Vegetation of Northwestern North America, as an Aid in Interpretation of Geologic Data

By ROBERT S. SIGAFOOS

CONTRIBUTIONS TO GENERAL GEOLOGY

GEOLOGICAL SURVEY BULLETIN 1061-E

A map and description of the boreal forest and some treeless vegetation

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1958

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

Sigafoos, Robert Sumner, 1920–

Vegetation of northwestern North America, as an aid in interpretation of geologic data. Washington, U. S. Govt. Print. Off., 1958.

iii, 165–185 p. illus., maps (1 col. in pocket) 25 cm. (U. S. Geological Survey. Bulletin 1061–E. Contributions to general geology)

"References pertaining to key map": p. 169–171.
"References cited"; p. 182–183.

1. Phythogeography. 2. Botany—North America. 3. Botany—Ecology. I. Title. (Series: U. S. Geological Survey. Bulletin 1061–E. Series: U. S. Geological Survey. Contributions to general geology)

581.9711

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 75 cents (paper cover)

CONTENTS

ILLUSTRATIONS

CONTRIBUTIONS TO GENERAL GEOLOGY

VEGETATION OF NORTHWESTERN NORTH AMERICA, AS AN AID IN INTERPRETATION OF GEOLOGIC DATA

By Robert S. Sigafoos

ABSTRACT

A distribution map of the major forest groups of northwestern North America and some treeless vegetation types of parts of Alaska has been prepared from published large-scale maps and data collected during recent field studies by the U. S. Geological Survey. The most common plant communities in the interior spruce and birch forest, coastal spruce and hemlock forest, and treeless regions are briefly described. Engelmann spruce and lodgepole pine grow in the extreme southeastern part of the region mapped. Examples are cited to demonstrate the importance of a knowledge of vegetation in aiding in interpretation of local distribution of permafrost, and the significance of upper Pleistocene and recent fossil plants, and as a part of background material for future ecologic, geomorphologic, and hydrologic studies. The usefulness of accurate knowledge of the geographic distribution of various species is discussed and maps of the principal tree species are included.

INTRODUCTION

A distribution map of major forest groups in North America north and west of Hecate Strait, British Columbia, and some treeless vegetation types in parts of Alaska has been compiled from published large-scale vegetation maps and data collected during recent field studies incidental to the geological and ecological research program of the U. S. Geological Survey. Although a preliminary map initially compiled for the writer's use, it may be useful to others as an aid in the interpretation of much geologic data.

Comments on the relationship between the distribution of vegetation and what is loosely called permafrost are read in the literature. Forest and treeless vegetation, with the exception of some mosses and lichens, grow only on unconsolidated surficial deposits in Alaska, and a comparison of the vegetation map with the map of permafrost zones (Hopkins and Karlstrom, 1955, p. 116) shows no correlation between the distribution of vegetation and permafrost. The distribution of forest vegetation and factors responsible for keeping surficial materials frozen (Hopkins and Karlstrom, 1955, p. 115–116) are determined by past and present climatic, biotic, and physical variables. The distribution of vegetation is determined, in part, by the present and past effects of many environmental variables upon the physiology

of the component species; the temperature and physical characteristics of the subsoil are but two of these factors.

Locally, plant communities in both the treeless vegetation and white spruce and white birch forest regions and the local boundaries between them can be correlated with factors related to the depth of perennially frozen materials. More deeply thawed soil is more stable (Hopkins and Sigafoos, 1951, p. 63–65; Raup, 1951, p. 111) because it is better drained and is, therefore, subject to less intense frost action. Willow shrubs and scattered trees in areas of predominantly treeless vegetation grow along streams where fine soil thaws to greater depths than in surrounding areas (pl. 13). Forest grows on slopes mantled with silty soils that thaw completely or thaw to considerable depths each summer in western Alaska; in nearby areas, tundra communities grow on silty soil that thaws to depths from 1 to 2 feet. In parts of the Kobuk River valley, Alaska, white spruce woods grow on parts of small sand dunes that completely thaw during each summer. Adjoining surfaces, upon which the dunes are being deposited, are characterized by tundra communities and are underlain by perennially frozen sand that lies at depths ranging from 1 to 2 feet (pl. 10). On the north side of the Alaska Range in the vicinity of the railroad near Healy, black spruce grows more rapidly and to greater heights on well-drained, unfrozen, gravelly soil than on sites that are underlain by perennially frozen silt and clay. Black spruce, on sites underlain by perennially frozen materials, grow faster where depth to the frozen layer is deeper.

The geologic and climatic significance of fossil plants is inferred from the present distributional relationships of the species or of closely related ones. Because of increased interest and activity in the study of glacial problems in Alaska and other parts of the north country, an increasingly large number of fossils are being collected and identified (Hansen, 1953; Hopkins and Benninghoff, 1953; Heusser, 1955; Livingstone, 1955; and Benninghoff, 1957). The vegetation map depicts the present distribution of the major vegetation types, which include most of the living representatives of plant species found in upper Pleistocene and Recent deposits in Alaska. A knowledge of the distribution of these species and an understanding of their significance will aid in the interpretation of the fossils. The existing maps (Hulten, 1941, p. 120–121, figs. 55–66; Taylor and Little, 1950, p. 30–31; and Hustich, 1953, p. 152–154, figs. 2–5) are published on a small scale and thus are difficult to use. Heusser's maps (1955, p. 190, fig. 3) are on a larger scale but show only a small part of the area.

The vegetation map is an index map upon which ecological, combined ecological and geological, and hydrologic studies may be placed

with reference to the vegetation. Because most Alaskan vegetation grows only in unconsolidated deposits, which are widespread, studies of surficial geology must be concerned with the vegetation. Many early reports of the U. S. Geological Survey on the geography and geology of selected areas in Alaska invariably discussed mass movement of surficial materials—noting the significance of vegetation in the development of small landforms.

The importance of vegetation in the water cycle in temperate latitudes is becoming better understood. The relationship of vegetation to the water cycle in Alaska is almost unknown, but investigations in this field will undoubtedly occupy part of future hyrdologic studies. As pointed out by Hopkins and Karlstrom (1955, p. 114), inadequate water supply contributes to limiting the economic development of Alaska. Increasing demand for water for domestic and industrial uses will require comprehensive studies of the water cycle, including the role of vegetation.

The map (pl. 9) will probably be of value to persons interested in problems of wildlife research, soil genesis and classification, land management and land-use planning, as well as other studies in natural history.

