Wrangell (Fig. 2). Elsewhere, as along the highway which runs south along Zimovia Strait, the topography is generally too steep for muskeg formation. In the neighborhood of the Wrangell Indian Institute, however, a slope muskeg is found at the site of

[2] Dr. W. D. Wilkinson of the Geology Department at Oregon State College, who kindly examined this material, was unable to indicate its nature due to the small size of the crystals.

the ski trail, 5 miles south of Wrangell. Ski Trail muskeg (#3) covers an extensive, southwest-facing area and is the steepest muskeg of this study (Fig. 8). The peat is not deep. Approximately two dozen test borings made at various places revealed a maximum depth of 1.2 meters. This muskeg is more thickly wooded than most muskegs. Such a condition is attributed to better drainage due to the high angle of slope and the shallowness of the peat.

Lodgepole pine is the most abundant tree and averages about twenty feet in height. Its associate is largely Alaska yellow cedar, but both species of hemlock, western red cedar, and low juniper are also found. None of these minor associates attains any important size. Labrador tea is the most prevalent shrub. The remainder of the ground cover consists largely of cloudberry, crowberry, swamp laurel, sedge (_Scirpus caespitosus_ var. _callosus_), bunchberry, club moss, and burnet with some sphagnum (Table 2).

The peat section studied consists almost entirely of sedge with some moss in the upper portion (Fig. 19). The underlying material is sandy, blue-gray clay. Volcanic glass occurs from 0.5-0.8 meter and at 0.6 meter is abundant. The absence of wood in the section suggests that conifers have invaded this slope quite recently. The peat is well preserved and has not been oxidized or

Fig. 8. Ski Trail muskeg (#3) near Wrangell, Southeastern Alaska, showing poor growth lodgepole pine and a ground cover of sedge.

disturbed by fire.

North Wrangell muskeg (#4) is on the road that leads to the far end of the island, about one mile beyond the port (Fig. 2). It lies immediately east of an abandoned cannery, and its surface is flat and slopes southeast, south and southwest. The surface is firm, and there are no open pockets. It supports scrubby lodgepole pine, no more than twelve feet in height, and the only other conifer is low juniper. The muskeg forms a narrow ecotone with the forest along its southern edge, although an arm extends southeastward, becoming continuous with a complex network of muskeg dispersed throughout the forest east of Wrangell. The forest is composed principally of western hemlock with Sitka spruce and Alaska yellow cedar. Labrador tea, bunchberry, blueberry, and crowberry comprise the shrub layer, while sedge (Carex pauciflora), burnet, western tofieldia, bunchberry, and cloudberry are the important herbs (Table 2). Sphagnum covers the surface along with the other plants.

Sampling of the North Wrangell muskeg disclosed a depth of 3.9 meters (Fig. 20). The peat is mostly sedge with moss at the surface and in the upper few decimeters. Woody horizons are present two-thirds down in the section, and at 3.8 meters, decomposed sedge peat grades into light sand. The section has been disturbed by fire at 0.8-0.9

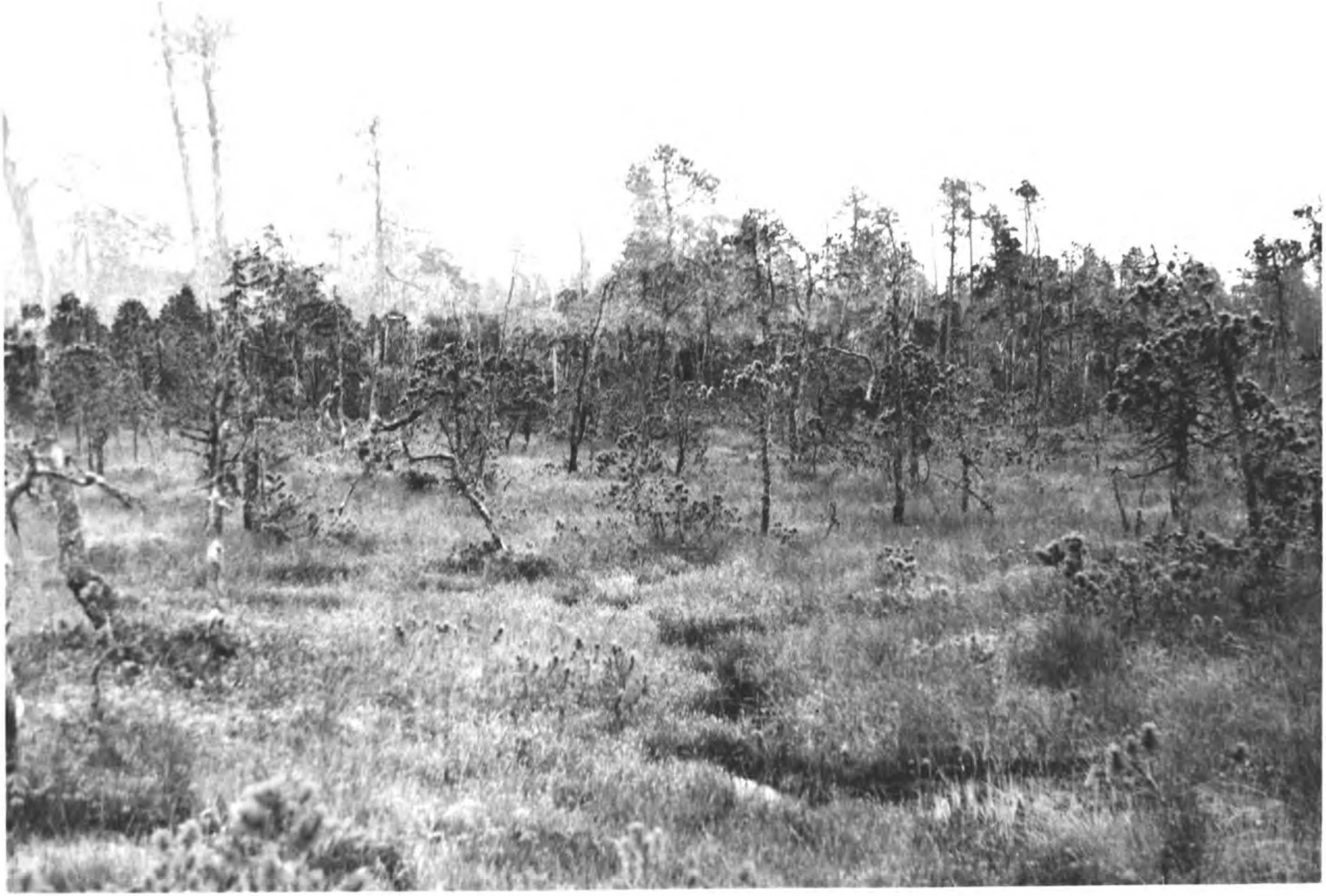
meter and by oxidation from 3.3 to 3.6 meters. Volcanic ash is well distributed in the upper two meters. Unknown acicular crystals, similar to those at Pt. Higgins, occur at 1.4 meters and from 3.0 to 3.7 meters.

Petersburg District

Petersburg is situated 35 miles northwest of Wrangell at the northern end of Mitkof Island (Fig. 2). This island is separated from the mainland on the east by Frederick Sound and from Kupreanof Island on the west by the Wrangell Narrows. Aerial photographs show that much of the island is covered by muskeg with strips of forest occupying the better drained land. In fact, the town of Petersburg has been built on muskeg, and many of the roads are made from planking. One sampling station is located just east of the town near the Pan-American World Airways Radio Station, while the other is about 10 miles south on Mitkof Highway.

Mitkof Highway muskeg (#5) is illustrated in Figure 9. This is a slope type which is developed as a broad platform, moderately inclined on all sides. It differs from Petersburg muskeg (#6), in that the latter is more extensive and undulating. Both contain small pockets which are filled with water. A scrub of lodgepole pine is

Fig. 9. Mitkof Highway muskeg (#5) near Petersburg, Southeastern Alaska, showing scrubby lodgepole pine with an undergrowth of sedge; wet pocket is seen on the right foreground.



found growing on each, although Petersburg muskeg is more open. The plants are alike at both sampling sites (Table 2). Sedges (Carex pauciflora, Scirpus caespitosus var. callosus, and Rynchospora alba), bunchberry, cloudberry, swamp laurel, bog rosemary (Andromeda polifolia), Labrador tea, blueberry, and cranberry are found.

Sedge forms most of the peat in both sections. It is overlain by moss which is more evident at Mitkof Highway (Figs. 21 and 22). Woody horizons are likewise better shown at Mitkof Highway. Fragments of volcanic glass occur at similar stratigraphical levels in each deposit. The peat at Petersburg is 2.8 meters deep and rests on sand and gravel, while that at Mitkof Highway is 3.0 meters and underlain by gray silt. In the latter section, needle-like crystals, previously mentioned, are found from 1.1-1.3, 1.5-1.6, and 2.0-2.1 meters. Septate hyphae are present from 1.5 to 2.0 meters at Petersburg. Both sections appear little disturbed.

Sitka District

Sitka is about 95 miles west-northwest of Petersburg and approximately an equal distance southwest of Juneau (Fig. 1). It is the only major Southeastern Alaska port on the Pacific Ocean and is located on Baranof Island

and adjacent Japonski Island in Sitka Sound (Fig. 2). There is a considerable number of slope muskegs in the region, formed near the coast. In this part of Baranof Island, the rugged, mountainous country has restricted muskegs to this narrow strip.

Peat sections were obtained on the Halibut Point Road (#7) and on the Silver Bay Road (#8). The station on Halibut Point Road is on the northern outskirts of Sitka, a short distance beyond Swan Lake (Fig. 2). The surface of the muskeg slopes westward from the edge of the road. Prior to the building of the road, the muskeg was contiguous to a gravel ridge which the road now separates. A few small trees grow on the muskeg, although a greater proportion occur in a depression on the slope. These include lodgepole pine, Sitka spruce, and western hemlock (Table 2). The shrubs present are Labrador tea, blueberry, lingen berry (Vaccinium vitis-idea), and crowberry. Western tofieldia, burnet, bunchberry, cloudberry, skunk cabbage, and sedge (Carex spp.) constitute most of the plants of the herb flora. Sphagnum is abundant.

This muskeg was sampled to a depth of 5.0 meters (Fig. 23). Moss peat is present in the surface layers and is plainly visible in the samples to a depth of two meters. Below this level, it becomes increasingly sparse and is not in evidence lower than 3.8 meters. The bulk of the section is formed by sedge peat. Layers of wood are intercalated at 2.0, 4.1, 4.5, 4.8, and 4.9 meters, and spruce needles are found at 4.8 meters. The muskeg lies on sandy pumice, and the pollen-bearing sediments contain pumice from 4.4 meters to the bottom. A trace of volcanic glass is recorded at 0.9 meter. The peat is well preserved and appears not to have been disturbed.

A second peat section was obtained on Silver Bay Road about four and a half miles eastward from Sitka (Fig. 2). The muskeg is one of several that has developed on a series of benches along the downgrade of the road in this locality (Fig. 10). The surface is essentially flat and firm and covered with sedge (*Carex pauciflora* and *Carex* spp.), crowberry, blueberry, and swamp laurel (Table 2). In a wet depression at one end of the muskeg, buckbean (*Menyanthes trifoliata*) and deer cabbage (*Fauria crista-galli*) are found. A few scattered, shrubby trees of Alaska yellow cedar, both species of hemlock, and Sitka spruce are growing in the peat. These are better developed on the margins where the muskeg grades into the upland forest. No lodgepole pine appears at this station.

The peat section contains a high proportion of sedge, except in the upper 0.4 meter where moss is present and at the horizons where wood remains are found (Fig. 24). The wood peat reaches 3.3 meters, but pollen is

Fig. 10. Silver Bay Road muskeg (#8) near Sitka, Southeastern Alaska, showing sedge cover and poor growth hemlocks; Alaska yellow cedar is seen on the right at the edge of the muskeg.

contained in the undersediments of brown, sandy pumice to a maximum depth of 3.7 meters. This volcanic sediment contains undetermined acicular crystals at 3.6 meters mixed with fragments of glass. In general, the peat appears undisturbed except between 1.6 and 2.4 meters where it has been partly decomposed through oxidation. Septate hyphae are present from 1.6 to 3.1 meters. Only a small amount of moss peat occurs in this section as compared to that at Halibut Point Road.

Juneau District

The muskegs located between the glaciers on the western side of the Juneau Ice Field and the waterways of Gastineau Channel, Auke Bay, and Favorite Channel, are divided into three categories: those at less than 75 feet above mean sea level, that at about 150 feet elevation, and that at about 750 feet (Fig. 3). This breakdown is followed in order to better report on the area as a whole and to afford greater clarity for the discussion which follows.

The muskegs at less than 75 feet elevation are in the proximity of nearby waterways except Mendenhall Lake (#15) which is about three miles in from Auke Bay. The deeper stations are treated first. Lemon Creek muskeg

(#9) is situated on Sunny Point at milepost 7½ on the Glacier Highway northwest of Juneau (Fig. 3). It is a raised type which is covered with a better growth of trees, especially on the margins. Lodgepole pine is most common with both species of hemlock well represented. Cloudberry, bunchberry, crowberry, Labrador tea, and blueberry are important ground plants. The floristics of this station is given in Table 2.

Lemon Creek muskeg was sampled to 4.8 meters into gray, sandy clay (Fig. 25). Woody peat rests at two levels in the section, and both are bounded above and below by sedge peat. Moss forms most of the upper half of the deposit. Charred peat occurs at 2.6 and 2.7 meters and oxidized layers at 2.8, 2.9, and 3.3 meters. Septate hyphae are present from 3.1 to 3.6 meters and glass shards occur at 1.1 meters. Figure 11 illustrates an exposed section of this deposit.

Lena Beach muskeg (#12) is similar to the Lemon Creek deposit in that it is of comparable depth. It occurs at mile 17½ on the Glacier Highway (Fig. 3). The surface is somewhat raised and contains a number of water pockets. An open growth of lodgepole pine is low with some individuals as much as 20 feet tall. Many dead trees are also present with a ground cover of Labrador tea, cloudberry, and crowberry with tussocks of sedge (<u>Scirpus</u>

Fig. 11. Exposed peat section at Lemon Creek muskeg (#9) near Juneau, Southeastern Alaska, showing roots of conifers which invaded during the warm, dry period; overlying moss and sedge peat indicate cool, wet conditions, while the presence of forest growing on the surface discloses a present period of decreasing moisture.

caesnitosus var. callosus) (Table 2).

The peat column is typologically similar to that at Lemon Creek except that sedge is more intermixed with moss in the upper levels (Fig. 29). Woody peat and volcanic ash are stratigraphically correlated in each section. Septate hyphae are contained between 4.1 to 4.7 meters. At 5.0 meters, the base of the organic sediments rests on sandy gravel.

Eagle Harbor muskeg (#14) is the last of the deeper sections of the low altitude group. This deposit is located at Dotsons Landing on Favorite Channel near the end of the road leading west from approximately mile 25 on the Glacier Highway (Fig. 3). The surface is greatly convex and is thickly overgrown with Labrador tea, cloudberry, and crowberry (Table 2). Small western hemlocks are numerous with a few lodgepole pine.

Sampling of this muskeg reveals a section to 5.0 meters much like those at Lemon Creek and Lena Beach (Fig. 30). The presence of woody debris at three horizons and the absence of sedge beneath the lowermost woody stratum make this column somewhat different than that for Lemon Creek, in particular. Volcanic glass is noted at 1.1 meters with unknown needle-like crystals. These "needles" are also at 4.3 meters, although in the absence of glass. Septate hyphal strands are manifest from 2.6 to

3.3 meters, while the peat at 3.0 meters shows signs of oxidation. The muskeg has developed on greenish sand.

The more shallow muskegs of the group nearest sea level are at Mendenhall River, Auke Bay, Herbert River Tributary, and Mendenhall Lake. These are presented in the order of their decreasing depth. Mendenhall River muskeg (#10) is found at mile 11½ on Glacier Highway between Mendenhall River and Auke Lake (Fig. 3). The slope is westward at a low angle with a few small pools in depressions on the surface. Lodgepole pine, in different size classes up to 35 feet in height and 1 foot d.b.h. (diameter breast high), is the commonest tree. Sedges are the most prevalent low plants with crowberry, blueberry, cloudberry, and bunchberry. Deer cabbage and buckbean are growing in the wet pockets (Table 2).

Sedge peat comprises the muskeg section with some moss near the surface and with interbedded woody layers (Fig. 26). The column is 2.9 meters thick, underlain with sandy clay. Volcanic ash occurs at 1.0 meter and oxidized peat at 2.9 meters.

Auke Bay muskeg is near mile 13 on the Glacier Highway at the junction with the Loop Road (Fig. 3). The surface slopes southward and supports the largest lodgepole pine encountered in this study. These trees include individuals as much as 2 feet d.b.h. and 50 feet high

(Fig. 12). Shrubs and small trees are numerous and consist mostly of both hemlock species, Labrador tea, bunchberry, cloudberry, crowberry, club moss, menziesia, and lingen berry. Skunk cabbage, buckbean, and deer cabbage grow in wet depressions (Table 2).

The depth of peat is 2.6 meters to blue-gray clay (Fig. 28). Sedge peat occurs at the bottom and grades upward into forest peat and moss, although it is again present in the top meter. A trace of glass shards occurs at 1.3 meters.

Herbert River Tributary (#13) is a flat muskeg at mile 26 on the Glacier Highway (Fig. 3). It occupies the floor of the valley from the vicinity of this station almost to the end of the road at the confluence of the Herbert and Eagle rivers. The flora is distinctive (Table 2) with extensive associes of cotton grass and buckbean and spongy tracts of moss. Ridges of Sitka spruce and thickets of willow (Salix spp.) and alder (Alnus spp.) intermingle on the flat. The peat is 0.4 meter thick and lies on gray silty sand (Fig. 31). Sedge and sphagnum both occur. No volcanic ash is found.

