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Sitka Spruce

A Literature Review With Special Reference to British Columbia

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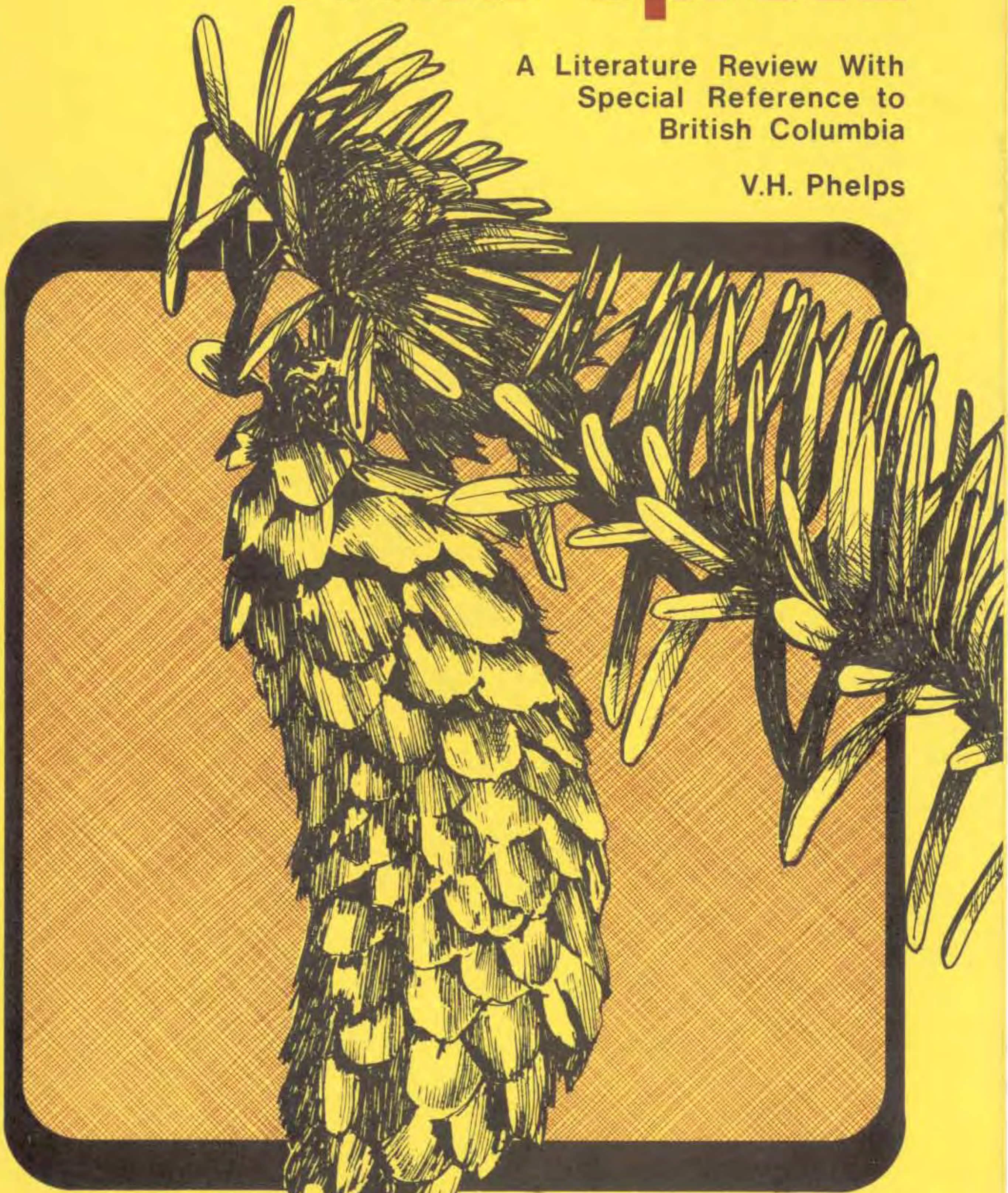

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SITKA SPRUCE: A LITERATURE REVIEW WITH SPECIAL REFERENCE TO BRITISH COLUMBIA

by

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CANADIAN FORESTRY SERVICE

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Nomenclature

Sitka spruce was first described as a native tree species of western North America by Archibald Menzies in 1792 (54). The botanical name is Picea sitchensis (Bong.) Carr. and the common names are Sitka spruce, western spruce, coast spruce, Tideland spruce, Menzies spruce and yellow spruce (84, 23).

