SILVICAL CHARACTERISTICS of SITKA SPRUCE

by ROBERT H. RUTH

SILVICAL SERIES - NO.8

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
R. W. COWLIN, DIRECTOR

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

PORTLAND, OREGON

OCTOBER 1958

CONTENTS

COVER: A stand of Sitka spruce on the Oregon Coast about one-eighth mile from the ocean. Most of the trees are from 30 to 40 inches in diameter.

SILVICAL CHARACTERISTICS OF SITKA SPRUCE

by

Robert H. Ruth

Willamette Research Center[1/]

Sitka spruce (Picea sitchensis)[2/] is the largest of the native spruces and a major timber and pulpwood tree of the Pacific Coast. The name Sitka, referring to Sitka, Alaska, and the names coast spruce, tideland spruce, and yellow spruce (11)[3/]--sometimes used for this species--are descriptive of its range, which is restricted to a long, narrow strip along the Pacific Ocean from California to Alaska (fig. 1). The range is over 1,800 miles long, yet so closely correlated with the coastal fog belt that it extends inland only a short distance. Width varies to a maximum of about 130 miles in Alaska, which is the distance from the western shore of the islands to the limit of the type on the sea slope of the coastal mountains. Moving south the range generally narrows but is very irregular, with spruce reaching many miles up coastal streams. Maximum width in Washington and Oregon is 25 to 30 miles, except for narrow strips up coastal streams. In California, the range of Sitka spruce is restricted to the mouth of streams and low valleys facing the ocean (12, 19).

[1/] Maintained at Corvallis in cooperation with the School of Forestry, Oregon State College.

[2/] Scientific and common names of trees in this publication follow: Little, Elbert L., Jr. Check list of native and naturalized trees of the United States (including Alaska). U.S. Dept. Agr. Handb. 41, 472 pp. 1953.

[3/] Underscored numbers in parentheses refer to Literature Cited.