The last station of the entire low elevation group is near Mendenhall Lake (#15), about a mile from the 1951 terminus of Mendenhall Glacier (Figs. 3 and 13). The deposit is 0.1 meter of sedge peat with some admixture of

Fig. 12. Auke Bay muskeg (#11) near Juneau, Southeastern Alaska, showing old growth lodgepole pine approximately 50 feet in height and 2 feet d.b.h. (diameter breast high); an undergrowth of heaths and hemlocks have recently invaded this muskeg.

Fig. 13. Hydrarch succession in a kettle in the outwash of Mendenhall Glacier at station #15, Southeastern Alaska; zonation is apparent on the periphery with northern bur-reed floating on the surface of the water and horsetail and spike-rush growing erect; young forest of black cottonwood is seen on the upland with an understory of Sitka spruce.

moss and horsetail (Equisetum variegatum) (Fig. 27). The peat is formed on sandy silt in what appears to be an old kettle in the pitted outwash in front of the glacier. The station is beyond the 1909-1910 recessional moraine which is about an eighth of a mile northeast, cutting through Mendenhall Lake (58, p. 201). Upon this basis, the deposit would seem to be between 50 and 75 years in age. Hydrarch succession reveals a number of stages from floating northern bur-reed (Sparganium hyperboreum) through mare's tail (Hippuris vulgaris), spike-rush (Eleocharis palustris), and horsetail to upland willow, black cottonwood (Populus trichocarpa), and Sitka spruce (Table 2). No submerged plants are apparent.

Lower Montana Creek muskeg (#16) occurs at about 150 feet elevation on Montana Creek Road, a little more than a mile distant from station #15 (Fig. 3). The surface is somewhat undulating with a number of hollows, although it is essentially raised on the northeast side of the creek. At a low point near the creek, a large pool exists which contains yellowpond lily (Nuphar polysepalum) and other aquatics. Sedges are important in the ground cover, as is sphagnum moss, while heaths, crowberry, and cloudberry are localized. Lodgepole pine is common while both hemlocks are also present (Table 2).

This muskeg, 5.9 meters deep, is the deepest of the seventeen samples in Southeastern Alaska. The majority of the peat is moss (Fig. 33). Wood peat occupies the lowest level overlying sandy gravel, and several woody horizons lie above this between layers of moss and sedge. Glass fragments are only found at 1.3 meters. The peat does not show signs of disturbance.

Upper Montana Creek (#17) is the highest sampling station of this study (at about 750 feet elevation). It is located 3 miles from the end of the Montana Creek Road on the divide which leads to Windfall Lake. (Fig. 3). Many muskegs are present at this elevation and at higher elevations to the south. The peat at this locality slopes onto the flat divide from the west, where it is bordered higher up by a forest fringe. Eastward, it is also terminated by forest which occurs on the margin of the flat. The muskeg, in general, is elongate, open and "park-like", and follows the trough of the divide. No lodgepole pine was noted at this elevation. In fact, trees on the muskeg are few and are mostly low mountain and western hemlocks. A number of large pools with yellow pond lily occupy depressions in the flat. Sedges, crowberry, cloudberry, and heaths are the principal plants (Table 2).

The peat was sampled to 3.8 meters and consists of sedge with a few decimeters of moss at the surface and a conspicuous layer of wood material near the bottom

(Fig. 32). Decomposed sedge peat occupies the bottom of the section and overlies gray silt. Septate mycelium abounds from 1.3 to 1.8 meters. Some volcanic glass is present at 0.2 meter. More interesting, however, are the shards which are found from 3.6 meters to the bottom of the section. These do not underlie any of the other muskegs of this study, except those at Sitka (Figs. 23 and 24).

VEGETATION OF SOUTHEASTERN ALASKA

Vegetation in Southeastern Alaska may be classified primarily as forest, muskeg, and alpine tundra. These major types are largely the result of climatic and physiographic variation within the region. Zach (86, pp. 304-306) has pointed out that physiography appears to be the controlling factor in determining whether forest or muskeg develops, even though they exist under similar climatic conditions. Alpine tundra, on the other hand, is distributed at higher elevations beyond forest or muskeg due to a climatic difference. The Clementsian system would consider the mesophytic forest as climax with muskeg as post-climax and alpine tundra, pre-climax (81, pp. 82-86).

Forests

Southeastern Alaska lies within and near the northern limit of the Coast Forest which attains its greatest development from northern California to southern British Columbia. Weaver and Clements (81, pp. 500-503) named this the western red cedar-western hemlock formation. Actually, western red cedar is poorly represented over much of the range, and Sitka spruce is more commonly a constituent, especially along the immediate coast

(46, pp. 42-45).

In the southern part of Southeastern Alaska, the climax is known as the western hemlock-Sitka spruce-western red cedar association. Alaska yellow cedar, alpine fir, silver fir, mountain hemlock, and western yew are locally present. North of 57° north latitude, western red cedar is absent (77, p. 18), and the climax consists largely of western hemlock and Sitka spruce. Silver fir and western yew do not extend far north in the archipelago. Alpine fir occurs sporadically, usually inland on the slopes of the Coast Range. It has its greatest development in the vicinity of Skagway in the northeast at the head of Lynn Canal, and on White Pass, it is the only tree at timberline (24, p. 246). Mountain hemlock which is found largely at higher elevations in the southeast, also continues north at timberline, but descends to sea level in the vicinity of Juneau.

The Coast Forest of Southeastern Alaska, in general, is luxuriant from sea level to approximately 1,500 feet (78, p. 382). Its composition progressively changes, however, from sea level to timberline with a decrease of Sitka spruce and an increase of mountain hemlock. Timberline varies from 2,400 feet in the southeast to 1,800 feet in the northwest (24, p. 248). The forest loses continuity between 1,500 feet and timberline, and the trees become lower in stature, finally to assume a krummholz form at the limit of tree growth. Most of the trees on the higher slopes appear "bowed" near the base of their trunks, as a result of snow movement downslope. Shrubs and small trees which cover much of the upper slopes, such as Alaska alder (Alnus fruticosa var. sinuata), have been forced to grow essentially downslope, due to the weight of snow and its persistence late in the growing season.

The composition of the prevailing all-aged forest is western hemlock 73%, Sitka spruce 23%, western red cedar 3%, with the other species mentioned forming the remainder (78, p. 381). Although western hemlock is by far the most abundant dominant, it does not attain the size of Sitka spruce which is the most valuable commercial tree. Some specimens of Sitka spruce reach a diameter of 6½ feet and 175 feet in height (43, p. 228), whereas western hemlock attains a diameter of only 2½ feet and 125 feet in height (77, p. 14). Western red cedar at Ketchikan has been found with a diameter of over 3 feet (48, p. 14).

The coniferous forest borders on the bays and inlets and often extends down to the upper tidal limit. The latter is particularly true, if the shoreline is rough and rocky. A fringe of alder (Alnus oregona and A. fruticosa var. sinuata) and willow (Salix spp.), however, usually occurs at the outer edge of the forest, if a beach is present. Such shrubs and small trees extend inland along the rivers and with black cottonwood cover the flood plains. The interior of the climax forest is usually dense and dark, unless the canopy has been opened by windfall or other disturbance. Thick mats of moss cover the forest floor and are wet and spongy. In the darker understory, the frutescent and herbaceous synusiae are poorly developed, whereas with increased light, these layers are better defined. The most common shrubs and herbs are: red-berried elder (Sambucus racemosa subsp. pubens), devil's club (Oplopanax horridus), salmon berry (Rubus spectabilis), blueberry (Vaccinium ovalifolium), rusty menziesia (Menziesia ferruginea), bunchberry and gold thread (Coptis asplenifolia). Skunk cabbage is usually found as a rank undergrowth under swampy conditions. At higher elevations near timberline, such plants as American white hellebore (Veratrum eschscholtzii) and copper bush (Cladothamnus pyrolaeflorus) are common. Subseres, which are the result of snow avalanching on upper slopes, consist of various stages in which dwarf fireweed (Epilobium latifolium), goat's beard (Aruncus vulgaris), blue currant (Ribes bracteosum), red-berried elder, and Alaska alder are prominent.

The prisere on glacial outwash has been thoroughly investigated by Cooper (14, pp. 226-244) and Taylor

(78, pp. 382-385). The species participating in the succession vary in different parts of Southeastern Alaska, and a generalized scheme is thus presented. In the initial stage, dwarf fireweed and lupine (*Lupinus nootkatensis*) are important invaders of the moraines and pitted gravels. Seedlings of Sitka spruce, western hemlock, and mountain hemlock may invade this terrain simultaneously, although usually only spruce and mountain hemlock survive. Both of these ultimately become a part of the climax forest. The importance of legumes, such as lupine, in adding nitrogen to the soil has been discussed in the postglacial succession in Prince William Sound (60, pp. 563-564). Alder, willow, and black cottonwood may invade at or about the same time as those of the initial succession, but due to their rapid growth soon form a definite thicket stage, superseding temporarily the spruce and mountain hemlock. Sitka spruce and mountain hemlock continue to seed in as the succession progresses. Black cottonwood grows more rapidly and soon overtops the thicket, only later to be overtopped, in turn, by Sitka spruce. This sequence is shown in Figures 14, 15 and 16. Cottonwood is unable to persist, being shade intolerant, and dies out along with the willow and alder. Throughout these stages of succession, Sitka spruce with some mountain hemlock has persisted and now forms practically pure, even-aged stands.

Fig. 14. Ice front of Mendenhall Glacier, Southeastern Alaska, showing outwash recently exposed to plants of the early stages of the prisere; later stage of willow-alder thicket is evident in the foreground.

Fig. 15. Willow-alder thickets growing on outwash of the Mendenhall Glacier, Southeastern Alaska.

Fig. 16. Young forest of Sitka spruce and black cottonwood growing on recessional moraine of Mendenhall Glacier, Southeastern Alaska; erratic, moss-covered boulder is evident on the right.

Such stands may develop as early as 75 years following deglaciation. Sterile mineral soil at this stage is covered by a thin layer of organic debris left by the broad-leaved pioneers. Mosses soon become established, and litter and duff accumulate during this period of spruce predominance. The environment of the spruce forest is favorable for the seeding in of western hemlock, and gradually this species forms in the understory. The high degree of shade tolerance of western hemlock in the spruce forest, permits it to thrive and eventually gain control over the less tolerant spruce (1, p. 15). Thus, the climax consists largely of western hemlock and Sitka spruce. In this connection, it should be mentioned that spruce seedlings develop in greater proportion when nitrate-nitrogen is more available. Hemlock seedlings, on the other hand, are abundant under conditions where ammoniacal-nitrogen accumulates in seed beds containing organic matter (79, p. 600). This may explain the persistence of spruce on sterile, organic-free gravels and the inability of hemlock to develop under such conditions. It may also explain, in part, the establishment of western hemlock in the spruce forest and the fact that spruce seedlings are few. Sitka spruce and western and mountain hemlocks exhibit a layering habit in young transitional stands, and in this way they may reproduce vegetatively (16, pp. 441-445).

Hydrarch succession is also very common, as in kettles in the outwash of Mendenhall Glacier near Juneau (Fig. 13). No submerged stage is apparent, but rather the succession begins with the floating stage represented by northern bur-reed. Farther removed is a zone of mare's tail, spike-rush, and horsetail. This is followed by tussocks of sedge (Carex hindsii), reed grass (Calamagrostis canadensis), and cotton grass (Eriophorum chamissonis and E. scheuchzeri) with a varied assemblage of plants: buckbean, western tofieldia, grass-of-Parnassus (Parnassia palustris), white bog-orchid (Limnorchis dilitata), lousewort (Pedicularis seudetica), and mountain meadow bistort (Polygonum bistorta subsp. plumosum). Woody plants follow this stage, including blueberry (Vaccinium uliginosum), willow, and Sitka spruce, as forerunners of the mesophytic subclimax and climax forests, ultimately to develop.

The coast forest has been called the "asbestos forest" of Alaska. Heavy precipitation throughout the year prevents fire from becoming a dangerous hazard. Drier conditions prevail, however, at the heads of inlets and inland along the rivers, so that there is a greater danger of fire. Such is true at the head of Lynn Canal and along the Stikine River (32, p. 28). Fires may also be a danger in the archipelago during dry summer periods, although when they do occur, they are seldom more than a few acres in extent. Small fires occurred near Ketchikan during the dry month of June in 1951.

Muskegs

Muskegs are common in Southeastern Alaska and occupy considerable tracts dispersed throughout the forest. Rigg (70, pp. 167-182) and Dachnowski-Stokes (18, pp. 1-32) have studied their nature and formation, and the information at hand is largely the result of their observations. The term "muskeg" is of Indian origin and has become a colloquialism in Alaska, referable to such non-forested regions. Muskegs develop under poorly drained conditions and in the presence of peat forming plants, largely mosses and sedges. Three types have been classified: slope, raised, and flat muskegs.

Slope muskegs are the most typical of Southeastern Alaska. They have formed on inclined benches as a result of heavy rainfall and cool summers, both of which retard the decay of vegetable matter. Drainage on the low angle slopes is poor, but on steeper slopes which are better drained, forests are able to grow (86, pp. 304-305). Slope muskegs are better developed where the topography is low and hilly whereas in steeper areas, the peat is shallow and the proportion of forest trees greater.

An open, scrubby growth of lodgepole pine usually characterizes slope muskegs, although the trees never attain any great size. Lodgepole pine in Southeastern Alaska is almost entirely restricted to muskeg. It may at times occupy poorly drained swampy land in the forest, but under such conditions, it is usually successional as better drainage develops. Lodgepole pine has been mentioned as growing on outwash and in swales at Glacier Bay (15, p. 331). Western and mountain hemlock, Sitka spruce, western red cedar, and Alaska yellow cedar are commonly found where the slope has become almost too steep for muskeg to form. The shrubby cover on the peat is largely low heath consisting of blueberry (Vaccinium uliginosum), swamp laurel, and Labrador tea; other shrubs are crowberry and low juniper. Typical herbs include sedges (Carex pauciflora, Scirpus caespitosus var. callosus, Rynchospora alba, and Eriophorum spp.), club moss, western tofieldia, goldthread (Coptis trifoliata), sundew (Drosera rotundifolia), burnet, bunchberry, and cloudberry. Mosses are largely Sphagnum spp.

Raised muskegs occur more locally than the slope type, and in Southeastern Alaska, they are well developed near Juneau (71, p. 194). They are typically convex, slope gently outward, and appear to form where rainfall is less than average. They usually consist of a greater thickness of peat. Raised muskegs are better aerated, as indicated by the increased growth of lodgepole pine (Fig. 12). Besides pine, western and mountain hemlocks are often present with some Sitka spruce. The shrubs, typically, consist of blueberry (Vaccinium uliginosum), lingen berry, bog rosemary, swamp laurel, Labrador tea, menziesia, and crowberry. Sedges are common (Carex pauciflora, Scirpus caespitosus var. callosus, and Eriophorum spp.). Other herbs are skunk cabbage, goldthread, sundew, cloudberry, bunchberry, and cranberry. Sphagnum spp. for the most part comprise the moss layer.

Flat muskegs are found occupying the floors of glaciated, U-shaped valleys, lowlands, and broad areas of level country. They are found both on the mainland and on the islands, but are more common in the interior of Alaska and in the Yukon. Flat muskegs are generally shallow and usually formed of silty muck and sedge peat while sphagnum is only present at the surface. They are maintained because of a high water table and often have a quaking character. Open pools are sometimes present in which the early stages of hydroseres are evident. Trees are not common, and the vegetation has a meadow aspect.

Cotton grass often becomes prominent with buckbean, and the white bog-orchid, burnet, marsh marigold (<u>Caltha palustris</u> subsp. <u>asarifolia</u>), sundew, marsh cinquefoil (<u>Potentilla palustris</u>), Indian rice (<u>Fritillaria camtchatcensis</u>), and cranberry occur. Wild iris (<u>Iris setosa</u>) and skunk cabbage occupy the wetter depressions.

The almost total restriction of lodgepole pine to muskeg is probably due to its inability to compete elsewhere. It is very intolerant of shade when young, although it can persist in very dense stands for 20-30 years (75, p. 54). Its light requirements are thereby satisfied in muskeg, but where it is found beyond the limit of peat, it fails to compete and is early replaced by Sitka spruce. Its ecological amplitude is very broad when one considers the wide range of climatic conditions under which it grows. These range from a climate with 18 inches of precipitation and cold winters in the Rockies (63, p. 3) to one with over 150 inches precipitation and rather mild winters in coastal Alaska. This fact leads one to suspect the presence of ecotypes or ecologic races of lodgepole pine. One might argue that although it develops in a wide variation of climate, its presence in muskeg is due to the physiological dryness of this habitat, and in this respect, its habitat is essentially like that where rainfall is as low as 18 inches. Whether ecotypes exist, there is a strong possibility that the ecospecies may be subdivided. Some taxonomists have long regarded two distinct types of lodgepole pine: a coastal and an inland one. Biosystematy might resolve its true nature.

Alpine Tundra

An alpine flora is present above timberline and on the exposed slopes of nunataks in the ice fields throughout the Coast Range. This flora is, more or less, continuous immediately above timberline, but inland in the ice fields, it is sporadic, being found on south-facing slopes on nunataks above the névé. The youthful distribution of the flora is indicated by the discontinuity of the communities and the early stages of the alpine prisere, largely a result of the recent shrinkage of the ice and the denuding of terrain suitable for invasion.

In the Juneau Ice Field, plants occur sparsely between elevations of 3,600 and 6,000 feet, although at certain places, communities are well developed (42). Such communities are probably relict and may formerly have been of greater distribution, having survived in unglaciated refugia during the last ice maximum, beginning approximately 1,800 years ago. As many as 40 species of higher plants were collected in one community, in an area of about 150 square meters.