MAP UNITS

The map indicates the regions in which forests may be expected and where some different types of treeless vegetation predominate. The great complexity of different habitats—especially within the mountainous regions—and large areas that are only partly known botanically, make mapping of many types almost impossible on the present scale. The boundaries between different vegetation units are largely inferred from the known relationship between the distribution of the vegetation types and topography. Most lines are arbitrary because different vegetation types grade into each other. Most forest communities, especially those within the white spruce and birch region, are successional types that have developed after fire. Some of the species are shorter lived than others and thus have only a more or less temporary existence in the community. The old woods and successional types are discussed for each region.

The clear areas shown on the map are representations of regions above and beyond timberline. Bare rock is common; the predominant vegetation consists of low treeless types.

The interior spruce and birch forest corresponds to the Northern Interior group of forest-cover types, of the Society of American

Foresters (1954, p. 39), with the addition of lodgepole pine. The coastal spruce and hemlock forest consists of the northern representatives of the Society's North Pacific group. Englemann spruce and lodgepole pine forest corresponds to the Society's Englemann spruce-alpine fir type. The groups used in the compilation of Alaskan vegetation are the same as those used by Taylor and Little (1950), except that they separated lowland spruce and birch forest from that growing on the uplands.

The forest distribution in Alaska was compiled from field sketch maps published in U. S. Geological Survey bulletins and from field notes (fig. 31). The map by Taylor and Little (1950) was used for

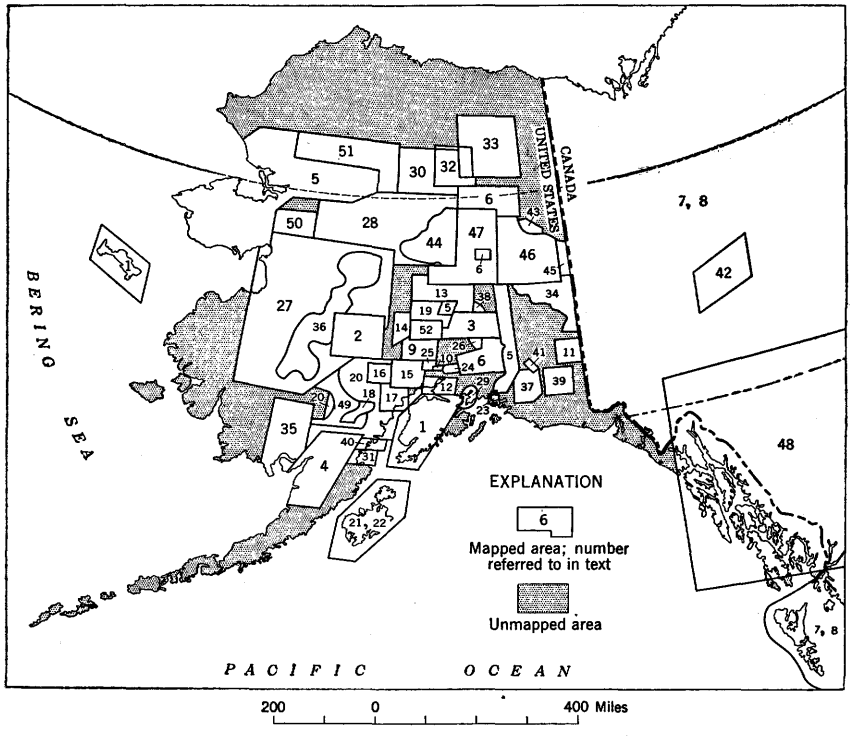


FIGURE 31.—Key map of northwestern North America showing sources of data.

areas not included in these field studies. Vegetation of northwestern British Columbia and southern Yukon Territories (area 48) [1] was compiled from an earlier investigation by Raup and Denny (1950). They mapped the vegetation on a larger scale and showed forest types not included on this map. The list of vegetation of the rest of Yukon Territory and Mackenzie district, except for that along the Canol

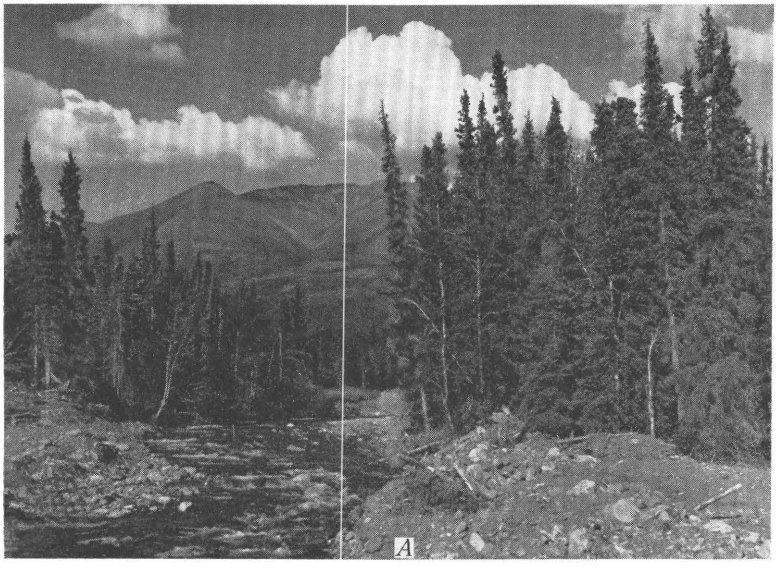
[1] References noted by area number refer to key map (fig. 31).

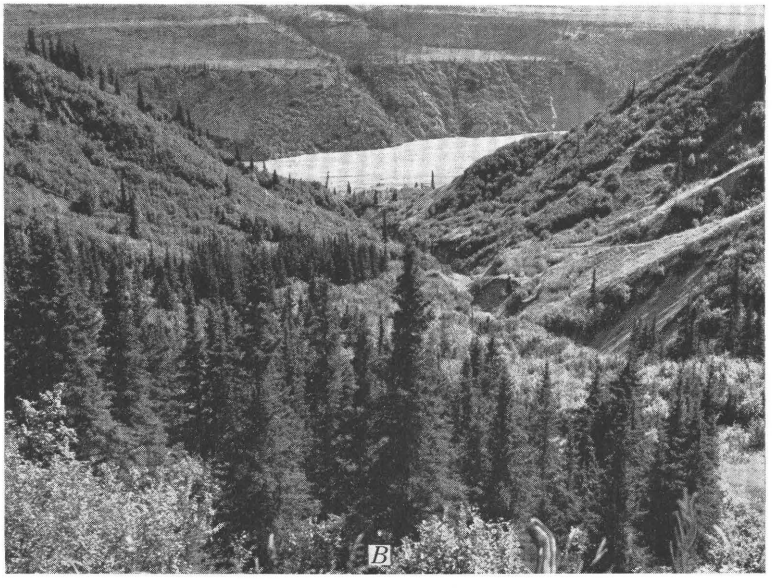
WOODS ADJOINING TUNDRA COMMUNITIES

White spruce and white birch growing on well-drained, deeply thawed sand dune. Herbaceous, lichen, and shrub tundra communities are in middle ground on poorly drained sand which is frozen within 18 inches of the surface. Kobuk River Valley, Alaska, August 1952,

TREELESS COMMUNITIES ON THE SEWARD PENINSULA

Treeless vegetation consists of shrub and herbaceous communities. Dark shrubs in foreground are dwarf birch and heath; cottongrass tussocks are at right foreground. Light grasslike plants are sedges. Near Dahl, Alaska. August 15, 1950.