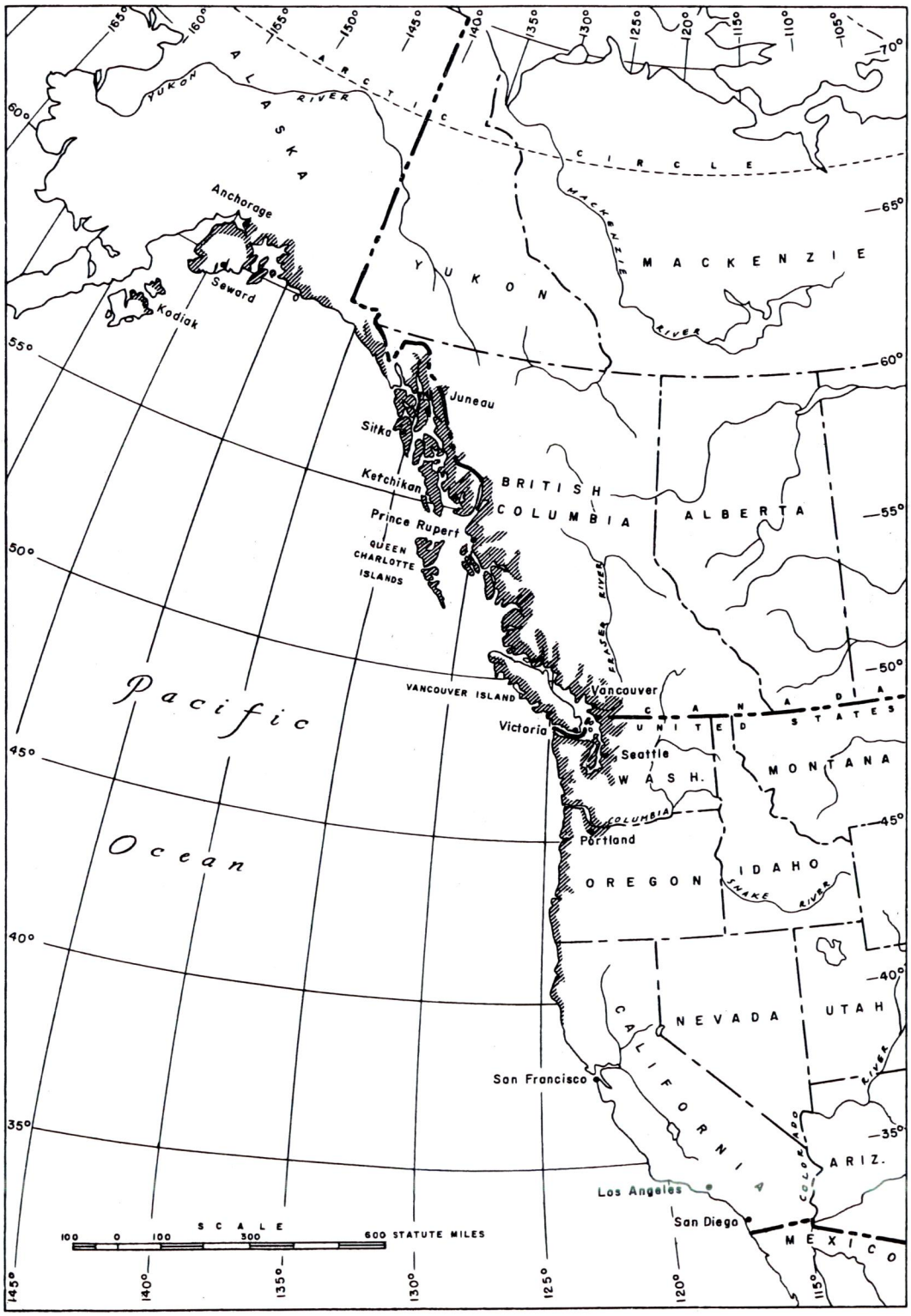

Figure 1.--Range of Sitka spruce.

HABITAT CONDITIONS

Climatic

Sitka spruce forests grow in a superhumid climate (22) greatly influenced by the prevailing westerly winds from the Pacific Ocean. Weather is characterized by equable temperatures, high precipitation, absence of extreme winter cold, and prolonged cloudiness (table 1).

The summer dry season, so common in the West, is not pronounced in the coastal strip because of frequent summer fogs that often develop into light rain or drizzle. This summer precipitation increases as one moves northward in the Sitka spruce belt. But in spite of the long north-to-south distribution of the species, climatic variations are not great because of the stabilizing influence of the North Pacific. Equable but moist winds from the ocean temper extremes of weather and bring high precipitation so characteristic of spruce forests. In addition, the shorter growing season in the north is partly offset by long summer days.

As distance from the ocean increases, climate is strongly influenced by differences in altitude, by mountain barriers, and by local topography. Precipitation on the west slopes of coastal mountains increases rapidly with elevation and a greater percentage falls as snow. Along the southern coast of Alaska, winter precipitation near tidewater is mostly rain; above 600 feet elevation, however, snowfall is common and the snowpack reaches great depths (8).

Westerly winds from the Pacific are also important from the standpoint of blowdown; they often reach velocities capable of uprooting or breaking mature trees. Each year wind takes a toll, and several extensive blowdowns have occurred, such as the Olympic blowdown in 1921 and the southern Oregon blowdown in 1951. Storm winds are usually accompanied by heavy rains--a tough combination for trees to withstand. Spruce trees in severely exposed places and at high elevations near timberline are dwarfed, sprawling, or even prostrate and do not reach merchantable size or form.

Sitka spruce reaches maximum development on the Olympic Peninsula of Washington and on the Queen Charlotte Islands of British Columbia. In these two areas, rain forests of Sitka spruce and western hemlock (Tsuga heterophylla) grow under what are believed to be the best forest growth conditions on the North American continent.

Table 1.--Climate of the commercial range of Sitka spruce[1/]

Location	Elevation	Average precipitation		Temperature					Average annual frost-free period
				Average			Absolute		
		April-Sept.	Annual	Annual	Jan.	July	Max.	Min.	
	Feet	Inches		Degrees F.					Days
Alaska:									
Seward	76	28.4	73.7	39.5	22.4	55.3	82	-20	132
Cordova	40	65.5	145.4	38.6	27.2	54.8	87	-19	149
Sitka	15	34.7	87.1	45.6	32.4	54.9	87	- 5	159
Wrangell	37	31.0	83.0	43.9	29.0	58.2	92	- 6	169
Ketchikan	0	57.5	150.9	46.4	32.6	57.5	96	- 8	165
British Columbia:									
Masset	30	20.8	53.9	45.6	35.8	58.1	84	- 2	169
Vancouver	136	15.9	58.7	49.0	35.6	63.3	92	2	219
Washington:									
Quinault	220	29.9	128.6	50.9	38.4	63.5	104	11	208
Aberdeen	135	18.7	82.9	49.9	39.2	59.6	105	6	191
Oregon:									
Astoria	220	17.0	77.5	51.2	40.3	60.9	97	10	273
Newport	155	15.0	66.2	50.9	43.7	56.8	100	1	248

1/ Compiled from U. S. Weather Bureau records and from weather records of the Department of Agriculture, British Columbia.

Edaphic

Sitka spruce grows in soils of several different parent materials. However, since the species is restricted to a narrow strip along the coast, the soils are fairly similar in development. Spruce grows best on deep, medium-textured, moist but well-drained soils. It also does well on coarse-textured soils if moisture is adequate. Soils on which spruce grows are usually high in organic matter, containing as much as 20 percent in surface horizons. Many areas, particularly in Alaska, have thick accumulations of raw humus or moss.

In the northern part of its range, Sitka spruce is often found on coarse-textured, thin soils and on wet, rocky slopes facing the sea. However, it grows poorly on these areas unless the rock structure is fractured to permit root penetration into crevices. On thin soils, western redcedar (Thuja plicata) and Alaska-cedar (Chamaecyparis nootkatensis) often make up a large part of the forest stand. In Alaska, soil drainage is a critical factor and growth is poor on swampy sites except where ground water is moving.