Such refugia have been a source of seed for initiating plant succession on the deglaciated slopes. The wood rush, *Luzula parviflora*, and sedges, *Carex* spp., are usually the first to invade and are followed by rush (*Juncus drummondii*) and heather (*Cassiope mertensiana*). The climax at 4,000 feet, as suggested by the composition of the relicts, appears to consist of a complex of plants: yellow heather (*Phyllodoce glanduliflora*), alpine azalea (*Loiseleuria procumbens*), heather (*Cassiope mertensiana*, *C. stelleriana*, *C. tetragona*, and *C. lycopodioides*), and blueberry (*Vaccinium uliginosum*) with club moss (*Lycopodium alpinum*), crowberry, lupine, partridge foot (*Luetkea pectinata*), and spotted saxifrage (*Saxifraga bronchialis* subsp. *funstonii*).

POSTGLACIAL FOREST SUCCESSION AND MUSKEG DEVELOPMENT

In order for the reader to be oriented as to the climatic and chronological considerations, which are treated in detail following the discussion of the forest succession as expressed by the pollen diagrams, the environmental sequence is included at this point:

Period V	warmer and drier	glacier recession
		200 years
Period IV	cooler and wetter	hemlock maximum
		2,000 years
Period III	maximum warmth and dryness	glacial advance; western hemlock predominance glacial minimum
		5,000 years
Period II	warming and drying	spruce and hemlock succession
		6,000 years
Period I	cool and moist	pine period; glacial recession
		8,000 years

This sequence consists of five periods based on climatic, edaphic, physiographic, pyric and biotic implications derived from the peat sections and the pollen profiles. The boundaries of these as divisions of postglacial time are not to be considered as rigidly fixed.

The total time since deglaciation of the earliest sites of pollen sedimentation is estimated at about 8,000 years. Period I is placed between 8,000 and 6,000 years ago, and it is characterized by a cool and moist climate and unstable edaphic and physiographic conditions. Period II is dated from 6,000 to 5,000 years ago and is a time of amelioration of climate, soil, and physiography. Period III is indicated as warm and dry and endured from 5,000 to 2,000 years ago. Period IV lasted until 200 years ago (1750) and is defined by an interval of cooler and wetter climate during which the glaciers in the region advanced. Period V is the most recent and marks the recession of the ice of Period IV and the arrival of white man.

Lodgepole pine was the earliest arboreal member of the postglacial prisere in Southeastern Alaska. In what are considered to be the oldest pollen containing sediments, (Period I) this species has been by far the most preponderant (Figs. 17, 18, 22, and 32). Its early invasion of deglaciated terrain is attributed to abundant seed production at an early age and an ability to withstand adverse conditions (36, pp. 72-73). Lodgepole pine will thrive on sterile soil with a low organic content and a dearth of nutrients such as nitrogen, but as this species modifies the microclimatic and edaphic conditions of the forest, it is successively replaced by spruce and hemlocks. Thus, the record of its presence from the oldest sediments of this study suggests that it may have endured for a few millennia. It may have persisted for longer periods, however, due to prolonged physiographic instability and the absence of successional conifers, as on Vancouver Island, British Columbia (38, pp. 273-274) and in the Puget Lowland of Washington (35, pp. 272, 274, and 277).

Sitka spruce is poorly represented during Period I, and its absence may be explained by the intolerance of the species to cold during the seedling stage (75, p. 84). Early postglacial terrain was probably colder at least in winter, than outwash recently exposed to spruce invasion is today. In any event, spruce was slow to increase regionally for some time following glaciation. Western hemlock is usually represented by lower percentages than spruce in the oldest deposits. Its development in postglacial time has been very largely the converse to that of spruce. The species may seed in early as it does on the outwash of Mendenhall Glacier, but seedlings do not survive. In the presence of a seed bed with sufficient organic material, however, it thrives and develops into climax stands. Mountain hemlock, a climax constituent and timberline tree, likewise developed slowly during Period I.

Lodgepole pine gradually increased above its initial decline during late Period II and continued to expand to the top of the profiles (Figs. 17, 18, 20, 21, 22, 23, 24, 25, 26, 28, 29, 30, 32, and 33). This increase in some cases to predominance over spruce and hemlocks (Fig. 18), is thought to have been caused by the local influence of a wetter climate. Lodgepole pine is almost entirely a muskeg dweller. It undoubtedly has persisted on muskegs since its suppression in early postglacial time (Period II), due to the inability of other conifers to succeed it on such areas. Under a drier climate, as existed in middle postglacial time (Period III), the pollen of other conifers was free to settle with that of pine on the surface of the muskeg. With increasing moisture in late postglacial time (Periods IV and V), however, pine has "masked" the record of the trees of the adjacent forest, since transport of their pollen was undoubtedly limited because of the wetter conditions.

Climatic and edaphic amelioration with increased physiographic stability occurred during Period II, as indicated by the trends of Sitka spruce and the hemlocks (Figs. 17, 18, 32, and 33). The expansion of spruce was rapid and preceded that of western and mountain hemlock. Spruce, as pine had done previously, brought about more favorable conditions for the development of the climax dominant, western hemlock. Alder maxima are in evidence during Period II (Tables 3, 4, 7, 8, 11, 15, 18, and 19) and portray the successional role of this invader.

Western hemlock superseded spruce during Period II as a result of the modification of the environment and continued to rise, reaching its highest percentage during Period IV as moisture conditions reached an optimum for hemlock development (Figs. 17, 20, 24, 25, 28, 29, 32, and 33). In certain cases such as Point Higgins (#2) near Ketchikan (Fig. 18), this peak is "masked" by an overrepresentation of pine during Period IV. The decline of Western Hemlock in late Period IV and during Period V may reflect the destruction of the climax forest by ice advance at upper elevations where this action was most effective.. Spruce being a tree of lower elevations apparently increased at this time, although its record of expansion may be merely relative because of the decrease of western hemlock. Mountain hemlock in general attained its maximum during Period III, and the highest altitudinal station of this study, Upper Montana Creek (#17) at about 750 feet elevation near Juneau (Fig. 32), shows the greatest abundance of this species. It would seem that during the warm, dry interval (Period III), mountain hemlock became more prevalent on the muskeg because of better ecological conditions or had migrated to higher elevations for the same reason. Since Period III it has again become abundant at sea level.

The general increase of spruce and decrease of hemlocks in upper Period IV and in Period V is attributed in part to the succession which is now attending the recent (1750) retreat of glaciers along the North Pacific coast. Lumbering operations, more recently, have also probably favored the increase of spruce through the creation of subseres.

There is little that can be added concerning post-Wisconsin glacier advance and retreat, other than to substantiate what has already been presented in the literature (50, pp. 681-700) and (58, pp. 191-223). There are, however, implications that early postglacial time was marked by a certain discontinuity in the manner of ice recession and even by ice readvance. The irregular increase of pine, spruce, and western hemlock at Upper Montana Creek (#17) in the Juneau District during Period I (Fig. 32) may be attributable to a fluctuating ice front during recession. At Upper Ward Creek (#1) in the Ketchikan District, a similar trend is depicted (Fig. 17). The profiles in the Petersburg District on Mitkof Island show a later Period II disruption of the successional trend, whereby the climax dominant, western hemlock, was diminished after having gained predominance (Figs. 21 and 22).

This Period II alteration is thought to have been due to a readvance of ice in the Stikine Valley nearby (Fig. 1), since the Wrangell District profile (Fig. 20), nearer the Stikine River, shows the most decided modification of the Period II curve. The Period II change is noted at Upper Montana Creek (Fig. 32) and appears to have been extensive along the Coast Range, although at Ketchikan (Figs. 17 and 18) in the south, it is not in evidence.

The fluctuations of the curves during Period III (warm, dry interval) are not deciphered as a result of glacier expansion, but rather of fire and the probable differential pollen preservation, as a result of oxidation which is evident in the peat. The increase of moisture with cooling during Period IV, as manifested by the maximum percentages of western hemlock, was probably responsible for the readvance of ice 2,000 years ago.

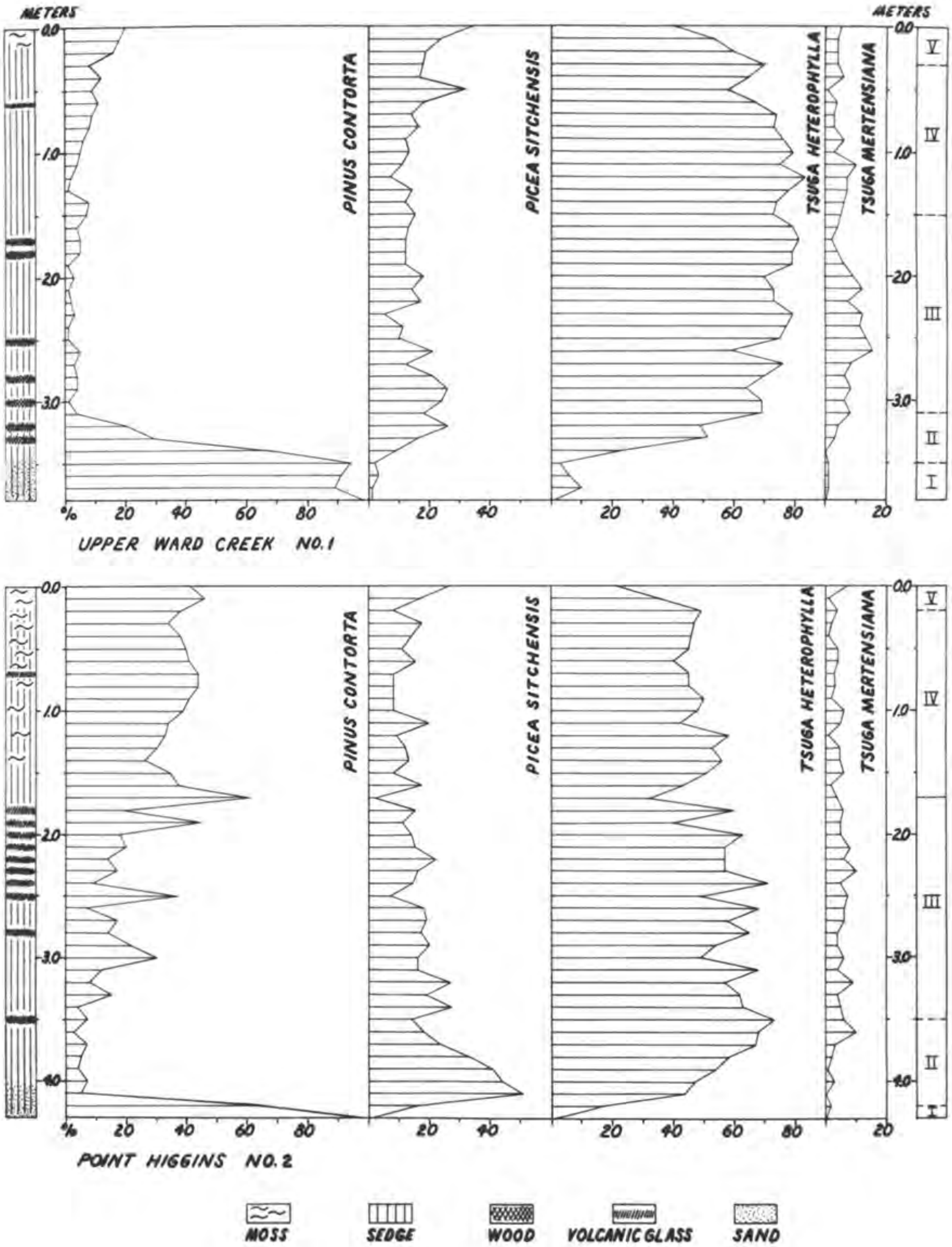
The typological succession of peat in the sedimentary columns is from sedge to wood to moss and sedge. This sequence discloses the developmental history of the muskegs. Wood peat forms the bottom type in some, but such deposits are usually younger in age (Figs. 23, 26, 30, 33). Skunk cabbage was a prominent plant in these early forests as indicated by the large amount of pollen found (Tables 3, 4, 6, 7, 9, 10, 11, 12, 13, and 15). A swamp habitat is visualized at this time similar to poorly drained forested lowland in Alaska today. The oldest sections as revealed by pollen analysis have begun with sedge peat. This is correlated with the cool and moist Period I and the ameliorating Period II. Wood peat is usually most evident during Period III. During a warmer and drier climate, forests were able to invade the sites of muskegs. Septate hyphae, which are thought to be the ascomycetous member of xeric lichens, and charred and oxidized peat are particularly in evidence and strengthen the justification for assuming a warmer and drier climatic interval at this time.

The sedge and moss peat in Periods IV and V bear witness to the increasingly wetter climate that succeeded the Period III "climatic optimum". The forests that invaded the muskegs during Period III were killed. The climate was probably also cooler, since glaciers advanced at this time. At present, the forests that have reinvaded the muskegs are indicative of a certain amount of drying since 1750. This is supported by the fact that no wood horizons are notably interposed between the woody peat of Period III and the surface.

No aquatic stages that supported plants of an early hydrosere are thought to have existed before and during Period III, as their pollen was not observed in peat of this early and middle postglacial time. Hansen (37, p.411) has reported this to be true of muskegs studied in the interior of British Columbia and Yukon Territory. The pools that are present on the muskegs do contain such aquatics as yellow pond lily, but apparently these have formed since the early succession of forest by moss and sedge peat (Period III). Muskeg seems to have originated from sites of insufficient drainage to support forest, but not of sufficient ponding to permit the growth of true aquatic plants. Muskegs that did not form during the wet and cool early postglacial climate, appear to have formed after the warm, dry interval.

Fig. 17. Peat section, pollen profiles, and environmental sequence for Upper Ward Creek muskeg (#1), Ketchikan District, Southeastern Alaska.

Fig. 18. Peat section, pollen profiles, and environmental sequence for Point Higgins muskeg (#2), Ketchikan District, Southeastern Alaska.



METERS
0.0
1.0
2.0
3.0
PINUS CONTORTA
PICEA SITCHENSIS
TSUGA HETEROPHYLLA
TSUGA MERTENSIANA
V
IV
III
II
I
%
20
40
60
80
20
40
20
40
60
80
20
UPPER WARD CREEK NO. 1
0.0
1.0
2.0
3.0
4.0
PINUS CONTORTA
PICEA SITCHENSIS
TSUGA HETEROPHYLLA
TSUGA MERTENSIANA
V
IV
III
II
I
%
20
40
60
80
20
40
20
40
60
80
20
POINT HIGGINS NO. 2
MOSS
SEDGE
WOOD
VOLCANIC GLASS
SAND

Table 3. Analysis of Upper Ward Creek Muskeg (No. 1), Ketchikan District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Pinus contorta[1]	20	18	16	8	12	9	11	9	8	6	5	4	2	1	8	7	4	5	5	1	3	1	2	3	1	1	5	3	4	4	1	4	20	29	68	94	91	89	98
Abies amabilis[1]	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	1	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Tsuga heterophylla[1]	41	53	60	70	65	58	67	74	73	76	79	75	83	78	74	73	79	81	79	79	70	73	73	79	77	75	59	76	70	64	69	69	49	51	23	3	6	10	1
Tsuga mertensiana[1]	5	4	4	4	6	1	4	3	3	6	3	10	7	7	6	5	4	2	4	6	9	12	7	12	11	11	15	8	6	8	6	8	4	3	..	1	1	1	..
Picea sitchensis[1]	34	24	19	18	17	32	18	14	16	12	13	11	7	14	12	15	13	12	12	12	18	14	17	5	11	10	21	12	21	25	24	15	26	16	9	2	3	1	1
Conifer complex[2]	93	17	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gramineads	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Cyperads	4	..	2	..	..	1	1	1	..	..	..	..	..	..	..	..	..	1	2	2	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..
Lysichitum	..	..	..	..	6	1	..	..	..	..	..	2	1	2	..	..	20	21	28	66	200	120	192	199	272	135	225	256	196	231	153	563	124	41	..	..	..	..	..
Salix	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Betula	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Alnus	13	9	2	7	7	4	9	11	9	..	14	7	3	3	..	3	13	4	7	2	2	5	6	7	3	7	1	5	6	1	17	142	77	42	14	8	3	8	6
Drosera	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubus	..	1	..	8	3	..	1	1	1	..	..	1	..	1	1	2	..	..	..	1	1	2	..	..	..	..	..	..	1	..	..	..	1	..	..	1	..	..	..
Empetrads-Ericads	..	3	1	14	24	27	17	20	25	107	62	65	27	13	15	6	9	10	11	4	7	2	8	7	5	1	3	5	7	6	3	28	10	1	..	..	8	2	2
Cornus	2	2	8	2	4	3	2	1	3	11	2	8	1	2	4	3	9	8	3	..	1	..	..	3	1	3	..	..	..	..	1	3	..	..	..	..	..	1	..
Unknown[3]	5	7	4	3	2	4	..	3	4	5	1	4	1	1	5	4	1	5	2	4	2	3	1	2	2	1	2	3	5	8	2	7	2	4	..	1	1	..	..

[1] Percent of 150 grain total count.

[2] Inaperturate grains not included in 150 grain count and probably including Taxus brevifolia, Juniperus communis var. montana, Thuja plicata, and Chamaecyparis nootkatensis.

[3] Number of unknown conifers which were included in 150 grain count.