VIEWS OF THE INTERIOR SPRUCE AND BIRCH FOREST REGION

A, Mature well-formed white spruce trees on alluvial fan in valley of the Nenana River between McKinley Park and Windy, Alaska. July 20, 1953. *B*, Forest, shrub, and grassland communities resulting from repeated fires in area north of Suntrana at Healy Creek, Alaska. July 25, 1953.

TREES GROWING ON THAWED STREAM BANKS

Scattered white spruce, white birch, and willow shrubs growing on well-drained, deeply thawed stream banks. Herbaceous tundra communities are characteristic of the surface underlain by perennially frozen ice-wedge polygons in right foreground. Kobuk River Valley, Alaska. June 1952.

Road, was compiled from the small-scale Canadian Resources Map (areas 7, 8). The small patch of forest depicted on the map along the mouth of the Andraefsky River, on the lower part of the Yukon River, was reported by Harrington (1918) as the extreme western limit of forest along the river. He further reported that spruce grows on the hills near the Yukon River, upstream from the Andraefsky River but did not include a map in his report or specifically locate other patches of woods. The vegetation of Seward Peninsula, Kobuk River valley and about Healy, Alaska, was mapped from field studies made by the writer and from the interpretation of aerial photographs.

REFERENCES PERTAINING TO KEY MAP

[Numbers refer to area shown on figure 31]

Field notes:

1. W. S. Benninghoff
2. W. H. Drury
3. D. M. Hopkins
   D. R. Nichols
4. E. H. Muller
5. R. S. Sigafoos
6. J. R. Williams

Published maps:

7. Canada, Department of Mines and Resources, 1944, Map of Canada Natural Resources; Scale, 1:636,000, Ottawa.
8. Canada, Department of Resources and Development, 1950, Native trees of Canada; Canada Dept. Resources and Devel. Bull. 61, 293 p.
9. Capps, S. R., 1913, The Yentna district, Alaska: U. S. Geol. Survey Bull. 534, 75 p.
10. ——— 1915, The Willow Creek district, Alaska: U. S. Geol. Survey Bull. 607, 86 p.
11. ——— 1916, The Chisana–White River district, Alaska: U. S. Geol. Survey Bull. 630, 130 p.
12. ——— 1916, The Turnagain–Knik region: U. S. Geol. Survey Bull. 642–E., p. 147–195.
13. ——— 1919, The Kantishna region, Alaska: U. S. Geol. Survey Bull. 687, 118 p.
14. ——— 1927, The Toklat–Tonzona region: U. S. Geol. Survey Bull. 792–C, p. 73–111.
15. ——— 1929, The Skwentna region, Alaska: U. S. Geol. Survey Bull. 797–B, p. 67–99.
16. ——— 1930, The Chakachamna–Stony region: U. S. Geol. Survey Bull. 813–C, p. 97–125.
17. ——— 1930, The Mount Spurr region: U. S. Geol. Survey Bull. 810–C, p. 141–172.
18. ——— 1931, The Lake Clark–Mulchatna region, Alaska: U. S. Geol. Survey Bull. 824–C, p. 125–154.
19. ——— 1932, The eastern portion of Mount McKinley National Park: U. S. Geol. Survey Bull. 836–D, p. 129–300.
20. ——— 1935, The southern Alaska Range: U. S. Geol. Survey Bull. 862, 101 p.

467777—58——2

Published maps—Continued

21. ——— 1937, Kodiak and adjacent islands: U. S. Geol. Survey Bull. 880–C, p. 111–184.
22. ——— 1937, Kodiak and vicinity: U. S. Geol. Survey Bull. 868–B, p. 93–133.
23. Capps, S. R. and B. L. Johnson, 1915, The Ellamar district, Alaska: U. S. Geol. Survey Bull. 605, 125 p.
24. Capps, S. R. and Mertie, J. B., Jr., 1927, Geology of the upper Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 791, 92 p.
25. Capps, S. R. and Tuck, Ralph, 1935, The Willow Creek–Kashwitna district, Alaska: U. S. Geol. Survey Bull. 864–B, p. 95–113.
26. Chapin, Theodore, 1918, The Nelchina–Susitna region, Alaska: U. S. Geol. Survey Bull. 668, 67 p.
27. Eakin, H. M., 1914, The Iditarod–Ruby region, Alaska: U. S. Geol. Survey Bull. 578, 45 p.
28. ——— 1916, The Yukon–Koyukuk region, Alaska: U. S. Geol. Survey Bull. 631, 88 p.
29. Johnson, B. L., 1914, The Port Wells gold-lode district: U. S. Geol. Survey Bull. 592–G, p. 195–237.
30. Maddren, A. G., 1913, The Koyukuk–Chandalar region, Alaska: U. S. Geol. Survey Bull. 532, 119 p.
31. Martin, G. C., and Katz, F. J., 1912, A geologic reconnaissance of the Iliamna region, Alaska: U. S. Geol. Survey Bull. 485, 138 p.
32. Mertie, J. B., Jr., 1925, Geology and gold placers of the Chandalar district: U. S. Geol. Survey Bull. 773–I, p. 215–267.
33. ——— 1929, The Chandalar–Sheenjek district, Alaska: U. S. Geol. Survey Bull. 810–B, p. 87–139.
34. ——— 1931, A geologic reconnaissance of the Dennison Fork district, Alaska: U. S. Geol. Survey Bull. 827, 44 p.
35. ——— 1938, The Nushagak district, Alaska: U. S. Geol. Survey Bull. 903, 96 p.
36. Mertie, J. B. and Harrington, G. L., 1924, The Ruby–Kuskokwim region, Alaska: U. S. Geol. Survey Bull. 754, 129 p.
37. Moffit, F. H., 1914, Geology of the Hanagita–Bremner region, Alaska: U. S. Geol. Survey Bull. 576, 56 p.
38. ——— 1915, The Broad Pass region, Alaska: U. S. Geol. Survey Bull. 608, 80 p.
39. ——— 1918, The upper Chitina Valley, Alaska: U. S. Geol. Survey Bull. 675, 82 p.
40. ——— 1927, The Iniskin–Chinitna Peninsula and the Snug Harbor district, Alaska: U. S. Geol. Survey Bull. 789, 71 p.
41. Moffit, F. H. and Mertie, J. B., Jr., 1923, The Kotsina–Kuskulana district, Alaska: U. S. Geol. Survey Bull. 745, 149 p.
42. Porsild, A. E., 1951, Botany of southeastern Yukon adjacent to Canol Road: Canada Nat. Mus. Bull. 121, p. 1–400.
43. Prindle, L. M., 1906, The Yukon–Tanana region, Alaska: U. S. Geol. Survey Bull. 295, 27 p.
44. ——— 1908, The Fairbanks and Rampart quadrangle, Yukon–Tanana region, Alaska: U. S. Geol. Survey Bull. 337, 102 p.
45. ——— 1909, The fortymile quadrangle, Yukon–Tanana region, Alaska: U. S. Geol. Survey Bull. 375, 52 p.