In the south, Sitka spruce is usually restricted to alluvial soils or sandy bottoms along streams. It does well on poorly drained soils but does not produce the high volumes per acre characteristic of better growing conditions. On poorly drained soils the root system spreads over a wide area resulting in fewer and poorer quality stems per acre.

Spruce follows lodgepole pine (Pinus contorta) in invasion of coastal sand dunes as they become stabilized by lesser vegetation, and on peat bogs as they mature. In many areas, Sitka spruce eventually gives way to hemlock as more humus is formed (7). It often maintains dominance, however, in situations where the supply of aerated water is large and constant (3). Some of the better soils for Sitka spruce in Oregon and Washington include the Astoria and related series. Values of pH from 4.0 to 5.7 are typical of soils supporting spruce stands.

Physiographic

Physiography has an important influence on occurrence of Sitka spruce. As moist winds from the Pacific flow up the slopes of coastal mountains, moisture falls in the form of rain or snow and creates a superhumid climate typical of Sitka spruce forests. On lee slopes of mountains, precipitation drops off rapidly and spruce soon

gives way to other species. In Oregon, for example, Sitka spruce is common on the west slope of the Coast Range; on the east slope it is replaced by species that can survive the dry summer season better.

In Alaska, Sitka spruce occurs in a relatively narrow coastal strip along the mainland, forms a band around the innumerable islands, and penetrates inland in the valleys. In the northern and western part of its range, commercial stands of Sitka spruce extend from tidewater to about 1,000 feet elevation. Spruce forests are by no means continuous over large areas, however; numerous patches of stunted trees and untimbered bogs of peat moss are common. Moving south, both quantity and quality of timber increase and the species grows at higher elevations, reaching 2,000 to 3,000 feet in southeastern Alaska. As would be expected, however, trees growing at higher elevations are poorer in quality, and volumes per acre are less than at lower elevations. In southeastern Alaska, the mountains rise abruptly from the shore so that a strip of timber extending to 3,000 feet in elevation is usually all within sight of tidewater. In fact, timbered areas are seldom found more than 5 to 6 miles inland and three-fourths of the commercial stands are estimated to be within 2-1/2 miles of tidewater (8). In altitudinal distribution, Sitka is unique among the spruces: other species occur mostly at higher elevations (25).

Still further south, in British Columbia, both density and quality of timber continue to improve. Here, however, Sitka spruce is seldom found at elevations exceeding 1,000 feet; the highest on record is 2,500 feet. Again, timber quality is poorer at the higher elevations. Sitka spruce reaches its maximum development in the Queen Charlotte Islands of British Columbia and in northwestern Washington, where trees 250 feet high and 10 feet in diameter are not uncommon (4). Continuing south through southwestern Washington and western Oregon to northern California, the spruce belt gradually narrows, and timber quality decreases. The upper elevational limits also gradually decrease until, in northern California, merchantable trees can only be found in narrow strips along coastal streams.

Biotic

The most common associate of Sitka spruce is western hemlock. In fact, spruce grows in mixture with hemlock over most of the spruce range and is found in pure stands only on a relatively small part of the area. Sitka Spruce—Western Hemlock Type 225 (18) is the major forest type of coastal Alaska, where there are vast areas of virgin stands. Stands on the Tongass National Forest in southeastern Alaska

are estimated to contain 61 percent western hemlock, 30 percent Sitka spruce, 5 percent western redcedar and Alaska-cedar, and 4 percent other softwoods. The cedars usually occur in small patches on the wetter soils (8).

Douglas-fir (Pseudotsuga menziesii) becomes an associate of Sitka spruce beginning at latitude 53° N. and extending south into California. The proportion of Douglas-fir increases in the eastern part of the spruce belt as the climate becomes warmer and drier. Lodgepole pine is another common associate throughout the range of spruce, particularly near peat bogs and sand dunes, where lodgepole precedes spruce in invasion of these areas. Other associates include red alder (Alnus rubra), mostly along streams but often encroaching as a subclimax type on cutover or burned-over land; Pacific silver fir (Abies amabilis), at higher elevations in Oregon and Washington and at lower elevations in British Columbia; the white spruce (Picea glauca)—birch (Betula spp.) type and the mountain hemlock (Tsuga mertensiana)—subalpine fir (Abies lasiocarpa) type, both in Alaska; Port-Orford-cedar (Chamaecyparis lawsoniana), in southwestern Oregon; and redwood (Sequoia sempervirens), in northern California (18, 19). Associated trees of little commercial value include vine maple (Acer circinatum) and willow (Salix spp.).

Pure Sitka spruce stands are not uncommon, however, with Sitka Spruce Type 223 being particularly well defined at the extreme northern and southern limits of hemlock and other associates. Pure spruce stands often become established and grow very well on bare mineral soil following destruction of existing vegetation by fire, landslide, or other catastrophe, and--in Alaska--following glacial recession.