Range and Occurrence

Spruces (Piceae) originated in eastern Asia, from where they migrated to N. America, Eurasia and Europe. More than 30 species have been identified (100). Variations in morphology occur but they are small, and the species reveal a general uniformity in wood anatomy, growth, ecology, shape of crown and, except for Sitka spruce, all are found at high latitudes or high altitudes. Most occupy mesophytic sites, although black (P. mariana) and Yeddo spruce (P. jezoensis) occur in swamps and Sitka spruce (P. sitchensis) in skunk cabbage (Lysichitum americanum) bogs.

In Canada, there are five native species: white (P. glauca (Moench) Voss), black (P. mariana (Mill.) B.S.P.), Sitka (P. sitchensis (Bong.) Carr.), Engelmann (P. engelmannii Parry) and red (P. rubens Sarg.) and all except the last occur in British Columbia. They have probably occupied their present range through the Pleistocene epoch (100). In British Columbia, Sitka spruce is mainly confined to the Queen Charlotte Islands where it grows to the high tide mark along the seashore, Vancouver Island and coastal regions. It occurs as a narrow belt along the coast, sometimes extending inland for about 50 miles into valleys subject to humid sea air; although it is occasionally found at elevations up to 2500', it is usually at altitudes below 1000' (23). Large trees have been observed at Terrace, Sooke on Vancouver Island and Stanek (87) reports the occurrence of individual trees at the U.B.C. forest at Haney. Krajina (56) describes the particular tolerance of Sitka spruce to ocean spray and points to good development on alluvial plains rich in available calcium and magnesium and on glacial till affected by permanent seepage water. It is more frequently a component in the early successional stages of the forest than in the climax. Its range overlaps that of white spruce and approaches that of Engelmann spruce.

Morphology

Sitka spruce is a vigorous, fast-growing tree that may live beyond 500 years of age. It is the largest of the genus (24). Its shade tolerance is generally low but its ability to withstand shade varies with the bigeoclimatic zone in which it is growing (56). In a tolerance table prepared by Baker (5), based on opinions from foresters mainly connected with schools and experiment stations it is classed as very tolerant or tolerant. At lower elevations, where optimum growth is obtained, trees 8-12 feet in diameter and 250 feet in height are encountered (23). The boles are straight and clean and frequently have heavily buttressed bases (39). Trees growing in the open are inclined to be limby.

The crowns vary from short and rather open with the main branches often fastooned with mosses and long hanging branches to broadly conical with dense foliage or narrowly spired (28).

The needles are straight, slender, sharp-pointed and 15 to 25 mm in length. New ones are soft, yellowish green and become stiff and bluish green with age and bristle out around the twigs. In cross-section they are flat, distinguishing them from the 4-sided needles of other spruces native to Canada (100). The needles have two medium resin canals, 6-8 rows of stomata on the upper surface and 2-4 rows on the lower surface (100). Margins of juvenile needles are smooth, which distinguishes them from white spruce (77).

The twigs are short, stiff and smooth, and the pointed resinous terminal buds are encircled by needles (24). The bark of the main stem is thin, 15 to 25 mm in thickness, and broken into loosely attached reddish scales that distinguishes it from its associates (24).