Published maps—Continued

46. ——— 1913, A geologic reconnaissance of the Circle quadrangle, Alaska: U. S. Geol. Survey Bull. 538, 82 p.
47. ——— 1913, A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U. S. Geol. Survey Bull. 525, 220 p.
48. Raup, H. M. and Denny, C. S., 1950, Photo interpretation of the terrain along the southern part of the Alaska Highway: U. S. Geol. Survey Bull. 963–D, p. 95–135.
49. Smith, P. S. 1917, The Lake Clark-central Kuskokwim region, Alaska: U. S. Geol. Survey Bull. 655, 162 p.
50. Smith, P. S., and Eakin, H. M., 1911, A geologic reconnaissance in southeastern Seward Peninsula and Norton Bay–Nulato region, Alaska: U. S. Geological Survey Bull. 449, 146 p.
51. Smith, P. S., and Mertie, J. B., Jr., 1930, Geology and mineral resources of northwestern Alaska: U. S. Geol. Survey Bull. 815, 351 p.
52. Tuck, Ralph, 1934, The Curry district, Alaska: U. S. Geol. Survey Bull. 857–C, p. 99–140.

ACKNOWLEDGMENTS

Sincere appreciation is expressed to the individuals who contributed information on the following areas: parts of the Brooks and Alaska ranges, northern Yukon Territory, and Mackenzie district by W. P. Brosgé, M. D. Mangus, and T. L. Péwé of the U. S. Geological Survey and Galen Smith of the U. S. Air Force; the upper Kushokwim River region by W. H. Drury of Lincoln, Mass.; and the Kenai Peninsula-Cook Inlet area by J. W. Scott of the Bureau of Land Management.

R. R. Robinson of the Bureau of Land Management, R. F. Taylor of the U. S. Forest Service, Drury, and Scott kindly reviewed an early draft of the manuscript.

INTERIOR SPRUCE AND BIRCH FOREST REGION

The region mapped as interior spruce and birch forest is the northwestern extension of the Canadian boreal forest and contains many forest types, including some treeless plant communities. Many forest types have developed as the result of fires on sites that prior to burning varied greatly in forest and physical characteristics. The existing stands show differences in species composition, plant form, and age (pl. 12*B*). Lutz (1956) has described the most common forest communities located mostly along the highways in east central Alaska. He points out, as did Raup (1945) and Raup and Denny (1950), that the significance of the communities in terms of vegetation development and history of the land surface can be perceived only if the importance of fire is appreciated. The development of vegetation after fire is extremely complex and will not be discussed here; Lutz (1956) has thoroughly discussed the ecological effects of fire on forests in the interior of Alaska. He relates differences in morphology and seeding

habits of species to establishment and maturation of forests. Raup and Denny (1950) describe succession of vegetation types following fire in the forests in parts of British Columbia.

The forest throughout the region has hardly been exploited, but some white spruce and white birch are cut for local consumption.

Only the larger areas of treeless communities within the forested region have been mapped. Treeless communities result from poor drainage or soil instability, which prevents tree growth, or from repeated burning of forests.

WHITE SPRUCE

Pure white spruce forest and a mixture of white spruce and white birch forest are characteristic of most of the forested lowlands and well-drained uplands in a larger part of the interior spruce and birch forest region.

Mature stands of white spruce, either pure or with some admixtures of white birch, form dense forests. The trees on most lowland sites reach heights ranging from 50 to 70 feet, and some of their trunks range from about 10 to 20 inches in diameter, although they are smaller in most stands. Trees grow most rapidly, attain their greatest height and diameter, and trunks show less tapering on well-drained alluvial fans underlain by coarse material (pl. 12*A*). On flood plains in the interior of British Columbia, the height of some trees is more than 100 feet, and diameters range from 18 to 24 inches (Raup and Denny, 1950, p. 07). The understory, composed of willow, alder, and heath shrubs, may be either dense or sparse, depending on spacing of the trees and density of the canopy.

Pure stands of white spruce are characteristic of the western and northern limit of forest on Seward Peninsula and southward-trending river valleys through the Brooks Range. They are also common in lowlands throughout the interior spruce and birch forest region. White spruce stands are prevalent on uplands, but commonly contain small numbers of white birch, aspen, and balsam poplar. Poplar and aspen, which are short lived, grow in openings in forests of older spruce. White spruce with local admixtures of scattered lodgepole pine and aspen are characteristic of rolling uplands in British Columbia, except in the coastal mountains region (Raup and Denny, 1950, p. 109).

WHITE SPRUCE AND WHITE BIRCH

White spruce and white birch forests are characteristic of some lowlands and well-drained uplands and river terraces throughout the forest region. These forests are similar to white spruce forests except that they are somewhat more open owing to the thin, feathery,

white birch canopy. Some additional willow species and rosaceous species occur in the shrub layer, which is typically more dense than that under white spruce—possibly because of the more open nature of the forest.

White birch deteriorates before white spruce in some older stands, suggesting that white birch is only a temporary member of the forest. However, some old white birch produce vigorous sprouts when the main stem dies; and thus, the ratio of white birch trees to white spruce trees is maintained for long periods of time. Lutz (1956, p. 41) believes that the white spruce and white birch forest is a stage in succession following fire.

Scattered black spruce are locally associated with white spruce and white birch on uplands in the Mackenzie Mountains (Porsild, 1951a, p. 28).