Table 4. Analysis of Point Higgins Muskeg (No. 2), Ketchikan District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Pinus contorta[1]	42	46	38	34	38	40	41	44	44	41	39	34	33	30	26	35	38	41	39	45	18	23	14	17	9	37	7	17	14	22	30	12	8	15	4	7	3	7	5	4	7	5	66	96
Abies amabilis[1]	1	..	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	..	..
Tsuga heterophylla[1]	23	36	49	47	46	45	40	45	45	50	48	42	58	53	55	51	43	32	60	40	63	57	57	57	71	49	69	58	65	54	49	58	57	62	61	73	68	67	58	54	47	44	16	2
Tsuga mertensiana[1]	7	1	4	2	1	4	4	3	3	2	6	5	1	5	5	6	2	4	4	5	5	8	6	10	5	7	6	6	4	4	6	4	9	4	5	6	10	3	2	1	3	..	2	..
Picea sitchensis[1]	26	17	8	17	14	11	15	8	8	8	8	20	9	12	13	8	17	2	15	11	14	19	22	14	16	7	13	10	17	20	16	16	27	19	27	14	18	24	34	41	44	51	15	2
Conifer complex[2]	80	34	16	10	17	14	9	4	..	3	2	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gramineads	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cyperads	..	2	..	..	..	..	..	1	..	..	2	2	1	1	..	3	1	1	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1	..	..	..
Lysichitum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	28	122	49	33	245	352	148	28	16	12	..	2
Salix	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Betula	..	1	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus	4	5	5	3	2	5	2	1	1	17	2	12	9	6	3	13	8	9	6	5	2	3	1	..	2	7	2	..	..	2	2	..	2	2	1	12	8	7	114	131	128	82	66	8
Drosera	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubus	1	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Empetrads-Ericads	..	3	..	6	..	2	1	2	..	..	1	2	2	5	2	1	1	1	1	5	3	18	21	14	9	4	5	2	4	..	1	..	2	..	..	2	8	5	7	3	5	2	2	..
Cornus	..	2	5	4	1	4	4	2	..	10	2	2	..	4	3	6	4	2	1	4	2	2	1	1	..	2	1	2	..	..	1	..	..	1	..	..	..	..	1	1	4	..	..	..
Unknown[3]	6	1	7	5	3	8	5	2	6	5	5	4	6	4	7	6	3	11	8	1	3	7	7	6	4	12	9	4	8	3	2	1	5	5	10	6	7	1	4	3	2	1	1	..

[1] Percent of 150 grain total count.

[2] Inaperturate grains not included in 150 grain count and probable including Taxus brevifolia, Juniperus communis var. montana, Thuja plicata, and Chamaecyparis nootkatensis.

Fig. 19. Peat section, pollen profiles, and environmental sequence for Ski Trail muskeg (#3), Wrangell District, Southeastern Alaska.

Fig. 20. Peat section, pollen profiles, and environmental sequence for North Wrangell muskeg (#4), Wrangell District, Southeastern Alaska.

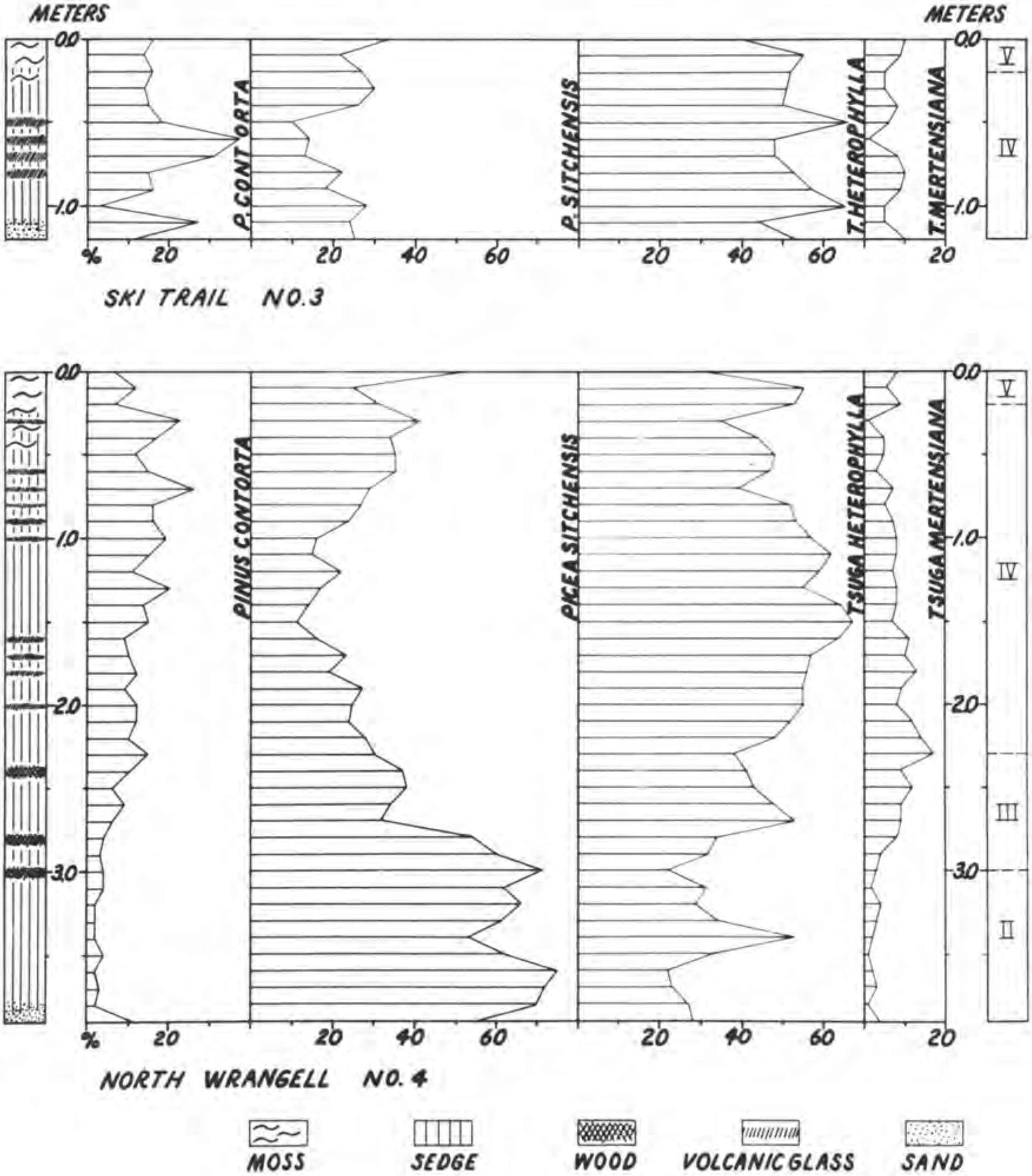

METERS
0.0
1.0
%
20
P. CONTORTA
40
60
P. SITCHENSIS
T. HETEROPHYLLA
T. MERTENSIANA
V
IV
SKI TRAIL NO. 3
2.0
3.0
PINUS CONTORTA
PICEA SITCHENSIS
TSUGA HETEROPHYLLA
TSUGA MERTENSIANA
III
II
NORTH WRANGELL NO. 4
MOSS
SEDGE
WOOD
VOLCANIC GLASS
SAND

Table 5. Analysis of Ski Trail Muskeg (No. 3), Wrangell District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12
Pinus contorta[1].....	16	14	16	14	15	18	17	31	15	16	3	27	12
Tsuga heterophylla[1].	41	55	52	51	50	66	48	48	53	57	65	44	53
Tsuga mertensiana[1]..	10	9	5	5	8	6	1	8	10	9	5	5	10
Picea sitchensis[1]...	33	22	27	30	26	10	14	13	22	18	28	24	25
Conifer complex[2]....	68	13	5	2	..	..	..	..	2	..	..	..	..
Graminads...........	..	1	..	..	..	..	..	..	..	..	..	..	..
Cyperads............	6	1	..	1	..	..	..	..	..	..	..	..	..
Lysichitum..........	..	23	108	75	26	76	38	651	93	400	27	102	216
Betula..............	..	..	..	1	..	..	..	1	..	..	..	..	..
Alnus...............	67	15	10	11	8	4	..	26	14	12	9	17	19
Empetrads-Ericads...	7	9	8	9	13	20	22	19	14	12	6	12	10
Cornus..............	10	9	7	2	..	..	1	2	..	..	..	..	2
Unknown[3]............	3	4	5	6	5	5	3	6	7	10	6	9	12

[1] Percent of 150 grain total count.

[2] Inaperturate grains not included in 150 grain count and probably including Juniperus communis var. montana, Thuja plicata, and Chamaecyparis nootkatensis.

[3] Number of unknown conifers which were included in 150 grain count.

Table 6. Analysis of Wrangell Muskeg (No. 4), Wrangell District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Pinus contorta[1].....	7	12	7	23	17	12	15	26	16	16	19	15	11	20	14	15	9	10	12	9
Abies amabilis[1].....	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tsuga heterophylla[1].	32	55	53	35	44	48	47	39	52	53	57	62	59	55	64	67	64	57	56	55
Tsuga mertensiana[1]..	8	6	9	1	5	5	3	7	5	7	8	8	7	8	8	7	11	10	11	9
Picea sitchensis[1]...	52	25	31	41	34	35	35	29	27	24	16	15	22	17	14	11	16	23	19	27
Conifer complex[2]....	50	38	8	12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cyperads............	3	..	..	..	..	..	..	..	..	..	..	3	..	2	4	..	2	..	1	6
Lysichitum..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Salix...............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
Betula..............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus...............	..	4	..	..	..	..	..	4	..	12	..	..	20	6	18	18	5	2	7	8
Drosera.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubus...............	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	1	..
Empetrads-Ericads...	..	3	..	..	16	6	..	2	3	11	..	7	10	7	9	22	18	11	19	21
Cornus..............	7	13	2	1	..	1	..	..	4	3	5	5	3	..	3	..	..	1	..	..
Unknown[3]............	2	5	..	..	..	..	..	..	3	2	..	..	..	4	2	..	2	7	6	3

Depth in decimeters	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Pinus contorta[1].....	12	12	10	15	12	6	9	6	4	3	4	4	2	2	2	4	2	3	2	11
Abies amabilis[1].....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tsuga heterophylla[1].	55	52	48	38	41	43	48	53	34	32	22	31	29	34	53	33	22	23	27	28
Tsuga mertensiana[1]..	8	12	14	17	9	12	9	9	8	4	3	2	4	3	2	1	2	3	1	4
Picea sitchensis[1]...	25	24	28	30	37	38	34	32	54	60	71	62	66	61	43	62	75	72	70	56
Conifer complex[2]....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cyperads............	3	..	2	2	..	3	3	3	1	2	3	3	..	..	..	..	..	..	2	3
Lysichitum..........	..	..	..	3	6	..	22	9	208	504	117	40	132	96	25	14	18	12	3	..
Salix...............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Betula..............	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Alnus...............	12	..	3	3	7	8	12	15	14	4	13	10	12	12	9	28	17	8	42	47
Drosera.............	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubus...............	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Empetrads-Ericads...	8	55	9	4	69	24	6	4	16	5	11	8	10	5	4	..	4	..	1	2
Cornus..............	2	..	..	..	..	..	..	3	1	..	..	..	..	..	3	..	..	..	1	..
Unknown[3]............	5	3	5	5	3	5	6	8	12	11	13	10	10	10	25	26	20	18	22	26

[1] Percent of 150 grain total count.

[2] Inaperturate grains not included in 150 grain count and probably including Juniperus communis var. montana, Thuja plicata, and Chamaecyparis nootkatensis.

[3] Number of unknown conifers which were included in 150 grain count.

Fig. 21. Peat section, pollen profiles, and environmental sequence for Mitkof Highway muskeg (#5), Petersburg District, Southeastern Alaska.

Fig. 22. Peat section, pollen profiles, and environmental sequence for Petersburg muskeg (#6), Petersburg District, Southeastern Alaska.

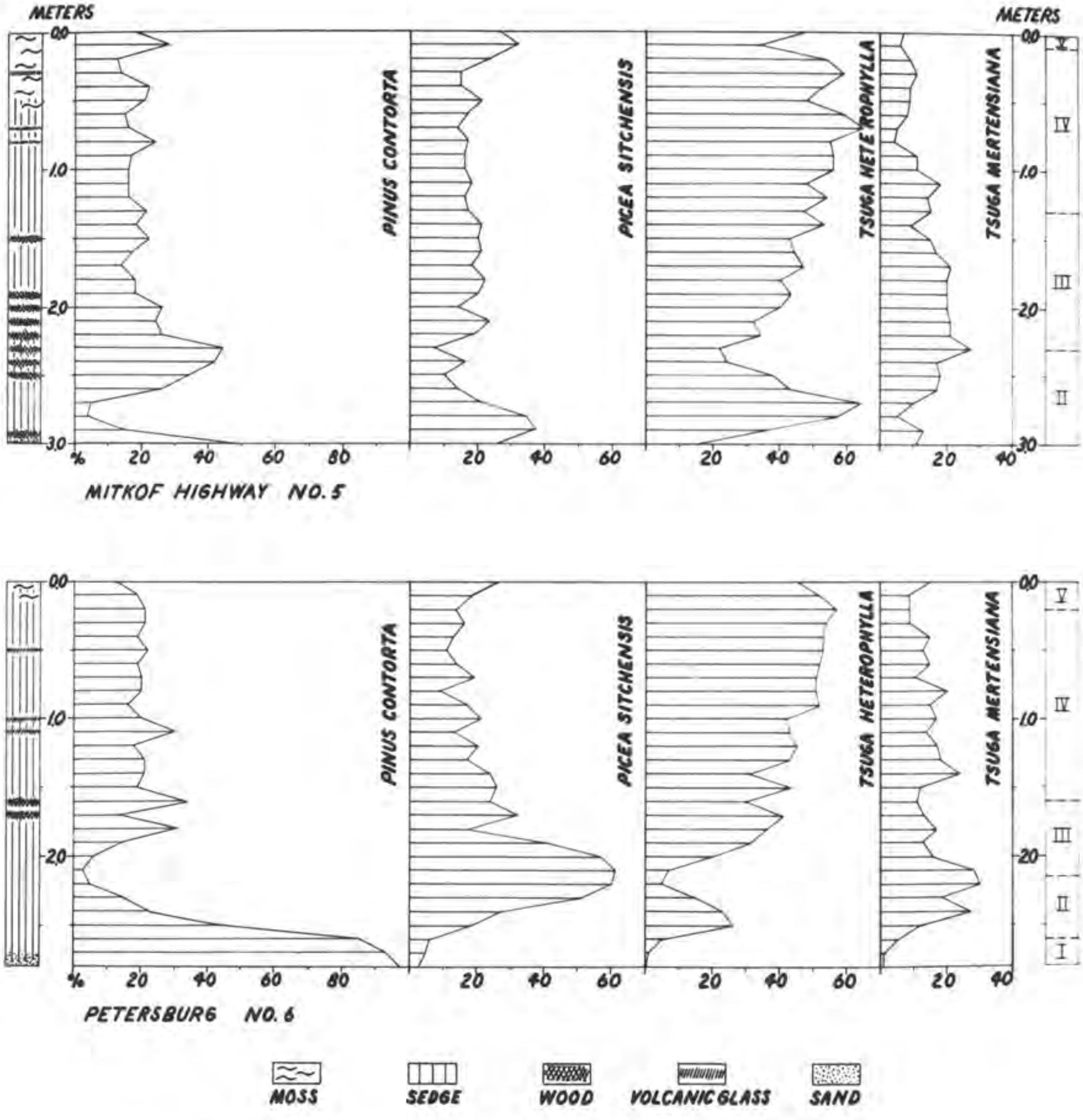

METERS
0.0
1.0
2.0
3.0
%
20
40
60
80
PINUS CONTORTA
PICEA SITCHENSIS
TSUGA HETEROPHYLLA
TSUGA MERTENSIANA
V
IV
III
II
MITKOF HIGHWAY NO. 5
PETERSBURG NO. 6
I
MOSS
SEDGE
WOOD
VOLCANIC GLASS
SAND

Table 7. Analysis of Mitkof Highway Muskeg (No. 5), Petersburg District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Pinus contorta[1].....	19	28	13	14	22	21	15	16	24	17	16	16	16	21	18	22	17	14	18	18	26	24	26	44	42	34	26	5	4	15	47
Tsuga heterophylla[1].	47	34	54	59	53	48	59	65	55	56	56	48	54	47	53	43	44	47	40	43	40	32	34	22	24	38	43	64	57	35	16
Tsuga mertensiana[1]..	7	6	9	11	9	9	8	5	4	11	11	18	14	15	9	15	17	21	20	20	20	21	21	27	17	18	17	10	5	13	11
Picea sitchensis[1]...	27	32	24	15	15	21	17	14	17	16	16	18	16	17	21	20	21	18	22	20	14	23	19	7	16	10	14	21	34	37	26
Conifer complex[2]....	47	37	13	17	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cyperads...........	3	2	8	2	1	2	2	3	..	1	2	3	2	3	2	1	2	3	2	2	..	..	1	8	1	2	..	3	..	3	3
Lysichitum..........	..	..	..	..	..	..	..	..	..	..	..	..	..	9	28	37	54	72	12	195	144	18	27	56	47	91	37	30	12	29	76
Salix..............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..
Betula..............	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus..............	7	7	7	14	7	4	4	8	4	7	16	5	4	11	7	8	4	8	9	6	17	19	9	67	6	4	9	156	81	243	1276
Rubus..............	..	..	..	1	1	..	..	..	1	..	..	..	..	..	..	..	..	2	..	..	..	1	..	..	..	..	..	..	..	..	..
Empetrads-Ericads...	2	..	6	4	2	1	3	44	13	13	8	3	15	12	21	11	3	17	4	12	37	18	29	..	36	34	18	28	11	19	34
Cornus..............	7	3	5	8	3	3	3	6	9	4	1	..	..	..	..	1	..	..	..	..	..	1	..	2	4	2	1	..	..	1	..
Unknown[3]...........	2	..	..	..	6	1	..	2	2	1	2	1	3	1	10	10	7	5	4	2	5	10	5	7	6	7	5	10	5	6	9

[1] Percent of 150 grain total count.

[2] Inaperturate grains not included in 150 grain count and probably including Juniperus communis var. montana, Thuja plicata, and Chamaecyparis nootkatensis.