Several shrubs typical of Sitka spruce stands are very important competitors during seedling establishment and early growth. These include salmonberry (Rubus spectabilis),[4/] western thimbleberry (Rubus parviflorus), Pacific red elder (Sambucus callicarpa), rusty menziesia (Menziesia ferruginea), devilsclub (Oplopanax horridus), salal (Gaultheria shallon), and several species of Vaccinium, which are commonly called huckleberries in the Pacific Northwest.

[4/] Scientific and common names of shrubs and herbs in this publication follow: Kelsey, Harlan P., and Dayton, William A. Standardized plant names. Ed. 2, 675 pp. Harrisburg, Pa. 1942.

Sitka spruce trees growing in areas with more than average fog and mist often have moss-covered branches. This is characteristic of trees on Graham Island, British Columbia (3).

LIFE HISTORY

Seeding Habits

Flowering and fruiting.--The reproduction cycle of Sitka spruce starts in the fall with formation of male and female flower buds borne separately on the same tree. These buds remain inconspicuous until they start to swell in the spring.

In the central and southern part of the range, flowering occurs in late March and April. Staminate buds, produced in large numbers near the ends of lateral branchlets, develop into conspicuous rose-red flowers from 3/4 to 1-1/2 inches long and about 1/2 inch in diameter. Pistillate flowers are borne on the ends of the primary branches and are erect, yellowish green (often tinged with red), and about an inch long and a half inch thick. Pollen shedding begins the last week in April along the central Oregon Coast and ends the latter part of May. After pollination the small cones turn down; slowly lose their red appearance, except sometimes on the side near the sun; and develop into mature pale yellow to reddish-brown cones 2-1/2 to 4 inches long. Cones begin to open in late September.

In southeastern Alaska, seed development is completed in a shorter period, probably because of longer summer days. Staminate flowers are produced in May and pollen shedding begins from mid-May to late May. Seeds ripen about mid-September.

Seed production and dissemination.--Sitka spruce is generally considered a prolific seed producer, with a good crop of cones every 3 to 4 years and light crops intervening. Seed crop failures are uncommon. Seed production starts in 20- to 40-year-old stands with a few cones in the upper crowns. Open-grown trees produce more seed and start seed production a few years earlier. Production increases with age of stand and reaches a maximum on mature dominant or open-grown trees.

In Alaska, seed production is apparently not as good as it is farther south, with a greater interval between seed crops and crop failures more common. Conditions for seed production are generally less favorable at higher elevations and in the more northern latitudes.

Observations on the central Oregon Coast from 1949 through 1952 (14) indicated that seed fall in this area starts during the last 10 days in October and is triggered by the first dry easterly winds that occur during this period. Drying winds earlier in the month fail to advance the beginning date. The first day's fall is usually very heavy and dissemination during these short dry periods is from east to west. When drying winds fail to occur, only a few seeds fall during October; the main crop falls later and is disseminated from southwest to northeast. Fifty percent of the viable seed crop is normally on the ground by mid-November and 90 percent by about February 1. Some seed falls as late as April and May.

Small clear-cut tracts harvested under the staggered-setting pattern received an abundant and well-distributed supply of seed from surrounding green timber. The central Oregon Coast study further showed that seed fall under dense timber is 15 times greater than on clear-cut tracts and that spruce is not as prolific a seed producer as its most common associate, western hemlock. Western hemlock has also been reported to be a more prolific seed producer in British Columbia.

Sitka spruce seed is small, averaging 210,000 cleaned seeds per pound (23). Average rate of fall in still air has been calculated to be 3.1 feet per second (17).

Several climatic and biotic factors may interrupt the reproductive cycle between flower bud formation and seed dissemination. Storm winds may whip off branchlets during winter, abnormal frosts may interfere with flower growth in spring, and prolonged heavy rains may hinder pollination. One insect, a seed chalcid (Megastigmus piceae), feeds on and destroys the tissue within Sitka spruce seeds in Oregon and California. In some cases a high percentage of the seed crop has been ruined by this insect. Also, two species of cone moths have been identified working in spruce cones. These are Laspeyresia youngana and Heinrichia fuscodorsana (9). When cones are almost mature, chipmunks (Tamias spp.) and squirrels (Tamiasciurus spp.) begin clipping them from trees and cache them away for the winter. In light seed years these rodents can destroy much of the crop. After seed dissemination they consume seed on the ground, but at this stage mice (primarily Peromyscus spp.) and shrews (Sorex spp.) account for most of the loss. The percentage of seed normally consumed by rodents is unknown, but it is probably an important amount, particularly in light seed years.

Vegetative Reproduction

Vegetative reproduction is uncommon. Sitka spruce does not sprout from stump or root. Layering has been known to occur but is not used in management of the species. Spruce cuttings have been successfully rooted in the greenhouse (10).