BALSAM POPLAR

Dense stands of large balsam poplar with some white birch grade into pure white spruce and into white spruce and white birch forests on river flood plains throughout the region. Lutz (1953, p. 23) reports that young balsam poplar stands are dense, remaining so even in old stands. Mature trees range from 70 to 100 feet in height and are as much as 36 inches in diameter. White spruce is commonly associated with balsam poplar in older stands, and together they form a tall, dense forest characteristic of older surfaces along large rivers. Pure stands of poplar that range from 30 to 40 feet in height and 4 to 6 inches in diameter grow along flood plains beyond the northern limit of white spruce in the Brooks Range (Spetzman, Minnesota Univ. unpublished thesis, 1951); stands of smaller trees grow as far west as Nome, Alaska, on the Seward Peninsula.

Balsam poplar is the first tree species, excluding willows, to invade recently deposited alluvium along river flood plains. Stands are invaded by white spruce, but because the poplar is relatively long lived, it persists for long periods.

BLACK SPRUCE

Black spruce stands vary widely in form, density, and structure. The trees range from a few feet to 50 feet in height and from scrubby to nearly symmetrical form. The density of the stands ranges from those that contain scattered, poorly formed individuals to stands with large, straight-trunked trees from 2 to 5 feet apart.

Black spruce in pure stands is characteristic of poorly drained sites, underlain by thick peat layers and fine-grained soils, throughout the interior spruce and birch forest region. It also grows on steep, rocky slopes in British Columbia (Raup and Denny, 1950, p. 107–108) and

in northern and central Alaska. Pure stands of black spruce and some with admixtures of aspen and white birch grow on well-drained uplands throughout the region. Lutz (1956, p. 67–68) believes that in some places the black spruce has invaded previously burned over areas. Stands are common on sand dunes in parts of western Alaska. In parts of the Mackenzie Mountains, black spruce and scattered white birch grow on heavy, glaciated soils (Porsild, 1951a, p. 28). Black spruce, lodgepole pine, and white spruce grow on heavy clay soils in interior British Columbia (Raup, 1945, p. 32). Larch is associated with black spruce in some lowland depressions in parts of central Alaska, Yukon, and British Columbia.

ASPEN AND BIRCH

Pure stands of aspen, pure stands of birch, and mixtures of the two species are common throughout Alaska in areas of recent fires. Pure aspen stands grow on the better-drained ridges throughout the region and follow burning on drier sites. Trees reach heights ranging from 30 to 50 feet in mature woods and trunk diameters range from less than 1 to 8 inches. White spruce commonly invades aspen and birch stands and replaces them if the site is not burned over (Lutz, 1956, p. 37–39, 45–47). Aspen and birch appear to persist for long periods on many of the driest sites, because they are the only tree species that produce seedlings here. Raup and Denny (1950, p. 109) found pure aspen stands on dry, southward-facing slopes in British Columbia; and they, too, believe that the type persists for long periods of time.

LODGEPOLE PINE

Open stands of lodgepole pine are characteristic of sandy, well-drained soils throughout central and northern British Columbia, and on heavier soils where spruce forest has been burned off (Raup and Denny, 1950, p. 108–109). Lodgepole pine replaces itself only on well-drained soils and elsewhere it is replaced by white spruce.

WHITE SPRUCE, ALPINE FIR, LODGEPOLE PINE, AND BLACK SPRUCE

Alpine fir grows in tall forests with white spruce, lodgepole pine, and black spruce on some steep mountain slopes in interior British Columbia in areas that have not been burned recently (Raup and Denny, 1950, p. 112–113). The forests are generally old.

TREELESS COMMUNITIES

Communities of characteristic shrubs, grasses, or grasslike plants are distributed throughout the interior spruce and birch forest. The shrub communities consist of various mixtures of dwarf birch, wil-

lows, and heaths. They grow throughout interior Alaska (Lutz, 1953, p. 28) and British Columbia (Raup and Denny, 1950, p. 113) where forests have been repeatedly burned. Shrub communities in western and central Alaska grow with small white spruce stands near altitudinal and regional timberlines; stands that have not been burned appear to be old. Alder is an important component of the shrub community in timberline areas.

Extensive grasslands, which Raup and Denny (1950, p. 115–117) have termed prairies, occur throughout Alaska and British Columbia. In parts of western Alaska they appear to persist for long periods of time. In central Alaska the grasses grow on sites that are underlain by silty soil and have been repeatedly burned over. Throughout the interior spruce and birch forest, cottongrass tussocks and low woody plants are characteristic of poorly drained sites underlain by peat or silty soil.

TIMBERLINE FOREST

White spruce trees form upper timberline throughout most of the interior white spruce and white birch forest region. Local timberline is abrupt, especially in western Alaska; and in many places trees, comparable in size, form, and growth rate to those of the area as a whole, grow within a few tens of feet of treeless vegetation. The abrupt change from vegetation composed of large trees to tundra communities has been reported by many persons who have written vegetation descriptions in U. S. Geological Survey bulletins that describe the geology and geography of western and central Alaska. Typical of such reports is that of Smith and Mertie (1930, p. 72).

> At both of these places (Alatna and Noatak River valleys in the Brooks Range) the northern limit of trees comes abruptly. A few hundred yards south of the actual limit the trees are of about the same size as they are scores of miles to the south. . . . On the Unakserak spruce trees 8 to 10 inches in diameter, 30 feet tall, and nearly straight . . . were found . . ., but 100 yards beyond there were not even dwarf trees or any signs that there had been trees within many miles.

Alpine fir is the timberline tree at places in the Mackenzie Mountains (Porsild, 1951a, p. 28) and southward (Raup, 1945, p. 128). Lodgepole pine and white spruce grow on mountain slopes below altitudinal timberline in British Columbia (Raup and Denny, 1950, p. 128).

Timberline ranges in altitude from 200 to 800 feet above sea level in western Alaska, 1,000 to 1,500 feet on the south slopes of the Brooks Range, 2,000 to 3,000 feet in interior Alaska, and 4,000 to 5,000 feet in Yukon and interior British Columbia.

COASTAL SPRUCE AND HEMLOCK FOREST REGION

The upland forests of coastal southern Alaska and extreme northern British Columbia consist primarily of pure stands of Sitka spruce or mixtures of spruce and western hemlock. In southeastern Alaska, Alaska cedar and western red cedar grow locally in pure stands or with spruce and hemlock. Pacific silver fir forms pure stands and is associated with spruce and hemlock in extreme southeastern Alaska and British Columbia. Successional stages of alder and cottonwood characterize lowlands along streams.