[3] Number of unknown conifers which were included in 150 grain count.

Table 8. Analysis of Petersburg Muskeg (No. 6), Petersburg District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Pinus contorta[1].....	13	19	21	21	19	22	19	20	20	16	20	30	18	21	21	19	34	14	31	15	6	3	5	15	23	44	85	93	97
Tsuga heterophylla[1].	46	52	57	54	53	53	52	51	51	52	42	43	45	43	31	43	30	41	36	31	20	7	5	15	23	26	5	1	..
Tsuga mertensiana[1]..	15	9	9	9	15	13	15	11	20	15	17	14	17	18	24	12	11	13	17	13	16	28	30	19	27	12	5	1	1
Picea sitchensis[1]...	26	19	14	16	13	11	14	19	9	17	21	13	20	17	24	26	24	32	17	41	57	61	60	51	27	18	6	5	3
Conifer complex[2]....	33	8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cyperads...........	3	3	2	2	4	2	2	2	2	..	4	3	2	4	2	2	2	1	..	..	3	8	..	5	..	7	3	5	7
Lysichitum..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	..	..	..	..	..	4	..	..	..	..	..	5	..	..
Salix..............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1
Betula..............	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	..	..	..	1	..	..	..	..	..	..
Alnus..............	5	9	18	44	19	10	24	22	10	5	24	13	16	22	22	9	63	9	46	26	62	64	30	360	320	253	180	96	93
Drosera.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	1	..	..	..	..
Rubus..............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..
Empetrads-Ericads...	4	6	3	4	3	10	7	14	6	5	4	12	6	11	22	4	23	28	22	33	78	308	192	90	96	69	9	3	9
Cornus..............	5	4	5	5	4	3	6	8	7	10	8	6	1	2	2	3	3	..	..	..	..	..	..	2	5	8	3	2	..
Composites..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	9	7
Unknown[3]...........	1	1	..	..	..	..	..	..	..	..	..	2	..	..	2	..	2	..	1	..	6	5	1	..	4	..	1	..	..

[1] Percent of 150 grain total count.

[2] Inaperturate grains not included in 150 grain count and probably including Juniperus communis var. montana, Thuja plicata, and Chamaecyparis nootkatensis.

[3] Number of unknown conifers which were included in 150 grain count.

Fig. 23. Peat section, pollen profiles, and environmental sequence for Halibut Point Road muskeg (#7), Sitka District, Southeastern Alaska.

Fig. 24. Peat section, pollen profiles, and environmental sequence for Silver Bay Road muskeg (#8), Sitka District, Southeastern Alaska.

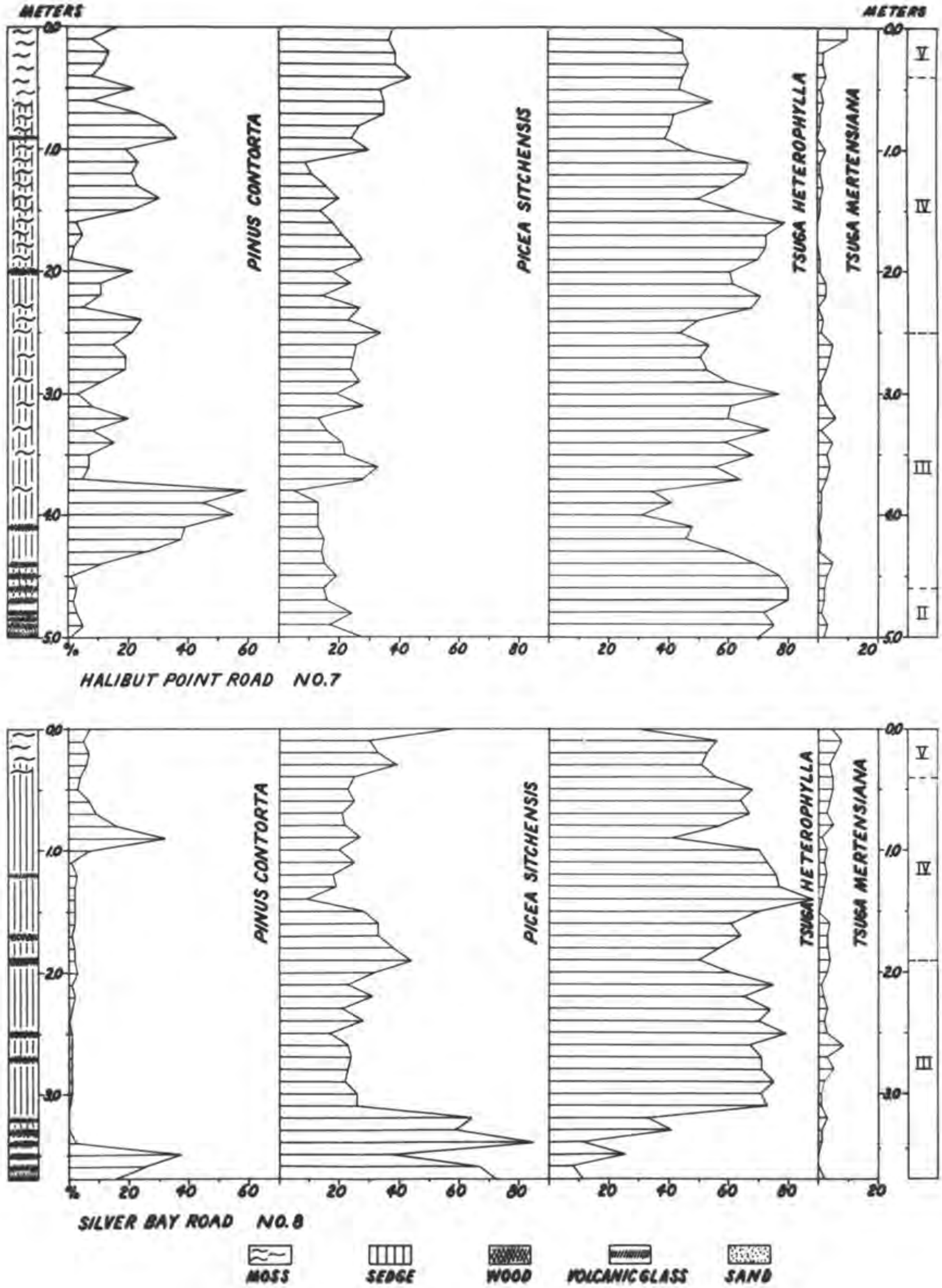

METERS
PINUS CONTORTA
PICEA SITCHENSIS
TSUGA HETEROPHYLLA
TSUGA MERTENSIANA
V
IV
III
II
HALIBUT POINT ROAD NO.7
SILVER BAY ROAD NO.8
MOSS
SEDGE
WOOD
VOLCANIC GLASS
SAND

Table 9. Analysis of Halibut Point Road Muskeg (No. 7), Sitka District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Pinus contorta[1].....	16	8	14	12	8	22	8	23	32	36	19	21	21	23	30	21	3	5	2	1	21	11	11	5	24	21	15	19	19	11	3	8	20	8	15	7	7	5	59	45	55	39	38	27	11	1	3	2	3	5	1
Tsuga heterophylla[1].	36	45	45	47	45	44	55	42	41	39	48	67	66	59	50	61	79	73	73	70	61	62	71	68	50	44	54	51	53	60	77	61	60	74	59	68	56	64	35	41	31	48	46	59	70	77	80	80	72	75	70
Tsuga mertensiana[1]..	10	10	2	2	3	1	2	1	1	..	3	1	1	2	1	1	..	..	..	1	1	3	3	..	2	1	5	4	3	1	1	3	6	1	5	3	4	3	1	1	1	..	1	..	5	3	2	2	1	3	2
Picea sitchensis[1]...	38	37	39	39	44	34	35	35	27	24	30	9	11	16	20	14	18	21	25	28	18	24	15	27	23	34	26	25	24	27	19	28	13	16	21	22	33	28	5	13	13	13	15	14	15	19	15	16	24	17	27
Conifer complex[2]....	17	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cyperads............	2	..	..	2	..	..	..	..	..	..	2	..	..	..	1	1	..	..	..	..	..	..	..	..	..	1	..	..	..	1	..	..	3	2	3	2	..	..	..	2	1	..	7	6	3	7	4	3	3	7	5
Lysichitum..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	11	28	42	330	24	39	34	44	52	100	230	680	160	1260	400	90	39	167	900	30
Alnus...............	9	4	3	6	5	6	4	6	..	7	..	4	4	2	5	2	..	..	..	25	19	5	..	..	..	5	53	15	..	..	11	..	5	3	..	..	..	4	11	13	10	5	64	15	15	40	20	10	26	93	56
Drosera.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubus...............	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Empetrads-Ericads...	19	12	82	52	232	120	52	102	41	40	20	50	156	44	..	48	30	38	16	24	44	32	78	62	30	30	52	39	6	60	12	66	26	30	5	..	13	10	5	3	10	4	27	10	75	20	10	26	52	31	60
Cornus..............	..	..	3	2	5	3	..	..	..	..	3	1	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	4	2	8	..	..	..	..	..	4	..	..	..	..	..	2	..	2	3	2	1
Composites..........	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..
Unknown[3]...........	1	..	2	8	5	3	4	4	..	3	2	..	5	..	1	4	2	3	2	..	4	2	..	1	1	2	..	..	4	..	..	2	..	3	3	2	..	1	..	..	..	..	..	..	..	..	..	..	2	3	5

[1] Percent of 150 grain total count.

[2] Inaperturate grains not included in 150 grain count and probably including Thuja plicata and Chamaecyparis nootkatensis.

[3] Number of unknown conifers which were included in 150 grain count.

Table 10. Analysis of Silver Bay Road Muskeg (No. 8), Sitka District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Pinus contorta[1].....	7	5	7	6	4	3	7	9	16	32	7	1	3	2	2	2	2	1	2	2	3	1	2	1	..	1	1	1	1	1	1	..	..	..	3	37	25	16
Tsuga heterophylla[1].	31	56	53	51	66	68	64	67	57	41	70	73	76	77	88	70	61	64	57	50	61	75	66	74	70	79	67	71	71	75	71	73	33	41	11	25	8	11
Tsuga mertensiana[1]..	5	8	6	4	5	5	4	3	5	1	3	2	3	2	3	..	4	3	3	4	3	1	2	3	2	3	8	3	5	2	1	1	3	1	1	..	..	2
Picea sitchensis[1]...	57	30	33	39	25	23	25	21	22	27	20	25	18	19	9	28	33	33	38	44	32	23	31	21	28	17	23	24	23	22	26	26	64	59	85	38	67	72
Conifer complex[2]....	34	9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Graminads...........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..
Cyperads............	12	2	4	3	3	3	2	5	4	3	4	2	..	3	2	2	..	..	..	..	..	2	..	3	..	..	..	..	..	2	..	2	..	5	7	4	4	5
Lysichitum..........	..	..	..	..	..	65	17	55	220	275	240	255	180	430	40	27	..	..	25	43	35	25	670	110	275	168	126	10	12	21	76	12	200	68	160	102	25	22
Betula..............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4
Alnus...............	28	12	5	24	18	36	22	128	8	5	45	30	35	75	10	22	18	8	35	..	20	15	30	10	23	5	60	10	..	15	5	10	375	28	288	300	120	75
Drosera.............	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Empetrads-Ericads...	..	5	64	96	8	18	4	78	11	5	..	..	..	15	..	20	29	20	30	..	..	..	..	..	..	..	..	..	6	..	16	..	..	4	6	..	24	23
Cornus..............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..
Unknown[3]...........	1	1	..	..	2	..	..	..	..	..	..	..	1	..	..	..	3	2	..	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	17

[1] Percent of 150 grain total count.

[2] Inaperturate grains not included in 150 grain count and probably including Thuja plicata and Chamaecyparis nootkatensis.

[3] Number of unknown conifers which were included in 150 grain count.

Fig. 25. Peat section, pollen profiles, and environmental sequence for Lemon Creek muskeg (#9), Juneau District, Southeastern Alaska.

Fig. 26. Peat section, pollen profiles, and environmental sequence for Mendenhall River muskeg (#10), Juneau District, Southeastern Alaska.

Fig. 27. Peat section, pollen profiles, and environmental period for Mendenhall Lake muskeg (#15), Juneau District, Southeastern Alaska.

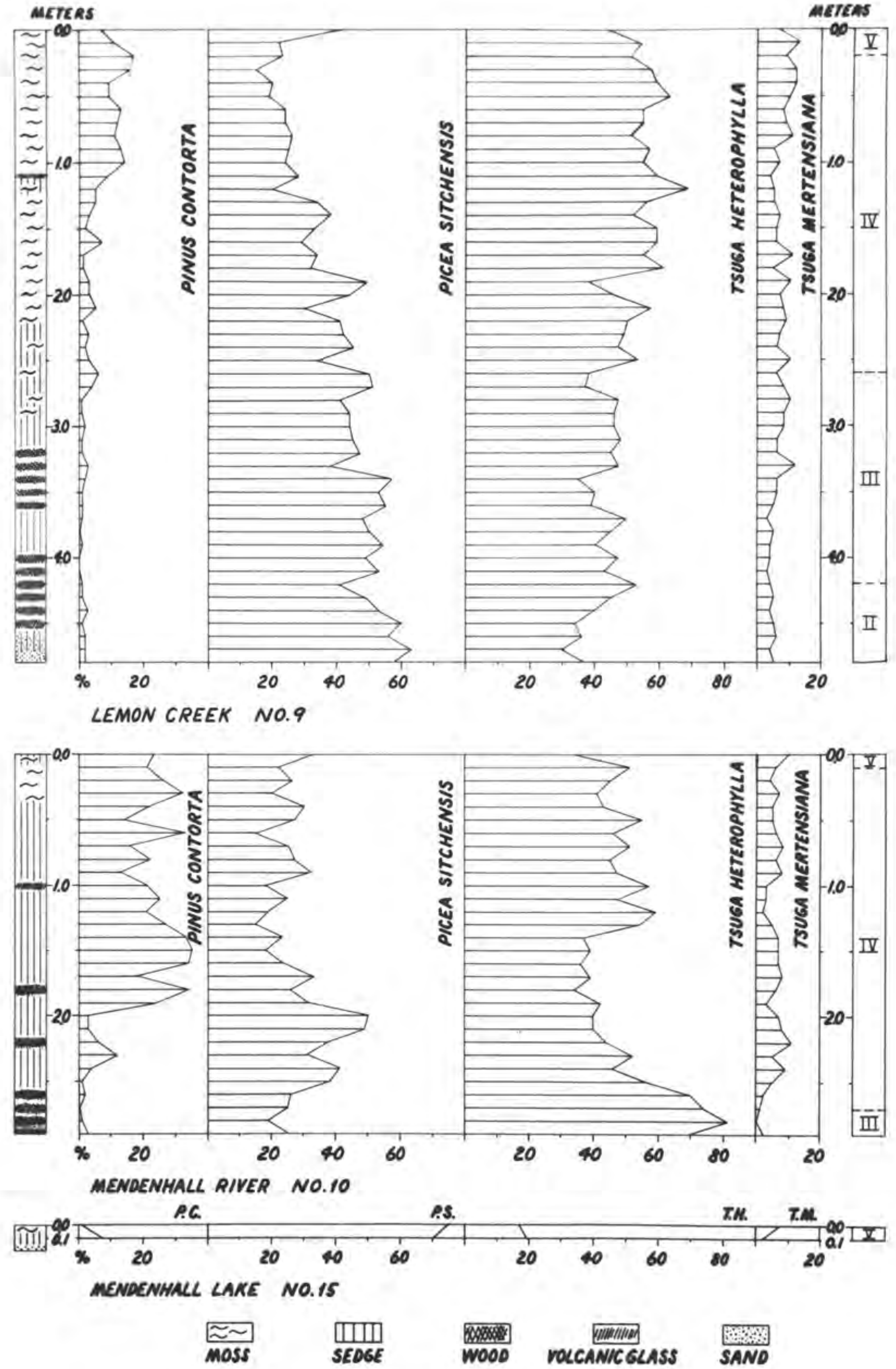

METERS
PINUS CONTORTA
PICEA SITCHENSIS
TSUGA HETEROPHYLLA
TSUGA MERTENSIANA
V
IV
III
II
LEMON CREEK NO.9
MENDENHALL RIVER NO.10
P.C.
P.S.
T.H.
T.M.
MENDENHALL LAKE NO.15
MOSS
SEDGE
WOOD
VOLCANIC GLASS
SAND

Table 11. Analysis of Lemon Creek Muskeg (No. 9), Juneau District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Pinus contorta[1].....	7	11	17	16	9	9	13	12	11	13	14	9	5	5	3	2	7	1	1	3	3	5	1	3	2
Abies lasiocarpa[1]...	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..
Tsuga heterophylla[1].	45	54	51	57	59	63	55	55	51	57	55	59	69	56	52	59	59	55	61	38	46	57	50	49	47
Tsuga mertensiana[1]..	7	13	9	12	12	10	8	9	11	5	7	4	5	5	7	6	6	11	5	10	7	8	9	7	6
Picea sitchensis[1]...	41	22	23	15	20	19	24	24	26	25	24	28	20	34	38	33	29	34	32	49	44	30	41	42	45
Cyperads............	2	..	..	2	3	2	..	..	2	2	2	4	3	2	2	2	2	3	..	1	..	..	3	..	4
Lysichitum..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Salix...............	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus...............	3	12	29	8	7	10	7	28	12	6	16	12	10	23	19	45	28	7	12	6	112	37	24	40	14
Drosera.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Rubus...............	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Empetrads-Ericads...	4	15	..	9	5	7	4	5	3	4	7	5	12	88	14	10	22	5	87	39	410	410	90	45	20
Cornus..............	..	1	3	2	2	2	3	1	..	..	1	1	2	..	..	..	..	..	..	..	..	..	..	..	..
Composites..........	..	..	..	..	..	..	..	4	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Unknown[2]............	..	2	..	..	4	6	1	..	..	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..