Seedling Development

Establishment. --Sitka spruce seed will germinate on almost any kind of seedbed if moisture is abundant, but germination is best in mineral soil with side shade and overhead light. Seedlings also establish themselves on organic seedbeds such as rotten wood, duff, or moss. In Alaska, however, moss and organic layers become very thick and form a seedbed in which moisture fluctuates greatly. Heavy seedling mortality occurs during dry spells, even when they are of short duration. At the same time the moss acts as a barrier preventing the spruce seed from reaching a more favorable seedbed (5). On most organic seedbeds, western hemlock germinates and survives better than Sitka spruce. Spruce has an advantage over hemlock, however, on bare soil and gravel banks, and the percentage of spruce reproduction can be increased by exposing more mineral soil during logging (6, 12). If the soil is fine textured, some seedling losses may result from frost heaving.

In Alaska, low temperatures during the growing season are apparently a limiting factor, and seedling survival and growth are better on south than on north slopes. Farther south, moisture becomes a limiting factor. The downward growth of roots of spruce seedlings on south slopes cannot keep pace with the desiccation of the soil during dry periods. At the end of the first growing season, the initial root system consists only of a few lateral roots often 4 inches or more long and spread out 1 to 3 inches under the soil surface. In this situation, seedling survival is better on north slopes.

Most Sitka spruce stands are harvested by clear cutting. Clear-cut areas are usually limited to about 80 acres in size, with green timber left on the surrounding area as a seed source. Since Sitka spruce is a tolerant tree and germinates and survives on a wide range of seedbeds, natural regeneration can be obtained by other silvicultural systems such as strip or shelterwood cutting or individual tree selection. Shelterwood and selective cutting, and thinnings as well, must be made with caution to avoid excessive wind damage.

Light cuts in mixed stands favor western hemlock reproduction because of its greater tolerance.

Early growth.--Probably the major obstacle to seedling growth is competition from other vegetation, particularly the woody plants--such as salmonberry and thimbleberry--that are commonly associated with Sitka spruce. The most acute problem is in moist locations near creeks where timber stands are often understocked and support a dense brush understory. In such situations, vegetative competition is believed to have contributed to poor stocking in the original stand. Removal of the overstory exposes the shrubs to full sunlight and they often grow rankly and soon dominate the site. Without silvicultural treatment only a few trees become established in these brush patches. Tree seedlings that survive are almost invariably growing on rotten wood, where shrub growth is inhibited. Silvicultural practices favoring seedling survival include (1) destroying as many brush plants as possible during logging, (2) burning slash to retard brush development, (3) planting trees to give them a head start over the brush, and (4) releasing trees being overtopped by brush (13).

Competition from red alder is another important obstacle to early growth. Alder quickly becomes established on cutover areas, particularly along creeks and on tractor roads, truck roads, and landings. It encroaches on benches and flats and sometimes on steep slopes where it was not even a minor component of the stand before logging. Because of rapid initial height growth, it overtops spruce seedlings and soon dominates the site. Red alder also often outgrows planted spruce during early development. Silvicultural practices recommended for alder control include (1) eliminating the alder seed source during logging, (2) slashing the competing alder seedlings, and (3) chemically controlling competing seedlings with foliage or basal sprays (15).

Browsing by deer (Odocoileus hemionus) sometimes retards seedling establishment. However, deer prefer hemlock, Douglas-fir, and the cedars to Sitka spruce and browsing of spruce seedlings has not been a serious problem.

Bud bursting of Sitka spruce begins in mid-April in Oregon, late April in Washington, and mostly in May in British Columbia and Alaska. Height growth continues well into the summer.

Sapling Stage to Maturity

Growth and yield.--Sitka spruce is a vigorous, fast-growing tree that readily overtops associated western hemlock and cedars to occupy the dominant position in the stand. The ideal "rain forest" from the standpoint of maximum volume and value is probably a well-stocked spruce-hemlock stand, with the larger and taller spruce occupying the dominant position in a canopy interspersed with codominant and intermediate hemlock. Spruce seldom survives as an understory to hemlock, but hemlock does very well as an understory to spruce (20). One yield plot in a 147-year-old stand in coastal Oregon contained 76 spruce trees averaging 34.3 inches in diameter and 210 feet in total height, and 13 hemlocks averaging 18.1 inches in diameter and 144 feet in height. Total volume per acre was 34,003 cubic feet or 261,284 board-feet (International 1/8-inch rule). Based on the Sitka spruce in the stand, site index was 174. Growth data for pure spruce stands are scarce, most measurements having been made in spruce-hemlock mixtures. On the best sites, mean annual gross growth of well-stocked spruce stands is about 2,000 board-feet (International) per acre at a rotation age of 80 to 90 years.

Old-growth Sitka spruce trees are very impressive, with swollen and buttressed bases and straight clean boles reaching up as high as 285 feet (fig. 2). In Alaska, average diameter of mature trees is 5 feet, with a maximum of 8 feet or more. In British Columbia, Washington, and Oregon, trees 10 feet in diameter are frequently found; the largest Sitka spruce on record has a diameter of 16.4 feet and is located on the Olympic Peninsula (1).