The coastal spruce and hemlock forest has only recently been utilized for lumber products and pulp. The average volume of timber in the coastal forest was estimated by Heintzlemann (1928) to be about 25,000 board feet per acre.

SITKA SPRUCE AND WESTERN HEMLOCK

Sitka spruce and western hemlock form dense stands in mixed forests on well-drained uplands from the eastern side of Kenai Peninsula to British Columbia. Western hemlock comprises from 70 to 80 percent of mature stands; Sitka spruce, 20 to 30 percent. Hemlocks range from 100 to 120 feet in height and 18 to 25 inches in diameter at 4½ feet above the ground. Some trees reach heights of 140 feet and diameters ranging from 3 to 4 feet. Mature spruce trees range from 160 to 200 feet in height and from 3 to 4 feet in diameter, although the maximum diameter may be as much as 6 feet.

Hemlock forms the main canopy throughout the area and is overtopped by individuals or small groups of Sitka spruce. Small hemlocks, heath species, and other shrubs form a dense understory that, together with the other forest trees, forms a forest community of almost tropical luxuriance. Fruticose and foliose lichens covering all tree trunks and shrub stems, an abundance of fallen trees, and a moss carpet ranging from 6 to 15 inches in depth are characteristic of the forest.

Other forest types, similar in form and somewhat similar in species composition have been defined (Soc. Am. Foresters, 1954). Within the coastal forest region, local stands of nearly pure western hemlock occupy sites comparable to those that elsewhere are characterized by Sitka spruce and western hemlock forest. From Valdez, Alaska, southeastward, Alaska cedar is associated with the western hemlock. In places south of Petersburg, Alaska, western red cedar is mixed with hemlock in sufficient numbers to noticeably change the nature of the forest. Such a forest type is called western red cedar and hemlock (Soc. Am. Foresters, 1954, p. 52). In extreme southeastern Alaska and coastal British Columbia, Pacific silver fir and western hemlock

are characteristic of the upland sites. Sitka spruce is in all these forests but in smaller numbers than in the typical Sitka spruce and hemlock forest.

SITKA SPRUCE

The pure stand of Sitka spruce, of the same size and structure as the spruce and hemlock forest, is a successional type which grows on recently deposited alluvium and glaciated materials. In the older stands western hemlock seedlings are abundant—as the spruce dies, it is replaced totally or partly by the hemlock (Taylor, 1932).

The coastal forest in southwestern Kenai Peninsula and on the west side of Cook Inlet is largely composed of Sitka spruce. Mountain hemlock grows only locally in northern Kenai Peninsula, where it comprises from 15 to 20 percent of mixed stands (J. W. Scott, personal communication, 1955). Western hemlock, an important component of the coastal forest elsewhere in Alaska, is not present in the Cook Inlet region. Sitka spruce is smaller in the Cook Inlet-Kenai Peninsula region than in the coastal areas to the southeast and is comparable in size to white spruce.

In southwestern Kenai Peninsula, Sitka spruce forest grades northward into the interior spruce and birch forest. Along the line shown on the map separating the two types, the forest is a mixture of Sitka and white spruce, which also have hybridized; the hybrid has characteristics between the two parent species (Little, 1953).

WESTERN RED CEDAR

Pure western red cedar stands of limited distribution grow on moist slopes and in lowlands along the coasts of southeastern Alaska and British Columbia (Soc. Am. Foresters, 1954, p. 53). Western red cedar is more extensive southward toward Washington, and its presence in Alaska is noted because of its commercial importance. Trees are large, reaching heights of more than 150 feet and trunk diameters of as much as 6 feet. They are spaced from 50 to 75 feet apart, making an extremely dense forest (Canada, 1950, p. 73, 76).

ALDER AND BLACK COTTONWOOD

Red alder and black cottonwood form extensive stands on well-drained lowlands throughout the coastal forests and are most prominent on recently deposited alluvium and glacial materials (Cooper, 1933). Alder and cottonwood each form pure stands; and even though each type may occupy a small area and both are replaced by Sitka spruce, the two species generally do not intermingle. Alder commonly invades surfaces exposed by avalanches on steep slopes, where it persists for long periods of time and forms dense stands.

The Society of American Foresters (1954, p. 50–51) has separated stands of the two species, describing them as red alder and a type composed of black cottonwood and willow. Because both grow in similar environments and are successional types, they are discussed here together.

LODGEPOLE PINE AND MOUNTAIN HEMLOCK

On poorly drained upland sites underlain by peat deposits, bent and malformed mountain hemlock grows both as isolated individuals and in scattered dense thickets. As far north as Skagway, lodgepole pine and a small number of Alaska cedar are associated with the hemlock in the bogs (Heintzlemann, 1928).

COASTAL TIMBERLINE FORESTS

From Skagway southeastward, trees of commercial value extend from sea level to an altitude of about 1,500 feet (Heintzlemann, 1928). Because of local relief from Yakutat Bay to Kenai Peninsula, most commercial forests are limited to coastal lowlands and are less extensive than in the area from Skagway southeastward. Trees of lesser or no commercial value grow at altitudes from 1,500 to 3,500 feet in coastal southeastern Alaska and British Columbia. Western hemlock and white spruce are the timberline species from Kenai Peninsula to the mouth of Copper River. Southeast of Skagway, mountain hemlock, apline fir, and scattered Alaska cedar grow at timberline.

ENGELMANN SPRUCE AND LODGEPOLE PINE FOREST REGION

The small area of Engelmann spruce and lodgepole pine in British Columbia is the northwestern limit of two somewhat extensive Rocky Mountain forest types. In the area shown on the map, the forest consists of relatively open Engelmann spruce on the mountain slopes and local admixtures of lodgepole pine. In places lodgepole pine forms pure stands. Locally, aspen and white birch have invaded burned-over spruce. Alpine fir is generally the only tree species at timberline, which is at an altitude of about 5,000 feet (Halliday, 1937).

TREELESS REGION

The region mapped as treeless includes several types of vegetation and several kinds of ground. Barren bedrock and rubble, and treeless vegetation characterize the land surface. The vegetation in this region consists of four major types: (*a*) Rock desert plant communities cover only a small fraction of the surface, which is dominated by rubble or gravel. They predominate in areas of high altitude and

also are common near sea level where the bedrock is exposed or rubble is at the surface; (*b*) tundra plant communities consist of types in which the plants dominate the surface; these communities are mixtures of herbaceous and shrubby plants that form the most common types of vegetation in the treeless region (pl. 11). They are characteristic of surfaces underlain by fine-grained soil materials. (*c*) Strand communities grow along the coasts; and (*d*) meadow plant communities are peculiar to parts of the Aleutian Islands and Bering Sea coast areas; this classification has been modified after Porsild (1951b, p. 12).