The flowers are unisexual and both sexes are borne on the same tree (23). The male flowers are red, approximately 25-60 mm in length, and occur on lateral branchlets; female flowers are erect, yellowish green, 30 to 40 mm in length, and are at the end of primary branches (100, 39). The bracts are exposed, which distinguishes them from flowers of all other species of the genus (100). The cones are cylindrical shaped and have thin, wavy-edged rhombic scales and when immature are yellowish green. Scale shape distinguishes this species from white spruce, whose scales are circular (100). The seed varies from 2-3.5 mm in length and is attached to a comparatively large wing, resulting in a total overall length of 13 to 16 mm (100).

Natural Variation

Variation in Sitka spruce has not been fully investigated, but it has been determined that the species exhibits patterns of geographic variation in height growth, wood qualities, response to day length and susceptibility to frost (21); differences have also been demonstrated in the coloration of the hypocotyl and the needles, which are considered to be responses to changing environmental conditions through the natural range (22). Studies with provenances of Sitka spruce seedlings from Alaska to Oregon (Lat 60½°N to 43°N) showed that differences of flushing dates for provenances were small but differences in date of growth cessation were large (63). Provenance differences in susceptibility to frost occur, and nursery stock raised from seeds collected in northern areas are generally more frost hardy (67). Patterns in spruce populations in the transitional zone between the coastal Sitka spruce forest and the montane white spruce forest in the Skeena Valley are clinal variations (79) and introgression (27). Natural hybrids (Lutz spruce) of these two species occur in southern Alaska and western British Columbia, and with Engelmann spruce in Northern Europe, where the two species were introduced (64). The intermediate forms are the most easily distinguished on the basis of the morphology of the cone scales.

Daubenmire (27) examined Sitka spruce collections from Alaska to California for evidence of evolution possibly resulting from isolation or stresses during Pleistocene and recent time, and possible hybridization between species whose ranges come into contact. He states that biotype depletion during glacial maxima, and introgression, seem to be the phenomena most likely to have produced patterns of variation that might be recognized over the geographic range of Sitka spruce. Three areas, none of which were in British Columbia, were strictly homologous from the standpoint of showing a north-south gradient of characters. The Sitka spruce characteristics included the phyllotaxy of ovuliferous cones, cone size and sterigma angle. He considered that the collections from the Upper and Lower Skeena River areas were hybrids, and that white spruce was the most likely introgressant. Needle length, cone diameter and length, scale length and width and index of dorsiventrality demonstrated varying intermediacies, the Upper Skeena trees being more closely allied to white spruce and the Lower Skeena trees closer to Sitka spruce. He also found consistent variability differences in proportions of the length-width ratios of ovuliferous scales between insular and mainland populations, but not between northern and southern populations.