Root development is variable, but Sitka spruce is generally considered shallow-rooted and susceptible to windthrow. In climax forests of southeastern Alaska, root penetration of spruce and hemlock into mineral soil averaged 6.5 inches in areas with good drainage. In poorly drained areas, it stopped in the thick organic horizons 10 inches above mineral soil (6). In contrast, Sitka spruce roots have been found at depths greater than 6 feet in deep, well-drained alluvial soils on the Queen Charlotte Islands of British Columbia (3).

Reaction to competition.--Sitka spruce is classed by Baker (2) as tolerant, placing it in the second of five tolerance classes. Its closest associate, western hemlock, is classed as very tolerant and placed at the top of the tolerance list of western conifers. Western redcedar is also more tolerant than Sitka spruce, but spruce is

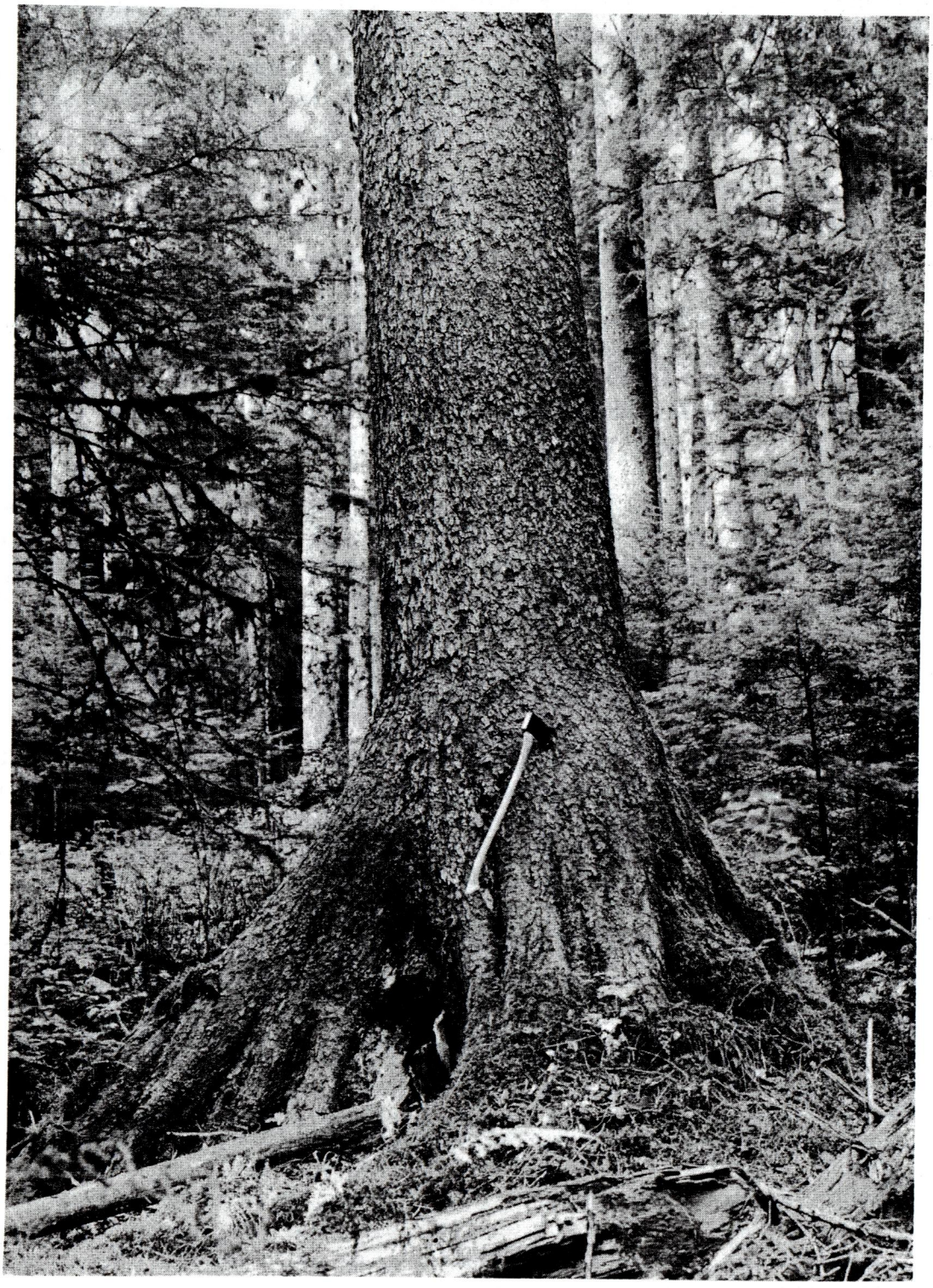

Figure 2.--An old-growth Sitka spruce in Alaska, showing characteristic basal swell.

considerably more tolerant than Douglas-fir. Pure spruce stands are essentially a subclimax type, eventually being replaced by the Sitka spruce—western hemlock or the western redcedar—western hemlock climax. The spruce—hemlock mixture is considered a climax type but with the qualification that hemlock is the more stable of the two species. Mixed stands of spruce—hemlock may originate as an even-aged stand following fire or other catastrophe, or they may result when hemlock originates as an understory in a spruce stand and eventually replaces part of the spruce overstory (18). As even-aged spruce—hemlock stands reach maturity, the hemlock dies out first since few trees live more than 500 years. Sitka spruce, in contrast, which may live to an age of 700 to 800 years, often remains as a scattered overstory. Since new reproduction under the stand is predominantly western hemlock, this more tolerant species eventually dominates the site when the veteran spruces die.