The patterns of Seward Peninsula outlined on the map, along the Kobuk River Valley and around Healy, Alaska, are areas in which the listed vegetation is predominant. Within any pattern other types are present, but generally occupy too small an area to map at this scale. Herbaceous tundra in the area consists mostly of cottongrass tussock, birch, and heath vegetation on poorly drained uplands and sedge sod in sluggish drainage channels and bogs. Shrub tundra consists of thickets of willow species, alder, and large dwarf birch and heaths. Shrub tundra grows on better drained soils, such as those on stream banks and hillsides mantled with silt and coarser materials. It grows within the area mapped as herbaceous tundra primarily along stream and lake banks. Herbaceous tundra grows in the areas mapped as shrub tundra and rock desert on all poorly drained soils. More detailed descriptions of these types and their relation to the environment have been described (Hopkins and Sigafoos, 1951; Hopkins and Sigafoos, 1954; Sigafoos, 1951; Sigafoos, 1952; and Sigafoos and Hopkins, 1952).

The vegetation of St. Lawrence Island was compiled from the interpretation of aerial photographs. W. S. Benninghoff (personal communication, 1956) states that most of the herbaceous tundra is composed of a discontinuous sedge sod, scattered low woody plants, and herbaceous dicotyledonous plants. Complete sedge sods grow on the wettest soils.

Bedrock is characteristic of extensive areas in the region and are completely void of plants. Barren bedrock is also characteristic of much of the surface at high altitudes of the Brooks and Alaska Ranges; outcrops of bedrock at lower altitudes are also barren.

GEOGRAPHIC DISTRIBUTION OF PROMINENT TREE SPECIES

The presence of a species at any particular site is determined by local environmental factors only if the site is within the present distributional range of the species. Thus, to understand the significance of the forest types, it is necessary to consider the distributional ranges of the dominant tree species (fig. 32). Of the approximately 15 tree

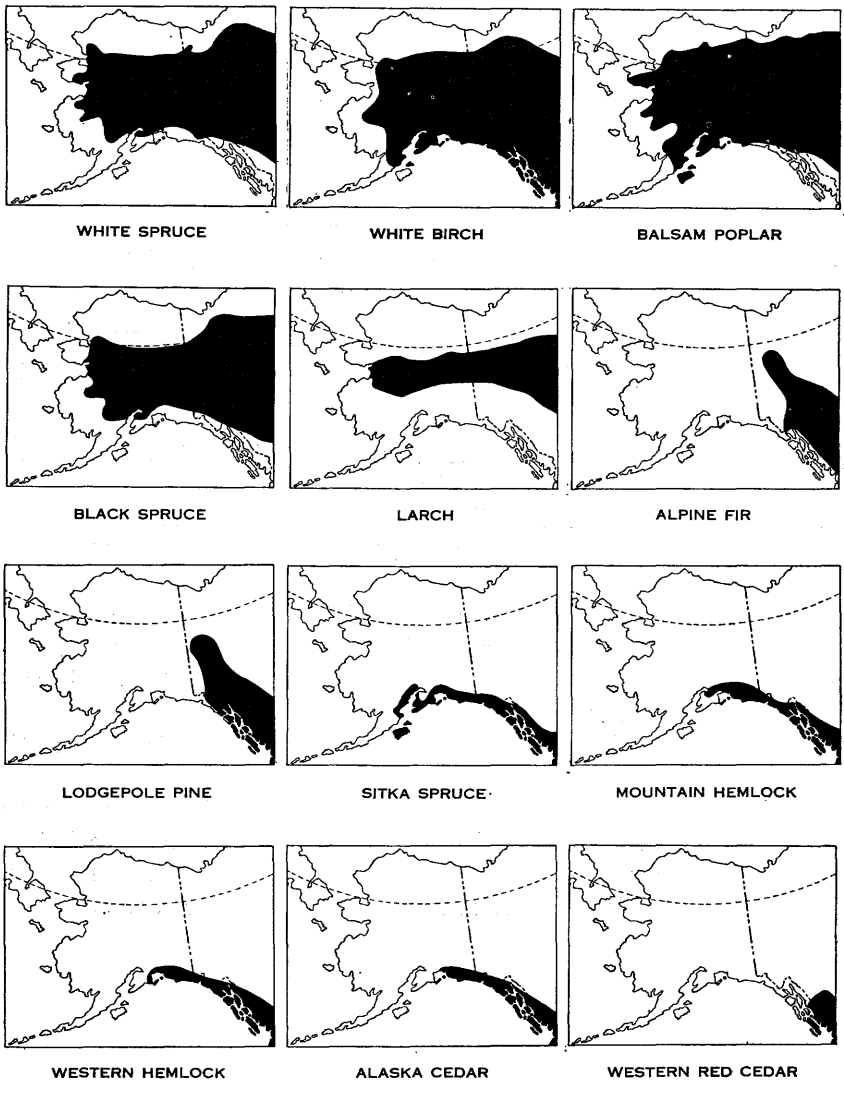


FIGURE 32.—Distribution of 12 common species of trees.

species that grow in the mapped area, the ranges of the 12 most common ones were compiled from the following sources: Canada (1950); Hultén (1941); Porsild (1951a); Raup and Denny (1950); Spetzman (Minnesota Univ. unpublished thesis, 1951); and Taylor and Little (1950).

Several species have been eliminated from consideration owing to their apparently temporary existence in forest development. Aspen, alders, and willows fill this role on most uplands in the interior spruce and birch forest, and in the coastal spruce and hemlock forest. Lodgepole pine in Yukon and British Columbia, possibly a component of a temporary forest type, is included. Black cottonwood, characteristic of well-drained lowlands in the coastal spruce and hemlock forest, is not included because cottonwood forests are succeeded by Sitka spruce. The range of Pacific silver fir nearly coincides with that of western red cedar in Alaska; therefore, silver fir has not been included.

The interior spruce and birch forest at its western limit consists generally of white spruce and local stands of balsam poplar. Although balsam poplar grows beyond the western and northern limits of white spruce, the limit of the forest is considered to coincide with the distribution of spruce. Eastward, the number of species increases; black spruce and white birch being the first additional species found. Larch grows only in the central part of the forest zone. Alpine fir and lodgepole pine grow farther eastward in the Canadian mountains.

Sitka spruce is the only representative of coastal forest tree species at the western limit of the coastal forest. Eastward and southward, mountain hemlock is followed in order by Alaska cedar and western red cedar. The southern limit of white spruce in Alaska overlaps part of the ranges of coastal forest types. The distributional range of white birch, which is considered a characteristic tree of the interior forest, overlaps nearly all ranges of the coastal forest tree species in the region covered by the map.