Tree Associations and Stand Types

Sitka spruce occurs in pure stands, but more frequently as a component in an admixture (28). Associated tree species in various stand types include western hemlock (Tsuga heterophylla (Raf.) Sarg.), western red cedar (Thuja plicata Donn), Douglas fir (Pseudotsuga menziesii (Mirb.) Franco), amabilis fir (Abies amabilis (Dougl.) Forbes), lodgepole pine (Pinus contorta Dougl.), red alder (Alnus rubra Bong.) and black cottonwood (Populus trichocarpa Torr. and Gray). It usually grows in areas of heavy rainfall and on soils that are continuously moist, well-drained and fairly rich in nutrients. Without such conditions, one or more of the associate species usually assumes dominance. The typical forests on the Queen Charlotte Islands and near Terrace, B.C., are dense admixtures of spruce, western hemlock and western red cedar. The spruce is predominant on well-drained alluvial soils in valley bottoms and on wet hillsides where drainage is good; where the soils are shallow, the trees show a relatively early decline in vigor (28). On productive sites on the Queen Charlotte Islands, there is a luxuriant growth of bracken (Pteridium aquilinum), salal (Gaultheria shallon), blue bilberry (Vaccinium ovalifolium), red huckleberry (Vaccinium parvifolium), bunchberry (Cornus canadensis), salmonberry (Rubus spectabilis), goose-berry (Ribes lacustre) and elderberry (Sambucus racemosa), and on muskeg sites, salal, Labrador tea (Ledum groenlandicum), kinnikinnik (Arctostaphylos uva-ursi), dwarf bilberry (Vaccinium caespitosum), skunk cabbage (Lysichitum americanum) and spiraea (Spiraea densiflora) (49). Cary (24) recognized both bottomland and slope forest types, differentiating between them mainly on the basis of tree development of stands. On moist river bottoms or on benches above the river, the spruce were large, heavily buttressed, limby, and associated with black cottonwood and red alder; on the moist and well-drained soils of hills and gentle slopes, the boles were long and clean and generally less inclined to relatively early decline in vigor. They were commonly associated with other conifers. Rowe (82) describes the coast forest region and states that in the C4 section, Sitka spruce, growing on well-drained sites and in association with western hemlock and western red cedar, attains higher quality than in any other part of the coastal forest. Other associate species are western yew (Taxus brevifolia Nutt), broadleaf maple (Acer macrophyllum Pursh), red alder and shore pine (Pinus contorta Dougl.). The bedrock of this section is Triassic and Tertiary sediments and volcanic rocks, which have been weathered to deep soils. Sitka spruce, either alone or with western hemlock, occurs on alluvial soils in the C3 section and, on some sites, yellow cedar (Chamaecyparis nootkatensis (D. Don) Spach), red alder, broadleaf maple and black cottonwood may be associates. On the southern part of the Coast Forest, C2 section, where there are alluvial soils with abundant seepage, Sitka spruce occurs with western red cedar, black cottonwood, grand fir (Abies grandis (Dougl.) Lindl.), red alder and broadleaf maple. The soil is from surface tills of the last glaciation, and the soil types belong to the brown podsolic, podzol, concretionary brown and alluvial regosol groups. In C1, Strait of Georgia section, spruce is found occasionally on low ground. Krajina (56) describes four associations in which Sitka spruce is one of the main components of the tree layer. The first occurs on coastal river deltas which brackish water at high tide. A characteristic associated plant is wild lily-of-the-valley (Maianthemum dilatatum). The second occurs on alluvial flood plains where Sitka spruce is associated with Pacific silver fir and western red cedar. Common understory plants include devil's club (Oplopanax horridus), stink current (Ribes bracteosum), salmonberry (Rubus spectabilis), sword fern (Polystichum munitum), and the mosses (Mnium insigne) and Leucolepis (Mnium) menziesii. The third is found in wet locations on black muck or humic gleysol soils. Western red cedar and red alder are the main associated trees, while skunk cabbage and the sedge Carex obnupta characterize the lesser vegetation. The fourth association occurs under better drained, sloping topography with weakly podzolized soils. Associated trees are Douglas-fir, Pacific silver fir and western red cedar. Sword fern is abundant, as are the mosses Mnium insigne, Leucolepis menziesii and Eurhynchium stokesii.

Silvical Characteristics

Silvical characteristics of Sitka spruce and characteristics suitable for species determination have been investigated by many persons (20,23,24,39,54,56,77,84,100).

1) Roots

The root system is variable (39,84). On poorly drained soils, the roots spread out in the organic layer above the mineral soil; on deep coherent soils that have a massive structure, there is good penetration by tap-roots although the branch roots may be poorly developed. Day (28,29) studied root development as it is related to soil and soil development. Rooting was shallow with horizontal runners near the surface in shallow river alluvia; in deep alluvial soils, tap roots penetrated to a depth of 7 feet and had distinct zones of abundant root development with intervening spaces where roots were sparse. Modifications in the root system were evident on hillside sites; they could be related to variations in microtopography, existence and depth of root-restricting layers in the soil profile and conditions of drainage.