Along the Oregon and Washington coasts, Sitka spruce is slowly replacing the less tolerant lodgepole pine, which is a pioneer tree species along the beach. A short distance inland, Sitka spruce may start as a pure stand but is usually invaded rapidly by western hemlock--particularly on the better drained soils--to form the widespread spruce—hemlock type. Farther inland, where there is less moisture, Sitka spruce is replaced by Douglas-fir.

In British Columbia, the spruce stands of the coast often merge with the western redcedar—western hemlock climax as they move inland. Farther from the coast and on higher and drier sites, Douglas-fir, Pacific silver fir, and grand fir (Abies grandis) slowly replace spruce in the stand (18).

In southeastern Alaska, the climax forests contain about 74 percent hemlock by volume compared to 20 percent spruce. Since spruce comes in best on exposed mineral soil, it will be favored by clear cutting, and second-growth stands are expected to contain about 50 percent spruce (21).

When alder stands become established on spruce sites, the more tolerant spruce comes up through and eventually replaces the alder canopy. This process, however, lengthens the rotation and the spruce stand is usually understocked and of poor quality. Sitka spruce that has been suppressed by alder or an overstory of other conifers responds well to release and grows vigorously.

Damaging agents.--Blowdown is a major problem. A survey in western Oregon revealed that storm winds in that area come from about S. 30° W. Ninety-three percent of blowdown on the borders of clear-cut areas was concentrated along northern and eastern boundaries. Losses were much heavier when these boundaries were located on the leeward side of ridges; that is, on north slopes. Spruce was more windfirm than hemlock. Silvicultural practices to minimize windthrow include (1) starting a clearcut at a natural opening and cutting progressive strips to windward, thus eliminating northern and eastern cutting boundaries, where most of the loss occurs; (2) when northern and eastern boundaries must be left, leaving them on windward slopes; and (3) locating windfirm cutting lines by avoiding shallow soils, soils with a high water table, and defective trees. Poorly stocked stands and patches of red alder make windfirm cutting boundaries (16).

Sitka spruce is very susceptible to decay following injury. In a study of partially cut stands in western Washington and western Oregon, 58 percent of the logging scars were infected. Brown crumbly rot, caused by the red belt fungus (Fomes pinicola), was the most destructive and most common, but 10 other rot fungi were identified. Penetration of decay was related to size and age of scar (24). To minimize decay, intermediate cuttings should be carried out by methods that will prevent serious logging injury to the boles and roots of reserve trees.

Spruce is also attacked by several species of insects that kill or damage large volumes of timber when their populations reach epidemic stages. Sitka spruce weevil (Pissodes sitchensis) attacks and kills terminal shoots of spruce. Trees 2 to 8 inches in diameter and 10 to 40 feet tall are most susceptible. The spruce aphid (Aphis abietina) has killed millions of feet of spruce in Oregon and Washington, particularly along the tidelands. The Sitka spruce beetle (Dendroctonus obesus) is considered a secondary enemy of this species but at times kills a considerable volume of timber (9).

SPECIAL FEATURES

Spruce is one of the few conifers that develops epicormic branches along the bole. Some branching is present, even in dense stands, and it increases materially when light is increased by removal of nearby trees (fig. 3). Some spruce along road rights-of-way develop a solid mass of new foliage from the base of the tree up

Figure 3.--Lower branches of these Sitka spruce trees died and broke off while trees were growing in a dense stand. Five years after cutting a telephone line right-of-way, new branches ranged up to 5 feet long.

to the crown. Any thinning designed to accelerate growth of clear wood on crop trees must be done with caution. In a dense stand, large limbs in the lower crown die and break off relatively early in the rotation. The branch stubs, however, are very resinous and remain on the stem for many years, delaying the production of clear lumber.

Sitka spruce is reasonably resistant--more so than western hemlock or Douglas-fir--to damage from herbicides in the concentrations commonly used for control of weeds and hardwoods growing in association with it. Good control of overtopping red alder can usually be obtained with aerial or ground sprays of the phenoxyacetic acid herbicides (2, 4-D and 2, 4, 5-T) without serious damage to the spruce, although some damage to leaders and upper crowns has been noted on exposed trees.