Although some tree species are common to both forest zones mentioned, other species and tree forms are so strikingly dissimilar that separation of them as distinctive units is justified.

LIST OF SPECIES

Common name	*Latin name*
Alaska cedar	*Chamaecyparis nootkatensis* (Donn) Spach
Alder	*Alnus* sp.
Alpine fir	*Abies lasiocarpa* (Hooker) Nuttal
Aspen	*Populus tremuloides* Michaux
Balsam poplar	*balsamifera* Linnæus
Black cottonwood	*trichocarpa* Torrey and Gray

Common name	*Latin name*
Black spruce	*Picea mariana* (Miller) Britton, Sterns, and Poggenburg
Cottongrass	*Eriophorum vaginatum* Linnæus *angustifolium* Honckeny
Devilsclub	*Oplopanax horridus* (Smith) Miquel
Dwarf birch	*Betula nana* Linnæus
Engelmann spruce	*Picea engelmannii* Parry
Heath	*Vaccinium* sp.
Larch	*Larix laricina* (DuRoi) K. Koch
Lodgepole pine	*Pinus contorta* Douglas
Mountain hemlock	*Tsuga mertensiana* (Bongard) Carriére
Pacific silver fir	*Abies amabilis* (Douglas) Forbes
Red alder	*Alnus rubra* Bongard
Sedge	*Carex aquatilis* Wahlenberg
Sitka spruce	*Picea sitchensis* (Bongard) Carrière
Western hemlock	*Tsuga heterophylla* (Rafinesque) Sargent
Western red cedar	*Thuja plicata* Donn
White birch	*Betula papyrifera* Marshall and varieties
White spruce	*Picea glauca* (Moench) Voss
Willow	*Salix* sp.
Yew	*Taxus Brevifolia* Nuttal

REFERENCES CITED

Benninghoff, W. S., 1957, Quarternary vegetation of central Alaska: Internat. Botany Cong., 8th, Paris, 1954, Proc. (abstract).

Canada, Department of Resources and Development, 1950, Native trees of Canada: Canada Dept. Resources and Devel. Bull. 61, p. 1–293.

Cooper, W. S., 1933, The recent ecological history of Glacier Bay, Alaska: Ecology, v. 4, p. 93–128; 223–246; 355–365.

Halliday, W. E. D., 1937, A forest classification for Canada: Canada Forest Service Bull. 89, p. 1–50.

Hansen, H. P., 1953, Postglacial forests in the Yukon Territory and Alaska: Am. Jour. Sci., v. 251, p. 505–542.

Harrington, G. L., 1918, The Anvik–Andraefski region, Alaska: U. S. Geol. Survey Bull. 683, 70 p.

Heintzleman, B. F., 1928, Pulp-timber resources of southeastern Alaska: U. S. Dept. Agriculture Misc. Pub. 41, 72 p.

Heusser, C. J., 1955, Pollen profiles from Prince William Sound and southeastern Kenai Peninsula, Alaska: Ecology, v. 36, p. 185–201.

Hopkins, D. C. and Benninghoff, W. S., 1953, Evidence of a very warm Pleistocene interglacial interval on Seward Peninsula, Alaska: Geol. Soc. America Bull., v. 64, p. 1435–1436.

Hopkins, D. M. and Karlstrom, T. N. V., 1955, Permafrost and ground water in Alaska: U. S. Geol. Survey Prof. Paper 264–F, p. 113–146.

Hopkins, D. M. and Sigafoos, R. S., 1951, Frost action and vegetation patterns on Seward Peninsula, Alaska: U. S. Geol. Survey Bull. 974–C, p. 51–100.

——— 1954, Role of frost thrusting in the formation of tussocks: Am. Jour. Sci., v. 252, p. 55–59.

Hultén, Eric, 1941, Flora of Alaska and Yukon: Lunds Univ. Arssk. band 37, no. 1, pt. 1, p. 1–127.

Hustich, Ilmari, 1953, The boreal limits of conifers, v. 6, p. 139–62.

Little, E. L., Jr., 1953, A natural hybrid spruce in Alaska: Jour. Forestry, v. 51, p. 745–747.

Livingstone, D. A., 1955, Some pollen profiles from Arctic Alaska: Ecology, v. 36, p. 587–600.

Lutz, H. J., 1953, The effects of forest fires on the vegetation of interior Alaska: Alaska Forest Research Center Station Paper 1.

——— 1956, Ecological effects of forest fires in the interior of Alaska: U. S. Dept. of Agriculture Tech. Paper 1133, p. 1–121.

Porsild, A. E., 1951a, Botany of southeastern Yukon adjacent to Canol Road: Canada Nat. Mus. Bull. 121, p. 1–100.

——— 1951b, Plant life in the Arctic: Canada Geog. Jour., v. 43, no. 3, p. 1–27.

Raup, H. M., 1945, Forests and gardens along the Alaska Highway: Geog. Rev., v. 35, p. 22–48.

——— 1947, The botany of southwestern Mackenzie: Sargentia VI, p. 1–275.

——— 1951, Vegetation and cryoplanation: Ohio Jour. Sci., v. 51, p. 105–116.

Raup, H. M., and Denny, C. S., 1950, Photo interpretation of the terrain along the southern part of the Alaska Highway: U. S. Geol. Survey Bull. 963–D, p. 93–135.

Sigafoos, R. S., 1951, Soil instability in tundra vegetation: Ohio Jour. Sci., v. 51, p. 281–298.

——— 1952, Frost action as a primary physical factor in tundra plant communities: Ecology, v. 33, p. 480–487.

Sigafoos, R. S., and Hopkins, D. M., 1952, Soil instability on slopes in regions of perennially frozen ground, *in* Frost action in soils—A symposium: Natl. Research Council Pub. 213, Highway Research Board Special Rept. 2, p. 176–192.

Smith, P. S., and Mertie, J. B., Jr., 1930, Geology and mineral resources of northwestern Alaska: U. S. Geol. Survey Bull. 815, 351 p.

Society of American Foresters, 1954, Forest cover types of North America—Report of the Committee on Forest Types: Soc. Am. Foresters, p. 1–67.

Taylor, R. F., 1932, The successional trend and its relation to second-growth forests in southeastern Alaska: Ecology, v. 13, p. 381–391.

Taylor, R. F. and Little, E. L., Jr., 1950, Pocket guide to Alaska trees: U. S. Dept. Agriculture Handb. 5, p. 1–63.

INDEX