2) Crowns

Variations in crown characteristics result from differences in growing conditions and from the incidence of root rot (28). On favorable sites, the crowns of well-developed trees are broadly conical and the foliage is dense; on shallow soil and where the roots are diseased, the crowns are thin and sparse. Sometimes the crowns of mature trees are narrowly spired, which is indicative of a stony soil in which seepage water flows, a soil deficiency in nutrients, or a shallow soil with a high water table (28). Narrow crowned trees were found to be the more efficient producers of volume increment and greater increment associated with greater tree dominance (43).

3) Flowers

The flowers which develop from ovoid-shaped resinous light-brown buds (3 to 5 mm in length) usually commence shedding pollen in mid-May and complete it by the end of that month. The buds are encased in tough, thin membranous scales and are produced in the late summer. After pollination, the female flowers turn downward and develop into cones (100,39).

4) Cones

Cones mature and open about mid-September when they are 8-10 cm long, pale yellow to reddish brown, and hang down conspicuously from upper branches of the tree (39). Most cones drop within a few months after seed dissemination, although a few may remain on the tree for several years.

5) Seed

Good seed crops occur about every 4-5 years and, although there are failures, usually some crop occurs in the intervening years (100). Yield per bushel of cones ranges from 8 to 20 oz and the number of seeds per pound from 150,000 to 400,000 (avg 21,000) (91). Crops of commercial importance may be obtainable when the trees are between 30 and 40 years of age.

(a) Dispersal

The seed matures in the fall and dispersal occurs after periods of drying wind. The major proportion of the crop is disseminated within a short period, but some seed falls during most months of the year. Over a 4-year period, dispersal consistently started in western Oregon during the last 10 days in October, and 50 per cent had fallen by November (85). In a pulp stand of western hemlock-spruce in southeastern Alaska, dispersal of a bumper crop of 5 lb. spruce seed per acre commenced October 12-19, when 72 per cent of it was disseminated (40); scrub stands, in which spruce was a minor component, dispersed most of its crop (1/5 lb.) during a light seed year between December 8 and January 14 (51). Distribution of the seed is usually most concentrated within 5 chains from its source, but on clear-cut and snow-covered areas, it may be distributed fairly uniformly to distances in excess of 30 chains (52). In southeast Alaska Sitka spruce seed was dispersed over a 1-year period, and the soundness of the seed decreased during the period of dispersal (44).

(b) Germination

Germination is slow in the spring and many seeds remain stored in the duff, retaining their viability for several years (24). They germinate on organic layers, rotten wood and mineral soil when moisture is abundant. A loose mineral soil with side-shade and partial over-head shade is the most suitable seed-bed medium (39). Surface moss is a poor seed bed due to its fluctuating moisture condition; only one-fifth as many seeds artificially sown on moss characteristic of the climax forests in southeast Alaska germinated as on mineral soil, and they had 28 per cent lower survival (41). Seed from Sitka spruce and western hemlock germinate well on mineral soil, but on moss and humus, western hemlock germinates better than the spruce; the percentage of spruce reproduction can often be increased by exposing mineral soil during a logging operation (71). An improvement in germination capacity is obtained when seed is stratified (53).

6) Seedlings

Young seedlings have slender and flexible stems. About 50 to 60 per cent have shallow root systems with 3-5 laterals that are 2 feet or more in length; others have either tap roots or oblique laterals which, at two years of age, penetrate permeable soil for about 2 feet (31). Soil where the pH value ranges between 4.0 to 5.7 is the most favorable for growth (39). Cultural treatment studies demonstrated that optimum seedling growth occurred when the pH was between 4.0 and 5.0, but the form of nitrogen had only minimal effect on total growth (62). However, in southeastern Alaska, natural spruce regeneration occurred mainly on seed beds where nitrification was active, and it became increasingly abundant where the nitrite concentration reached a level of about 50 ppm (90). Total dry weight of Sitka spruce seedlings grown in sand culture increased as the N nutrient concentration increased from 2 to 50 ppm, but decreased at 200 ppm; total dry weight also increased as the P concentration increased from 0.5 to 30.0 ppm and the K level from 2 to 20 ppm (93). Investigations on the growth response of Sitka spruce seedlings showed that in sand cultures growth response was greatest when ammonium and nitrate sources of N were provided in equal amounts; in artificial soil cultures, greater growth was obtained with ammonium N than with nitrate N at pH values between 5.4 and 7.5 (95). Soil densities for the growth of Sitka spruce seedlings are similar to that required for western hemlock and western red cedar, but less than for Douglas-fir and lodgepole pine (73). Winter flooding from 1 to 4 weeks has little effect on seedlings, but summer flooding for 4 to 8 weeks causes mortality (72). Breaking of bud dormancy for the resumption of normal growth requires about 6 to 8 weeks of chilling at 40°F or lower (76).