RACES AND HYBRIDS

No geographic races of Sitka spruce have been described. There is some range overlap with white spruce in Alaska and natural hybrids occur in that area. Hybrids between Sitka spruce and Engelmann spruce (Picea engelmannii) occur in Denmark, and crosses with Norway spruce (Picea abies) and Serbian spruce (Picea omorika) have been reported (25).

LITERATURE CITED

(1) American Forestry Association
1956. These are the champs. (Part 2.) Amer. Forests 62(4): 33-40, illus.

(2) Baker, Frederick S.
1950. Principles of silviculture. 414 pp., illus. New York, Toronto, etc.

(3) Day, W. R.
1957. Sitka spruce in British Columbia. Forestry Comn. Bul. 28. 110 pp., illus. London.

(4) Garman, E. H.
1953. Pocket guide to the trees and shrubs of British Columbia. Ed. 2. Brit. Columbia Forest Serv. Pub. B. 28, 102 pp., illus.

(5) Godman, R. M.
1953. Moss retards regeneration in southeast Alaska. U. S. Forest Serv. Alaska Forest Res. Ctr. Tech. Note 18, 1 p. (Processed.)

(6) _____ and Gregory, R. A.
1953. Physical soil characteristics related to site quality in climax stands of southeast Alaska. U. S. Forest Serv. Alaska Forest Res. Ctr. Tech. Note 17, 1 p. (Processed.)

(7) Hansen, Henry P.
1947. Postglacial forest succession, climate and chronology in the Pacific Northwest. Amer. Phil. Soc. Trans., New Ser., vol. 37, part 1, 130 pp.

(8) Heintzleman, B. Frank
1949. Forests of Alaska. U. S. Dept. Agr. Yearbook: 361-372, illus.

(9) Keen, F. P.
1952. Insect enemies of western forests. U. S. Dept. Agr. Misc. Pub. 273 (rev.), 280 pp., illus.

(10) Larsen, C. Muhle
1955. The seasonal variation in the natural rooting capacity of cuttings of Norway spruce (Picea abies) and Sitka spruce (P. sitchensis). Ztschr. f. Forstgenetik u. Forstpflanzenzüchtung 4: 69-80.

(11) Little, Elbert L., Jr.
1953. Check list of native and naturalized trees of the United States (including Alaska). U. S. Dept. Agr. Handb. 41, 472 pp.

(12) Meyer, Walter H.
1937. Yield of even-aged stands of Sitka spruce and western hemlock. U. S. Dept. Agr. Tech. Bul. 544, 86 pp., illus.

(13) Ruth, Robert H.
1956. Plantation survival and growth in two brush-threat areas in coastal Oregon. U. S. Forest Serv. Pac. NW. Forest and Range Expt. Sta. Res. Paper 17. 14 pp., illus. (Processed.)

(14) _____, and Berntsen, Carl M.
1955. A 4-year record of Sitka spruce and western hemlock seed fall on the Cascade Head Experimental Forest. U. S. Forest Serv. Pac. NW. Forest and Range Expt. Sta. Res. Paper 12, 13 pp., illus. (Processed.)

(15) _____ and Berntsen, Carl M.
1956. Chemical basal treatment to control red alder. U. S. Forest Serv. Pac. NW. Forest and Range Expt. Sta. Res. Note 128, 6 pp., illus. (Processed.)

(16) _____ and Yoder, Ray A.
1953. Reducing wind damage in the forests of the Oregon Coast Range. U. S. Forest Serv. Pac. NW. Forest and Range Expt. Sta. Res. Paper 7, 30 pp., illus. (Processed.)

(17) Siggins, Howard W.
1933. Distribution and rate of fall of conifer seeds. Jour. Agr. Res. 47(2): 119-128, illus.

(18) Society of American Foresters
1954. Forest cover types of North America (exclusive of Mexico). 67 pp., illus. Washington, D. C.

(19) Sudworth, George B.
1908. Forest trees of the Pacific slope. 441 pp., illus. Washington, D. C.

(20) Taylor, R. F.
1929. The role of Sitka spruce in the development of second growth in southeastern Alaska. Jour. Forestry 27: 532-534.

(21) _____
1934. Yield of second-growth western hemlock—Sitka spruce stands in southeastern Alaska. U. S. Dept. Agr. Tech. Bul. 412, 30 pp., illus.

(22) Thornthwaite, C. W.
1941. Atlas of climatic types in United States, 1900-1939. U. S. Dept. Agr. Misc. Pub. 421, 7 pp., 96 maps.

(23) U. S. Forest Service
1948. Woody-plant seed manual. U. S. Dept. Agr. Misc. Pub. 654, 416 pp., illus.

(24) Wright, Ernest, and Isaac, Leo A.
1956. Decay following logging injury to western hemlock, Sitka spruce, and true firs. U. S. Dept. Agr. Tech. Bul. 1148, 34 pp., illus.

(25) Wright, Johnathan W.
1955. Species crossability in spruce in relation to distribution and taxonomy. Forest Sci. 1: 319-349.