Depth in decimeters	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Pinus contorta[1].....	3	6	4	1	1	2	1	1	3	2	1	1	1	..	1	..	..	1	1	3	1	2	2	2
Abies lasiocarpa[1]...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Tsuga heterophylla[1].	51	38	37	47	46	46	48	45	47	35	40	39	49	45	40	47	43	53	45	40	34	36	30	36
Tsuga mertensiana[1]..	10	6	8	10	8	8	6	6	12	6	6	5	3	5	4	4	3	4	5	4	5	6	4	5
Picea sitchensis[1]...	34	50	51	41	44	44	45	47	38	57	53	55	48	50	54	49	53	41	49	53	60	56	61	58
Cyperads............	5	..	2	3	1	..	..	..	6	..	..	..	..	..	..	3	..	..	3	5	3	..	3	..
Lysichitum..........	..	1	3	..	12	4	1300	1150	8600*	2150	510	3000	600	310	470	380	650	2150	3100	2375	675	1675	4200	4000
Salix...............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus...............	14	10	16	15	16	7	38	12	600	50	15	20	60	12	10	12	10	10	155	36	13	20	75	56
Drosera.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubus...............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Empetrads-Ericads...	46	56	64	16	56	12	125	65	14	12	5	20	12	12	10	12	9	23	60	10	10	25	..	20
Cornus..............	..	..	..	..	..	..	..	..	6	..	..	5	..	..	..	..	..	2	..	..	1	1	..	..
Composites..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Unknown[2]............	4	4	5	10	5	..	..	..	20	..	1	..	..	2	2	..	..	..	..	..	10	6	15	20

1 Percent of 150 grain total count.

2 Number of unknown conifers which were included in 150 grain count.

* Approximate number computed by sampling unit slide area; applicable to all larger three and four digit figures.

Table 12. Analysis of Mendenhall River Muskeg (No. 10), Juneau District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Pinus contorta[1].....	23	21	26	32	22	14	33	16	22	13	21	25	21	27	33	35	34	18	34	24	3	3	6	12	4	1	2	..	1	3
Abies lasiocarpa[1]...	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	1	1	..	..	..	..	..	..	..
Tsuga heterophylla[1].	35	51	45	41	43	55	46	51	45	47	57	47	59	54	37	39	36	39	34	42	40	40	44	52	46	56	70	74	81	70
Tsuga mertensiana[1]..	10	6	4	7	5	5	6	8	6	8	3	3	2	5	7	7	7	8	6	3	7	8	11	5	9	5	2	1	..	2
Picea sitchensis[1]...	32	22	26	20	30	27	15	25	27	32	18	25	19	15	23	18	21	33	26	31	50	49	38	31	41	38	26	25	19	25
Graminads...........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..
Cyperads............	1	..	1	1	..	..	..	..	..	..	..	..	..	3	6	3	2	3	4	6	1	5	2	..	..	..	3	1	..	..
Lysichitum..........	..	17	..	6	..	..	..	..	7	16	..	6	17	6	3	8	2	1	2	1	1	164	468	427	307	58	38	6	..	1
Betula..............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Alnus...............	16	16	8	11	3	2	4	..	5	..	..	..	14	7	4	12	11	5	2	5	9	22	36	54	32	37	17	25	13	13
Empetrads-Ericads...	12	26	9	8	6	43	12	4	7	19	16	6	..	6	3	4	..	1	2	..	3	1	8	..	..	4	9	3	1	5
Cornus..............	1	1	12	1	1	..	..	..	2	..	1	4	3	5	1	9	5	3	6	9	5	4	1	1	..	..	5	3	1	4
Composites..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Unknown[2]............	..	..	1	..	2	..	3	3	1	..	3	4	..	..	5	3	..	3	6	8	6	8	9	3	2	4	5	1	5	4

1 Percent of 150 grain total count.

2 Number of unknown conifers which were included in 150 grain count.

Fig. 28. Peat section, pollen profiles, and environmental sequence for Auke Bay muskeg (#11), Juneau District, Southeastern Alaska.

Fig. 29. Peat section, pollen profiles, and environmental sequence for Lena Beach muskeg (#12), Juneau District, Southeastern Alaska.

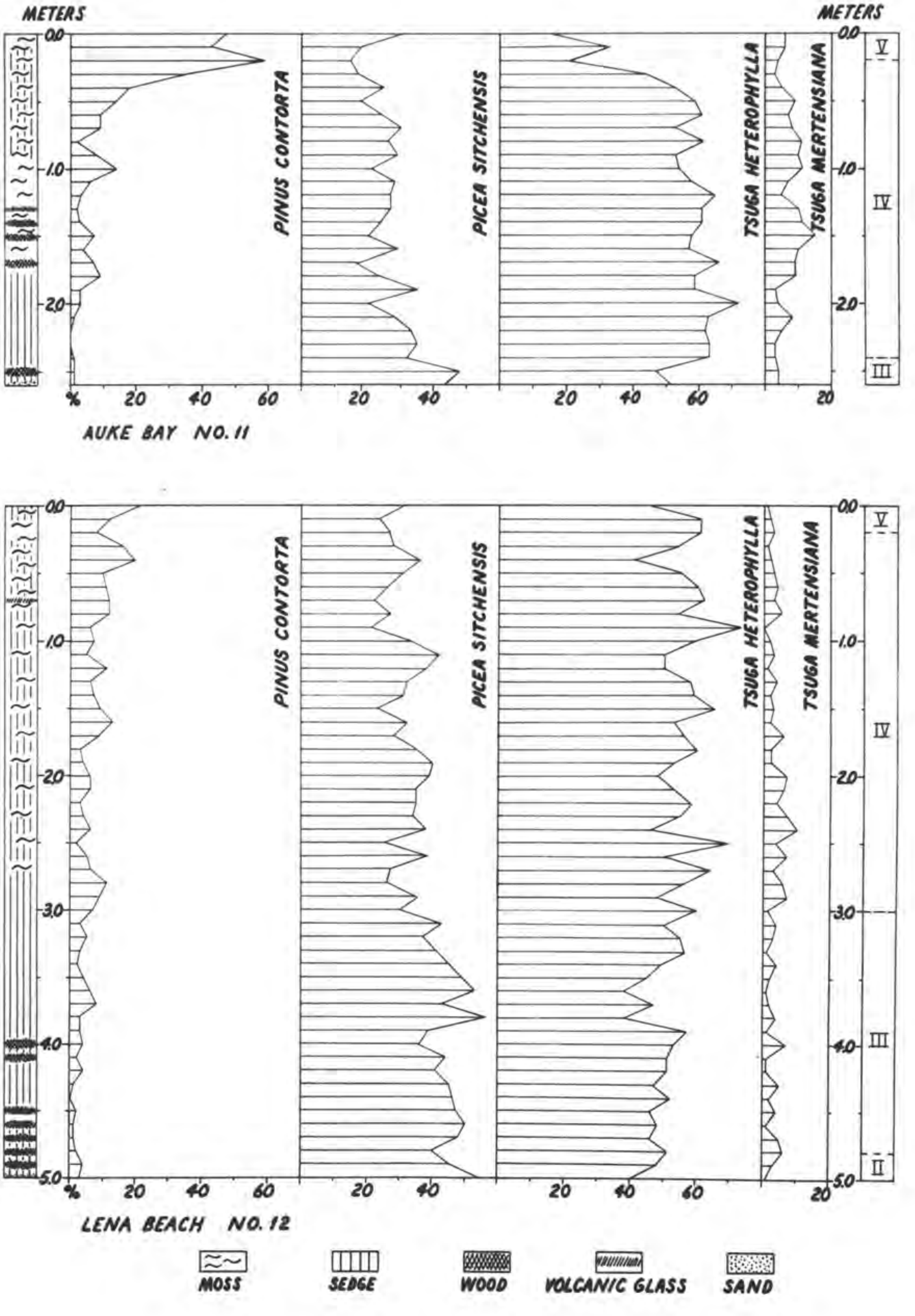

METERS
PINUS CONTORTA
PICEA SITCHENSIS
TSUGA HETEROPHYLLA
TSUGA MERTENSIANA
AUKE BAY NO. 11
LENA BEACH NO. 12
MOSS
SEDGE
WOOD
VOLCANIC GLASS
SAND

Table 13. Analysis of Auke Bay Muskeg (No. 11), Juneau District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Pinus contorta[1].....	47	43	59	36	18	14	9	9	2	8	14	6	3	2	3	7	4	7	9	3	3	1	..	..	1	1	1
Abies lasiocarpa[1]...	..	..	1	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tsuga heterophylla[1].	17	33	21	44	53	59	61	53	61	53	54	58	65	61	61	58	57	66	59	59	72	63	62	63	63	47	51
Tsuga mertensiana[1]..	6	6	4	3	5	9	7	8	11	10	11	7	5	10	11	15	10	9	9	3	4	8	5	3	3	4	4
Picea sitchensis[1]...	30	18	15	17	25	18	24	30	26	29	21	28	27	27	24	20	29	17	23	35	20	28	33	35	32	48	44
Cyperads...........	4	2	3	2	6	3	4	..	3	..	4	6	5	..	3	2	2	3	2	2	..	..	3	2	..	3	5
Lysichitum.........	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	3	3	4	32	10	18	16	5	12
Salix..............	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..
Alnus..............	9	8	12	2	4	12	16	5	3	..	3	2	..	15	5	4	..	..	5	9	7	16	14	10	12	4	6
Drosera............	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubus..............	..	..	..	..	1	2	1	..	..	..	..	..	..	..	..	1	..	..	..	2	..	..	..	..	..	..	..
Empetrads-Ericads...	..	..	..	9	14	4	10	5	30	11	5	4	5	16	35	70	27	10	5	5	18	16	6	3	10	5	12
Cornus.............	..	..	..	..	1	2	2	..	..	..	..	..	..	..	..	..	..	..	2	2	..	..	..	..	..	..	..
Unknown[2]..........	..	..	..	1	..	..	..	..	..	..	2	1	..	..	..	..	..	..	..	..	5	..	..	11	5	13	8

[1] Percent of 150 grain total count.

[2] Number of unknown conifers which were included in 150 grain count.

Table 14. Analysis of Lena Beach Muskeg (No. 12), Juneau District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Pinus contorta[1].....	21	12	8	16	20	10	11	12	12	6	7	5	11	6	7	9	13	9	3	4	6	6	3	4	6	2
Abies lasiocarpa[1]...	..	..	..	..	1	1	..	1	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	1	..
Tsuga heterophylla[1].	46	61	61	54	41	55	60	62	54	73	59	50	50	58	59	65	53	56	50	53	48	53	58	55	46	69
Tsuga mertensiana[1]..	1	2	3	1	2	3	4	3	5	..	2	3	1	4	2	1	2	6	2	2	7	6	4	7	10	4
Picea sitchensis[1]...	31	24	27	28	36	31	26	22	27	21	33	42	38	32	31	23	32	28	35	40	39	35	35	34	38	25
Cyperads...........	2	1	..	..	1	1	..	1	3	..	..	..	..	..	..	..	1	1	..	3	..	..	4	..	..	..
Lysichitum.........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Betula.............	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus..............	6	5	18	1	4	10	4	2	8	8	6	12	8	4	..	6	11	5	3	6	1	9	12	15	18	7
Empetrads-Ericads...	2	6	22	5	81	39	18	45	36	11	12	19	73	98	129	74	125	28	31	32	51	47	84	58	88	290
Epilobium..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cornus.............	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..
Composites.........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..
Unknown[2]..........	10	10	7	5	7	6	9	12	12	22	17	15	8	19	16	22	11	23	18	15	10	6	14	13	14	12

Depth in decimeters	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Pinus contorta[1].....	5	6	11	9	7	3	5	3	2	4	6	8	3	3	4	2	4	1	..	2	1	1	2	4	3
Abies lasiocarpa[1]...	1	1	1	1	1	..	..	..	..	..	1	..	..	..	1	1	1	1	..	..	..	..	..	..	1
Tsuga heterophylla[1].	50	64	56	48	60	50	55	56	49	45	38	47	38	57	53	51	51	47	52	46	48	46	51	48	41
Tsuga mertensiana[1]..	7	3	6	7	1	4	3	1	4	2	1	2	4	1	7	1	1	5	2	4	1	5	6	3	1
Picea sitchensis[1]...	38	27	26	35	30	43	37	41	45	49	53	43	56	39	36	44	41	45	46	47	50	48	40	45	54
Cyperads...........	..	3	..	..	1	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..
Lysichitum.........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	12	..	..	..	..	4	5	..
Betula.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus..............	2	13	4	4	6	4	7	6	7	2	7	3	9	21	8	1	4	5	14	10	9	5	4	3	7
Empetrads-Ericads...	74	138	59	45	69	132	129	126	256	124	173	120	116	101	67	91	59	48	29	21	40	42	103	40	17
Epilobium..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..
Cornus.............	..	1	..	1	..	..	1	1	..	2	3	3	1	3	3	3	4	3	7	2	..	1	..	1	..
Composites.........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Unknown[2]..........	17	12	8	9	11	10	8	8	9	11	6	10	6	5	12	10	10	13	9	13	11	7	14	13	23

[1] Percent of 150 grain total count.

[2] Number of unknown conifers which were included in 150 grain count.

Fig. 30. Peat section, pollen profiles, and environmental sequence for Eagle Harbor muskeg (#14), Juneau District, Southeastern Alaska.

Fig. 31. Peat section, pollen profiles, and environmental period for Herbert River Tributary muskeg (#13), Juneau District, Southeastern Alaska.

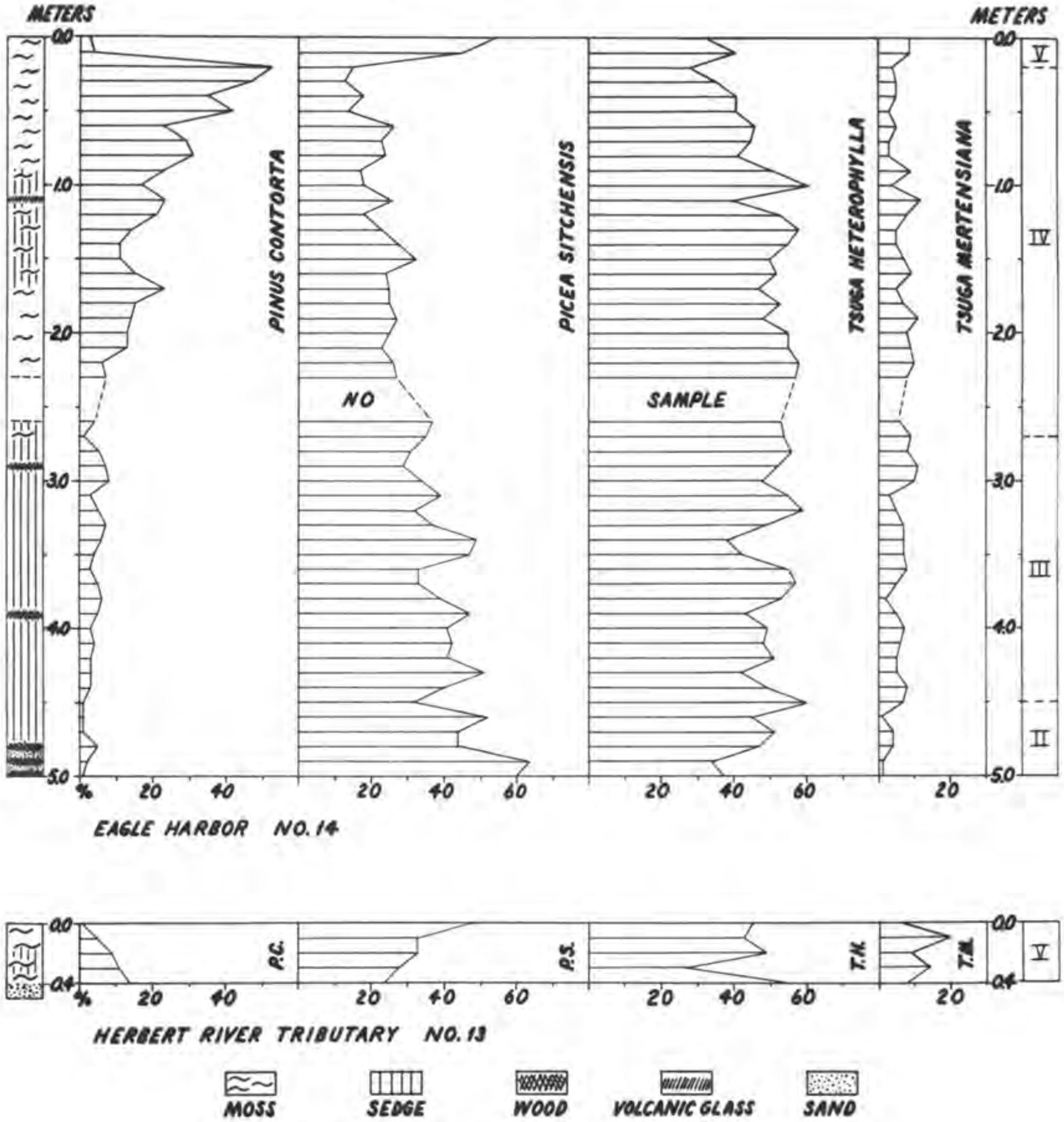

METERS
PINUS CONTORTA
PICEA SITCHENSIS
TSUGA HETEROPHYLLA
TSUGA MERTENSIANA
NO
SAMPLE
METERS
V
IV
III
II
0.0
1.0
2.0
3.0
4.0
5.0
%
20
40
60
EAGLE HARBOR NO. 14
P.C.
P.S.
T.H.
T.M.
0.4
HERBERT RIVER TRIBUTARY NO. 13
MOSS
SEDGE
WOOD
VOLCANIC GLASS
SAND

Table 15. Analysis of Eagle Harbor Muskeg (No. 14), Juneau District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Pinus contorta[1].....	3	4	53	47	35	42	23	29	31	23	17	23	21	14	11	11	15	23	15	14	13	13	6	7		
Abies lasiocarpa[1]...	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1	..	..		
Tsuga heterophylla[1].	33	41	28	35	41	41	46	45	41	51	61	40	53	58	55	50	52	47	53	48	55	55	58	57	E	E
Tsuga mertensiana[1]..	9	9	4	5	5	3	5	3	3	9	4	12	8	5	5	7	9	5	7	11	8	9	10	8	L	L
Picea sitchensis[1]...	54	45	15	13	18	14	26	23	24	17	18	25	18	23	28	32	24	25	25	27	25	23	26	27	P	P
Cyperads............	..	2	..	1	1	..	2	..	2	..	..	..	2	..	..	..	..	1	3	..	..	3	2	..	M	M
Lysichitum..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	18	11	..	A	A
Betula..............	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	S	S
Alnus...............	3	12	2	..	9	4	8	4	8	2	49	5	7	8	11	26	54	34	4	3	24	6	20	46		
Drosera.............	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	..	..	O	O
Rubus...............	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	N	N
Empetrads-Ericads...	2	37	26	36	21	91	59	40	30	4	116	29	50	44	44	39	96	170	48	20	24	12	22	35		
Unknown[2]...........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		

Depth in decimeters	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Pinus contorta[1].....	4	1	5	7	8	3	5	7	6	4	3	5	6	5	3	4	3	3	3	1	1	1	5	2	1
Abies lasiocarpa[1]...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tsuga heterophylla[1].	53	54	56	52	48	55	59	49	38	42	55	57	53	43	49	48	51	42	49	60	45	51	47	34	37
Tsuga mertensiana[1]..	6	9	8	11	10	3	5	7	7	7	8	5	2	5	7	6	5	5	8	7	1	4	4	1	1
Picea sitchensis[1]...	37	35	31	29	34	39	32	37	49	47	33	33	39	47	41	42	41	51	40	32	52	44	44	63	60
Cyperads............	..	..	2	..	..	4	1	2	..	..	..	..	2	..	2	..	..	..	..	..	..	..	..	2	2
Lysichitum..........	43	11	53	32	..	216	210	120	120	35	76	12	46	300	110	65	33	16	24	200	280	148	192	230	440
Betula..............	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus...............	6	42	32	13	..	36	27	24	66	88	36	72	87	250	132	88	44	228	250	180	210	333	432	184	396
Drosera.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubus...............	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Empetrads-Ericads...	9	11	11	20	..	25	30	5	..	5	12	10	42	43	..	..	..	4	..	..	..	..	..	..	..
Unknown[2]...........	..	..	..	..	6	2	..	2	5	..	..	..	10	..	2	..	..	..	6	..	5	3	..	6	7

[1] Percent of 150 grain total count.

2 Number of unknown conifers which were included in 150 grain count.

Table 16. Analysis of Herbert River Tributary Muskeg(No. 13), Juneau District, Alaska.

Depth in decimeters	0	1	2	3	4
Pinus contorta[1].....	1	5	9	11	14
Tsuga heterophylla[1].	45	43	49	27	54
Tsuga mertensiana[1]..	7	20	9	14	8
Picea sitchensis[1]...	47	33	33	28	24
Cyperads............	5	2	2	2	4
Lysichitum..........	..	..	..	..	1
Alnus...............	6	26	..	4	12
Unknown[2]...........	..	..	2	2	5

[1] Percent of 150 grain total count.

2 Number of unknown conifers which were included in 150 grain count.

Table 17. Analysis of Mendenhall Lake Bog (No. 15), Juneau District, Alaska.

Depth in decimeters	0	1
Pinus contorta[1].....	1	8
Tsuga heterophylla[1].	17	19
Tsuga mertensiana[1]..	7	2
Picea sitchensis[1]...	75	70
Cyperads............	9	21
Populus.............	..	2
Salix...............	1	14
Alnus...............	2	18
Composites..........	1	..
Unknown[2]...........	3	6

[1] Percent of 150 grain total count.

2 Number of unknown conifers which were included in 150 grain count.

Fig. 32. Peat section, pollen profiles, and environmental sequence for Upper Montana Creek muskeg (#17), Juneau District, Southeastern Alaska.

Fig. 33. Peat section, pollen profiles, and environmental sequence for Lower Montana Creek muskeg (#16), Juneau District, Southeastern Alaska.

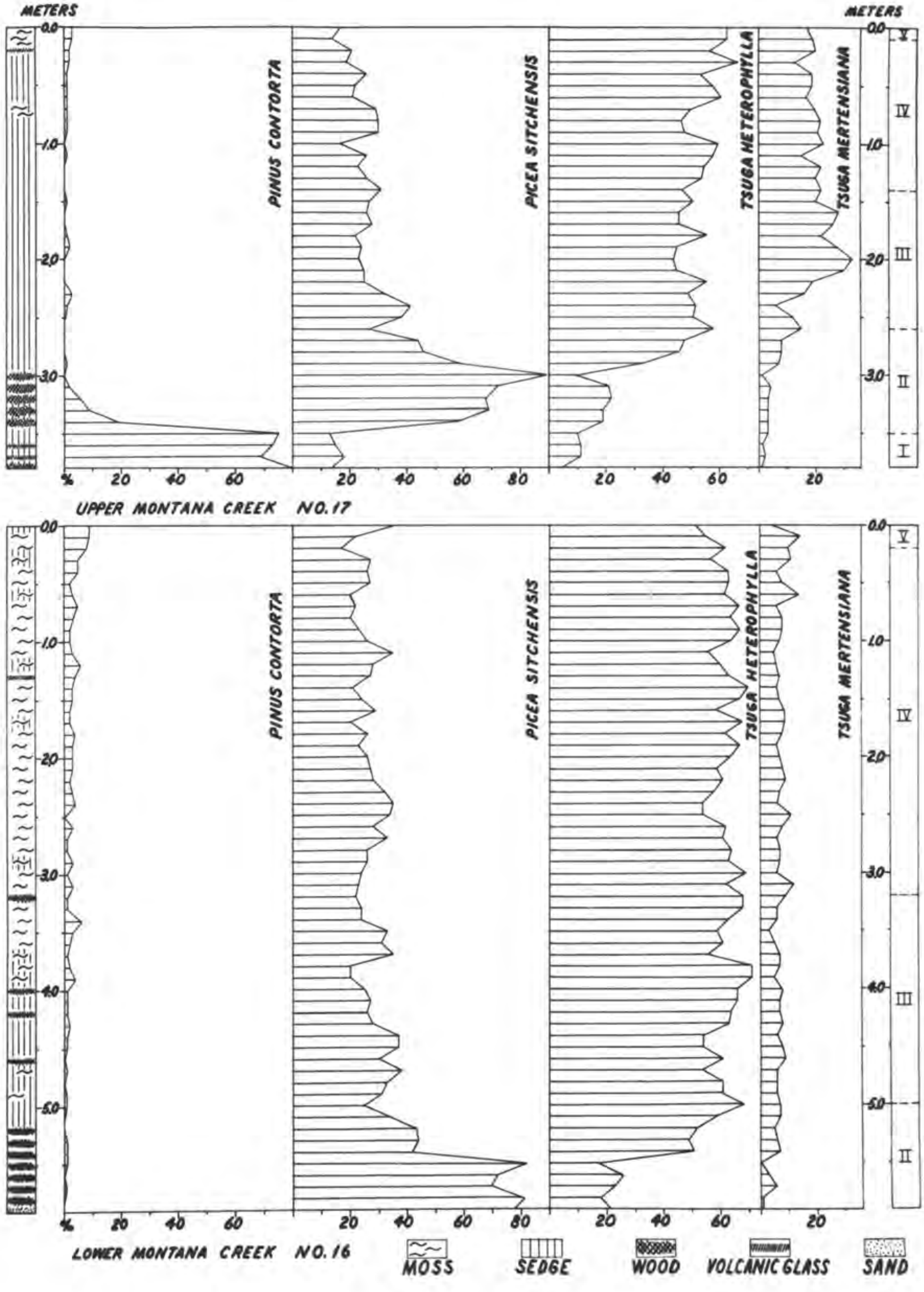

METERS
0.0
1.0
2.0
3.0
PINUS CONTORTA
PICEA SITCHENSIS
TSUGA HETEROPHYLLA
TSUGA MERTENSIANA
METERS
V
IV
III
II
I
%
20
40
60
80
UPPER MONTANA CREEK NO. 17
4.0
5.0
LOWER MONTANA CREEK NO. 16
MOSS
SEDGE
WOOD
VOLCANIC GLASS
SAND

Table 18. Analysis of Lower Montana Creek Muskeg (No. 16), Juneau District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Pinus contorta[1].....	9	9	8	5	5	2	3	5	6	2	2	3	5	4	3	3	2	2	4	3	3	3	2	3	4	..	3	1	1	3
Abies lasiocarpa[1]...	..	..	1	..	..	..	..	..	2	..	1	1	..	..	..	..	1	..	..	1	1	2	..	..	1	..	..	..	1	1
Tsuga heterophylla[1].	52	55	62	57	63	63	62	67	64	67	64	56	60	63	70	67	59	68	62	67	64	59	61	58	54	54	62	61	64	63
Tsuga mertensiana[1]..	5	14	10	11	6	8	14	6	8	8	7	5	6	7	6	7	9	9	8	6	7	8	9	7	6	11	8	6	7	7
Picea sitchensis[1]...	35	22	17	27	26	27	20	22	20	23	26	35	28	27	21	24	29	20	26	23	26	27	28	32	35	34	28	31	26	26
Gramineae...........	..	..	..	..	..	1	..	..	..	..	..	..	..	..	2	..	..	1	..	1	..	1	..	..	..	..	1	1	..	1
Cyperaceae............	1	2	..	..	..	1	..	..	1	..	..	..	1	1	..	..	..	..	2	2	1	..	..	..	..	1	2	3	..	3
Lysichitum..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Betula..............	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus..............	21	16	7	16	6	16	6	3	10	3	6	11	7	8	11	7	5	1	2	8	12	8	2	2	5	6	8	8	5	7
Drosera............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rubus..............	..	..	..	1	1	2	..	..	1	..	2	2	..	1	..	1	..	3	..	1	1	2	..	..	..	2	1	..	1	..
Empetraceae-Ericaceae...	79	72	109	65	22	53	21	7	14	10	26	33	4	15	20	22	16	4	7	11	63	41	7	28	124	36	64	59	27	40
Cornus..............	..	3	1	2	3	1	..	1	..	1	..	2	1	6	2	..	1	5	3	7	3	5	1	..	1	1	..	..	8	3
Compositae..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Unknown[2]............	11	5	7	8	12	9	7	3	8	9	13	14	6	8	5	6	6	1	4	4	2	4	4	5	8	5	7	9	1	6

Depth in decimeters	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
Pinus contorta[1].....	1	3	1	1	6	3	2	1	2	4	1	1	1	2	1	1	..	1	..	1	1	..	..	..	1	1	..	1	..	..
Abies lasiocarpa[1]...	..	..	1	..	1	..	1	..	1	..	..	..	1	..	..	..	..	..	..	1	..	..	..	1	..	..	..	..	..	..
Tsuga heterophylla[1].	69	62	68	68	63	59	61	56	71	71	66	66	64	63	54	54	61	54	61	61	68	59	52	49	51	17	25	23	18	21
Tsuga mertensiana[1]..	6	12	9	6	6	3	5	7	7	5	8	7	8	8	6	8	9	6	6	6	7	7	5	6	7	..	3	6	1	1
Picea sitchensis[1]...	24	23	22	24	24	33	31	35	20	20	25	27	26	28	37	37	30	38	33	31	25	34	43	44	42	82	72	70	81	78
Gramineae...........	1	..	..	1	..	1	..	..	1	1	..	..	..	..	..	..	1	..	1	..	..	..	1	..	1	1	..	..	..	..
Cyperaceae............	6	4	5	9	4	4	11	7	5	8	6	4	2	6	4	8	20	11	15	5	6	4	11	15	11	3	4	10	5	2
Lysichitum..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	36	43	10	7	45	12	..
Betula..............	..	..	1	..	..	..	1	..	..	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..
Alnus..............	2	10	8	16	9	14	10	11	10	17	12	10	3	10	5	15	15	13	14	3	7	8	5	14	28	298	71	113	132	75
Drosera............	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..
Rubus..............	..	..	3	1	..	..	2	..	2	1	1	..	..	..	..	..	1	..	..	..	1	1	..	1	1	..	..	..	..	..
Empetraceae-Ericaceae...	71	162	160	175	124	76	119	92	185	279	14	8	14	8	2	7	8	18	31	13	8	7	3	1	3	25	7	14	12	6
Cornus..............	1	3	3	7	7	5	6	7	7	7	16	3	2	4	6	6	..	4	1	..	..	3	2	2	2	1	..	1	1	..
Compositae..........	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..
Unknown[2]............	7	3	6	8	6	6	8	10	7	7	7	3	12	5	5	6	9	7	6	7	4	3	13	9	4	1	5	5	7	17

[1] Percent of 150 grain total count.

[2] Number of unknown conifers which were included in 150 grain count.

Table 19. Analysis of Upper Montana Creek Muskeg (No. 17), Juneau District, Alaska.

Depth in decimeters	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Pinus contorta[1].....	3	3	2	2	1	1	1	1	1	1	..	1	..	..	..	1	..	..	1	2
Abies lasiocarpa[1]...	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tsuga heterophylla[1].	63	63	57	67	54	58	61	50	47	48	60	58	55	54	47	51	46	46	56	45
Tsuga mertensiana[1]..	17	19	20	13	19	19	17	20	22	21	23	15	22	20	22	20	28	26	22	28
Picea sitchensis[1]...	17	14	21	19	26	22	21	29	30	30	17	26	23	26	31	27	26	28	22	24
Cyperaceae............	3	3	1	3	1	1	..	1	..	5	3	2	1	1	1	..	1	..	1	4
Lysichitum..........	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	1
Salix..............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Betula..............	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus..............	10	3	..	7	9	5	2	..	..	2	8	17	11	14	9	6	12	14	13	36
Drosera............	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Rubus..............	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..
Empetraceae-Ericaceae...	3	4	3	4	..	14	15	8	9	2	14	13	18	19	17	7	4	5	9	27
Cornus..............	..	..	..	..	..	..	..	..	..	1	2	..	1	..	..	..	1	..	3	11
Compositae..........	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Unknown[2]............	7	5	6	6	5	8	6	3	6	3	7	9	9	7	3	2	7	7	7	2

Depth in decimeters	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Pinus contorta[1].....	..	..	..	3	1	..	..	..	..	1	..	2	6	9	19	75	73	69	79
Abies lasiocarpa[1]...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Tsuga heterophylla[1].	44	45	56	49	52	51	58	48	46	33	10	21	22	19	19	10	11	11	5
Tsuga mertensiana[1]..	33	30	19	16	6	12	15	8	8	7	1	4	3	3	3	3	1	2	3
Picea sitchensis[1]...	23	25	25	32	41	39	27	44	46	59	89	72	68	69	58	13	15	18	14
Cyperaceae............	8	4	..	3	9	..	7	..	..	..	..	..	..	..	..	..	7	8	3
Lysichitum..........	..	..	..	..	..	6	1	..	..	..	..	13	..	..	..	..	..	..	..
Salix..............	..	..	..	..	..	..	..	1	..	..	..	..	1	7	4	17	..	8	..
Betula..............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Alnus..............	23	17	26	19	14	15	26	23	16	57	88	257	348	608	676	672	117	517	88
Drosera............	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..
Rubus..............	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..
Empetraceae-Ericaceae...	3	6	1	6	..	..	1	14	..	4	8	1	24	11	16	9	..	13	3
Cornus..............	3	9	18	6	3	5	8	3	7	6	4	4	..	5	5	..	4	..	8
Compositae..........	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	1	..	..
Unknown[2]............	11	2	8	3	7	6	7	2	6	..	..	1	2	2	1	4	2	5	4

[1] Percent of 150 grain total count.

[2] Number of unknown conifers which were included in 150 grain count.

POSTGLACIAL VULCANISM AND CHANGES IN SEA LEVEL

The profile for Halibut Point Road (#7) near Sitka (Fig. 23) is of interest since it reflects the response of pine to the postglacial eruption of Mount Edgecumbe, about 20 miles distant to the west of the station (56, p. 14). The behavior of pine in showing a marked expanse above the layers of volcanic glass while a climax forest is in evidence beneath this increase, establishes the eruption of Mount Edgecumbe at about 5,500 years ago, the middle of Period II. Hansen (34, pp. 217-218) has shown the influence of Mount Mazama pumice on lodgepole pine whereby it was released from competition with the yellow pine (Pinus ponderosa Dougl.) climax and greatly increased. Edaphic conditions at Sitka, which were modified by the pumice fall, were probably such that seedlings of spruce and hemlock were unable to germinate and perpetuate the climax forest. The profile at Silver Bay Road (#8) nearby may be confusing, as ash occurs above the pine expansion following the eruption (Fig. 24). This is explained from the location of the station which is stream fed. The ash which is at this level appears to have been reworked and washed in for some time following vulcanism. The slope location of Halibut Point Road precludes the possibility of secondary transport of the ash.

The concentrated study in the Juneau District has revealed a remarkable correlation between muskeg development and altitude and the differential uplift of the region. Upper Montana Creek (#17) which occurs at about 750 feet elevation, contains the oldest pine pollen sediments (Period I) (Fig. 32). Successively lower muskegs reveal younger pollen profiles in keeping with a decrease in elevation. Lower Montana Creek (#16), at approximately 150 feet (Fig. 33), does not bear the early pine period in evidence (Period I), and the oldest sediments of muskegs near the immediate waterways at elevations of less than 75 feet contain only a portion of Period II (Figs. 25, 29, and 30). The fact that marine fossils have been found as high as 400 feet in the Taku Valley (50, p. 693) and at 150 feet near Eagle River and 200 feet on Douglas Island (55, p. 33), attests to the presence of marine waters inland following ice retreat. Dachnowski-Stokes (18, p. 26) has disclosed, through the finding of marine shells underlying the Lemon Creek (#9) station, the genesis of muskeg at this site, as a result of the lowering of sea level relative to the land. The pollen profiles of this study substantiate the geological evidence presented. In addition, the correlation of profiles gives an estimate as to the amount and rate of sea withdrawal in postglacial time. Since marine fossils have been found no higher than 400 feet in the Juneau District, and the highest fossils found in the Coast Range are at 650 feet near Fraser River, British Columbia (45, p. 52), it appears safe to assume that higher sea levels did not affect Upper Montana Creek at 750 feet. The difference in the pollen record between this station and Lower Montana Creek (at 150 feet and presumably submerged in early post-glacial time) amounts to all of Period I and part of Period II. As the close of Period I is dated at 6,000 years, the beginning of the record at Lower Montana Creek is at a little less than 6,000 years, or the time of early eustatic change of sea level. The oldest of the muskegs at less than 75 feet elevation (Figs. 25, 29, and 30) begin later during Period II and are dated at just over 5,000 years. From this information, the sea level lowering from 150' to as low as approximately 10 feet (at Lemon Creek) occurred in less than 1,000 years, or between 6,000 and 5,000 years ago. High tide level has only been lowered about 10 feet since, as evidenced from the difference between the base of Lemon Creek (#9) (Fig. 25) and the present high sea level. Kerr (50, p. 693) was of the opinion that sea level was lowered 5,000 to 4,500 years ago and reached its present level about 2,500 years ago. The data given by these profiles would indicate an earlier date of approximately 6,000 years for the onset of the marine retreat. The muskegs of the other districts of this thesis are thought to reveal similar sea level trends. Generally, the sites of muskegs containing Period I are considered to have been elevated in early postglacial time, while those beginning with Period II suggest submergence during the preceding Period I.

The presence of abundant volcanic ash at the bottom (Period I) of the Upper Montana Creek muskeg further supports the claim of older age for this station, as related to others in the Juneau District where such sediment is absent. As the stations at lower elevations appear to have been submerged at this early time, volcanic ash, which undoubtedly settled over the entire area, was washed out by tidal action and covered by silt as the sea regressed. This ash at Upper Montana Creek was first thought to have been correlated with the ash underlying muskegs at Sitka, but as stations at Petersburg, as equidistant from Sitka as Juneau (Fig. 1), do not contain ash underlying Period I, this premise is ruled out. Ice covering at Petersburg may have prevented this ash from being recorded, since it may have fallen on the surface of retreating glaciers and was later flushed out. This may have been the case, but the presence of climax forest contemporaneous with the ash at Sitka, in an area that is definitely known to have been glaciated (56, p. 11), indicates that this ash is not logically correlated with that beneath Upper Montana Creek where the early pine Period I is in evidence. This is thought to be the case even under the consideration of the mode of retreat of Cordilleran ice northeastward, with an earlier uncovering at Sitka than at Upper Montana Creek at the edge of the Coast Range. Halibut Point Road (#7) does not contain a record of Period I (Fig. 23), as it was probably submerged beneath sea level during this early time. Halibut Point Road muskeg occurs near sea level at a lower elevation than the occurrence of marine fossils. As a result, the ash at Upper Montana Creek seems to be much earlier than that discharged by the eruption of Mount Edgecumbe. It is presumably early postglacial and originated east of the Coast Range. The Tuya-Teslin area, about 120 miles distant on the Stikine Plateau to the northeast, has been described as a region of apparent glacial vulcanism (64, p. 560). This area appears to have been a logical source for this ash, since the ice sheet may have overlain the Stikine Plateau while Upper Montana Creek was already deglaciated.

Volcanic ash of Mount Katmai, 800-900 miles distant from Southeastern Alaska, is not recorded in the peat sections studied. This volcano erupted in 1912, and the ash would be expected to be present at the surface where none is evident. Shards of volcanic glass are noted, however, at deeper levels in the first and second meter of peat, but is not conceivably Katmai in age. The ash appears to have originated in the neighborhood of Wrangell, as its concentration is greatest in the sections of this locality (Figs. 19 and 20). Kerr (51, p. 153) states that post-glacial vulcanism has occurred in the region of the Iskut and Unuk rivers, 50-60 miles east of Wrangell, to within approximately 100 years ago (Fig. 1). The depth of ash in the peat sections discloses that vulcanism has occurred within the last 500 years, but not as recent as 100 years. Lesser amounts of ash are recorded in the upper levels of peat sections farther removed from this area.

POSTGLACIAL CLIMATE

Since the retreat of the Cordilleran ice sheet, the climate of Southeastern Alaska has undergone certain changes, as indicated by both botanical and geological evidence. The greatest wealth of information is provided by the record of advance and recession of the glaciers of the Coast Range and the neighboring ranges in the northwest. These glaciers have waxed and waned largely in response to climatic fluctuations and have left excellent accounts of the postglacial climate.

There is evidence to indicate the existence of a warmer and/or drier period from Yakutat Bay in the extreme northwest to Portland Canal in the southeast. Buried forest remains at Disenchantment Bay near Yakutat have been exposed by recent deglaciation (72, p. 89), disclosing the presence of a forest which grew during a period of ameliorated climate when the glaciers of the St. Elias Range had greatly receded. Interstadial forests flourished at Glacier Bay, 150 miles to the southeast, as evidenced by buried stumps, logs, and other organic debris (17, pp. 88-93). At Muir Inlet in Glacier Bay, forest beds were observed at two stratigraphic levels suggesting a fluctuating ice front, which during periods of retreat permitted forests to become established. A buried forest horizon has been located in the outwash of Mendenhall Glacier in the Coast Range (Fig. 34) (55, p. 12), while in the Taku and Stikine river districts, interstadial forest remains are present in the outwash of Talsekwe and Great glaciers (53, p. 16) and (52, p. 17). Finally, as far south as the southeastern border of the Territory at Portland Canal, there is evidence of a warmer period from the Bear River delta (27, p. 495). This delta, which owes its formation largely to sedimentation of glaciofluvial materials, appears to have formed in recent time. Prior to this, glaciers occupied the region of the delta, so that it was not until the ice receded that development began. These data tend to indicate a warm climatic period.

In more recent time, this warm, dry period was terminated by a cooler and moister climate. Ice fields at higher elevations were rejuvenated, and glaciers again advanced into the lowlands. Since about 1750, however, the glaciers of the Juneau Ice Field (58, pp. 196-215) and Glacier Bay (14, pp. 98-104) have generally receded (Figs. 5, 14, and 35). Somewhat anomalous is the fact that certain coastal glaciers such as those at Prince William Sound are known to be advancing at present (25, p. 385). Glacial retreat and a milder climate, however, are further supported by an upward advance of timberline in the northern Coast Range of British Columbia (7, p. 37).

Fig. 34. Outwash of Mendenhall Glacier near Juneau, Southeastern Alaska, containing a stratum of stumps which were buried <u>in situ</u> as a result of overriding by ice as this glacier advanced about 1,800 years ago (57).

Fig. 35. Terminus of receding Norris Glacier in Taku Valley, Southeastern Alaska; the exposed, lateral rock fringes of the glacier give testimony of a former expanse of ice; plant succession below the trim line reveals the diminution of ice volume.

These climatic trends, so well corroborated in Southeastern Alaska, have been extensive in scope, as elsewhere along this Pacific coast border and in other parts of the world, similar changes have set the climatic scene. Griggs (33, pp. 80-96) and Bowman (6, pp. 97-100), both working on Kodiak Island at the northwest terminus of the Coast Forest range, have shown the advance of the forest into the tundra in recent time. Mathews' studies (65, pp. 360-371) at Garibaldi Park in southwestern British Columbia have disclosed the advance and retreat of glaciers in the map-area to also be of recent occurrence. Particularly strong in revealing the former xerothermic maximum in the Pacific Northwest are the pollen analyses of Hansen (36, pp. 114-115). Grasses, chenopods, and composites as well as oak and yellow pine are greatly expanded in many pollen profiles and reveal a marked warm and dry period. Above this expansion, there is a diminution of these indicators. Climate since has become cooler and wetter as indicated by an increase of more mesic species. Elsewhere in the world, there are numerous reports of a warmer period followed by increased moisture and/or cooling. At present, incipient climatic improvement also appears to be world wide. The data of Nichols and Miller in Patagonia (68, pp. 278-294), of Deevey in Southern New England (20, pp. 724-727), and of

Godwin in England and Wales (31, p. 372) are pertinent in this respect, and Matthes (66, pp. 190-215) has presented a summary of particular interest. A thorough review of postglacial climate throughout the world is presented by Hansen (36, pp. 108-121).

POSTGLACIAL CHRONOLOGY

Wisconsin stratigraphy in Southeastern Alaska is not sufficiently known to correlate substage deposits elsewhere in North America. Much of the earlier glacial deposits has been destroyed or buried by the Late Wisconsin glaciation. It is not definitely known whether the last ice sheet to cover this region was Late Wisconsin (Mankato), although the recent radiocarbon (C^{14}) dating of a peat deposit near Anchorage, Alaska would designate the last advance as this stage. The deposit is 10 inches thick and is located along Eagle River where it is overlain by till of the last ice sheet and underlain by gravel. It has been dated at 14,300±600 years (57, p. 568) and appears to be chronologically equivalent to the Two Creeks forest bed on the shore of Lake Michigan in Wisconsin (83, pp. 31-46). The Two Creeks deposit is known to be pre-Mankato and has been dated by C^{14} assay at 11,404±350 years (4, p. 118).

Post-Wisconsin time in Southeastern Alaska is of unknown duration, although by a greater number of C^{14} determinations in this area, the length of Recent time should eventually be established. Unfortunately, this study is made during an interim of progress while the C^{14} technique (59, pp. 227-228) and (3, pp. 678-680) has as yet been applied to only a few of the major study areas in North America. There are, nevertheless, certain data which have accumulated that can be used as a basis for estimating chronology.

An attempt at dating post-Mankato peat deposits of the pine period in the eastern United States has been made by means of C^{14} measurements (29, pp. 269-274). This period was determined for two Minnesota stations to be about 8,000 years in Cedar Creek Bog near Minneapolis and approximately 7,000 years near Ely, 220 miles north. In both of these bogs, peat of the pine period is underlain by peat of the initial spruce-fir period which is unknown in age. Also, both bogs have developed on Mankato drift. Since the Two Creeks deposit dates the Mankato at about 11,000 years, there remains 3,000-4,000 years of intervening time for glacial retreat and the subsequent formation of peat to the beginning of the pine maximum. Judging from the meter of eutrophic gyttja that formed during the bottom spruce-fir period at Cedar Creek Bog, it is reasonable to assume an interval of 2,000 years for the accumulation of this sediment (decimeter = 200 years). This would then place the beginning of pollen sedimentation at 10,000 years, allowing 1,000 years for the recession of the ice front to beyond the site of the bog and the initiation of the pollen record.

Owing to the position of Cedar Creek Bog, rather distantly removed from the Laurentide ice center on the

Canadian Shield, the ice was presumably thinner and wasted more rapidly than it did in Southeastern Alaska, where the nearby Cordilleran center resulted in a greater thickness of ice. Southeastern Alaska, as a result, was probably deglaciated at a later time, and the earliest postglacial pollen bearing sediments are dated at about 8,000 years.

Postglacial time in the region is equivalent to post-Mankato maximum. Mathews (65, p. 378) in southern British Columbia has also indicated 8,000 years for this interval. Kerr (50, p. 691) in northern British Columbia states that 9,000 years are figured, although his number is based on Antevs' dating for ice having retreated in eastern North America to Labrador, a chronology which now appears to be obsolete as a result of the radiocarbon method. Oddly enough, however, this figure of 9,000 years broadly fits the interpreted length of postglacial time in Southeastern Alaska. Capps (10, pp. 5-6) has given the age of a 39 foot peat section near Russell Glacier in the interior as 7,800 years. Of interest is another C^{14} figure given for an 8 foot (2.4 meter) peat deposit near Anchorage as 5,340±300 years (57, p. 568). It is presumably post-Mankato by reason of its younger age (compared to the Eagle River dating) and its uncovered position overlying blue clay. Such a section which is presently in a climate with 14 inches annual precipitation, can reasonably be correlated with deeper sections in Southeastern Alaska where precipitation is about 100 inches annually (54, p. 1211). It may not be feasible, however, to compare deposits as much as two and a half times deeper, i.e., the Lower Montana Creek muskeg which is nearly 20 feet in depth. For this reason and allowing for a differential of latitude (a slower recession of ice at Anchorage due to colder climate), the oldest Southeastern Alaska sediments as revealed by pollen analysis are dated at 8,000 years.

Further chronological considerations are based on both sedimentation and radiocarbon data. Kerr (50, pp. 687-690) has calculated a period of approximately 4,500 years for the development of the Stikine and Taku river deltas, which began to form about 9,000 years ago. The time of early delta building precedes the date of the earliest pollen record. During the 4,500 years deltas were built, glaciers receded into the Coast Range. Kerr states that alpine glaciers prevailed until about 4,500 years ago and recognizes the beginning of the warm period at 5,000-6,000 years in the past. The length of this warm interval is thought to be 3,000-4,000 years, as it was brought to a close about 2,000 years ago. The evidence for this 2,000 year date is well founded. Hanson (40, pp. 335-339) has been able to determine the approximate age of Tide Lake near Stewart, British Columbia on the basis of 150 feet of varved sediments and a rate of 1 varve (1 year) = 1 inch. Tide Lake was formed by ice blocking and subsequent moraine building during historic time and is about 2,000 years old. This figure agrees well with the C^{14} age of forest debris overridden by the latest advance of Mendenhall ice near Juneau (Fig. 34) which is given as 1,790±285 years (57, p. 568). Ice retreat has been dated by the dendrochronological studies of Lawrence at about 1750 or 200 years ago (58, p. 215).

SUMMARY

Seventeen peat sections were obtained from muskegs in the vicinity of Ketchikan, Wrangell, Petersburg, Sitka, and Juneau in Southeastern Alaska during the 1950 and 1951 field seasons. The samples were taken at decimeter intervals and studied macroscopically and later micro-analytically for their pollen content. Peat and pollen diagrams have been constructed from which the postglacial forests, climate, and chronology have been interpreted. The study is important since it enlarges our knowledge of the postglacial succession of the Coast Forest. The nearest investigations of this nature are 400 to 500 miles northward and southward.

Southeastern Alaska is the "panhandle" of the Territory, consisting of the islands and waterways of the Alexander Archipelago and the Coast Range of the mainland. Pleistocene glaciation has affected the entire region except possibly the higher peaks and has given rise to the present rugged topography. The last glaciation is correlated with the Mankato (Late Wisconsin) substage. The climate is cool and moist throughout the year and heavy snowfall occurs in the mountains in winter. There is abundant evidence to indicate that climate has fluctuated in postglacial time and is in the nature of glacially

derived features and plant remains. The present vegetation of the region consists largely of the hemlock-spruce climax with its minor associates. Muskeg is common where the terrain is inadequately drained.

The pollen profiles reveal the importance of lodgepole pine as an early regional postglacial invader. This species was early succeeded in post-Mankato time by a Sitka spruce consociation and ultimately by a western hemlock-spruce climax. Lodgepole pine today appears only occasionally in the invasion of areas recently denuded of ice and is almost entirely restricted to muskeg.

The time represented by the pollen profiles has been divided into five periods based upon the interpretation of the profiles. Period I from 8,000 to 6,000 years ago was cool and moist. Floristically it was represented by regional predominance of lodgepole pine. Period II from 6,000 to 5,000 years ago was characterized by a warmer and drier climate and almost complete replacement of lodgepole by Sitka spruce and later by the western hemlock-spruce climax. Period III is from 5,000 to 2,000 years ago. It is represented by continued warming and drying to a maximum (postglacial optimum). During this interval, western hemlock and spruce comprised the forest complex with hemlock constantly increasing. Period IV from 2,000 to 200 years ago marked the return of wetter and cooler climate. In the pollen profiles, Period IV is represented by a predominance and maximum of hemlock. The increase of spruce during late Period IV reflects the disturbance of the climax forest by glacier advance. The coincident increase of pine on the muskeg is attributed to wetter conditions. Period V is considered as the interval of the last 200 years when glaciers began to retreat.

The sedimentary columns contain a record of vulcanism, change in sea level, and recent fluctuation of the glaciers. The presence of volcanic ash in the Sitka sections during Period II has served as a basis for dating the eruption of Mt. Edgecumbe, 20 miles distant, at about 5,500 years. Vulcanism, which is especially evident from the ash in the sections near Wrangell and Petersburg, seems to be traceable to the Iskut and Unuk rivers region where postglacial lavas and ash are found. Ash at the bottom of the Upper Montana Creek section is attributable to vulcanism in the Tuya-Teslin area of northern British Columbia. No ash from the eruption of Mt. Katmai in 1912 is apparent in the sections. The pollen profiles of the Juneau District substantiate geological evidence for higher sea levels in early postglacial time. The Upper Montana Creek muskeg site with Period I in evidence is thought to have stood above sea level, while those adjacent areas with profiles beginning with Period II are considered to have been submerged during this earlier time. Evidence of glacier readvance early in post-Mankato time is especially shown at Wrangell and Petersburg. The sequence of expansion, contraction, and reexpansion of western hemlock in these profiles is interpreted as indicating, respectively, succession, subsequent disturbance by ice readvance, and succession as a result of glacial retreat.

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