Brix (20) grew Sitka spruce seedlings under controlled conditions of temperature and light intensity. He demonstrated that with constant day-night temperatures, total dry matter production increased almost linearly between 8° and 18°C; there was little or no change in growth response between 18° and 24°C, and at 28°C, growth decreased. The most favorable day-night combination was 24°C day and 18°C night. Height and diameter growth was optimum in the 18° to 24°C temperature range. Increasing light intensity from 450 ft-c to 1000 ft-c increased dry matter production and stem diameter, but had no effect on height growth. Photosynthesis of coniferous seedlings, preconditioned in light shade, approach light saturation near 2300 ft-c, and at 1250 ft-c when preconditioned in heavy shade; the photosynthetic rate of seedlings grown in heavy shade is significantly higher only at 200 ft-c (58). Growth responses of Sitka spruce seedlings to environment, interpreted from controlled conditions, have related photosynthesis, respiration and stomatal resistance to properties of the environment (65).

Regeneration

(a) Natural Regeneration

Sites that have loose mineral soil and are partially shaded favor the establishment and development of seedlings; growth in colder northern areas is usually best on southern slopes, but where moisture is a limiting factor on southernly aspects, it is best on northern slopes (39). Ruth (83) found, in coastal Oregon, that Sitka spruce seedlings established naturally in dense brush areas were almost invariably on rotten wood.

On well-drained sites, where the surface is relatively dry, there is little likelihood of regeneration without some site preparation, but in undisturbed forests on seepage sites or on those that are relatively moist with fresh water and where vegetation is not too severe, good seedling stocking and development is possible without disturbance of the soil (28). Warrack (97) reported that on the Queen Charlotte Islands, natural regeneration can be expected to establish an adequate second crop of mixed western hemlock, Sitka spruce and western red cedar if the contiguous clear-cut areas do not exceed 900 acres, an encircling seed source within one-half mile is left for a period up to 10 years, and the amount of slash is reduced to 50 per cent. He states that artificial regeneration will be necessary within three years after clear-cutting rich sites prone to early reclamation by alders, shrubs and grasses; burning resulted in purer stands, mainly composed of Sitka spruce, but was not considered a requisite to regeneration. In the dense forest types of the Juan de Fuca Strait region, where underbrush is generally light, stands should regenerate satisfactorily within a year or two after logging without need of special treatment, and if there is a good stand of advance growth and all other factors are favorable, slash may be left unburned (2). During the early stages of development, seedling survival may be difficult on soils devoid of nitrates unless leguminous plants or alder are present (89).

Repeated fires destroy seeds stored in the duff. Natural restocking is usually adequate on areas that have been logged but not subjected to repeated fires. It regenerates after logging and fire, even on relatively poor soils in areas distant from the ocean spray, but is later replaced by hemlock when the temporary enrichment of soil by ash is removed by heavy rainfall (56). Experimental seeding in Newfoundland indicated that scarification and seeding is necessary for adequate restocking if the area is lightly burned (98).

The invasion of shrubs on logged areas sometimes inhibits satisfactory restocking. Control of major species, including red alder, broadleaf maple, vine maple (Acer circinatum), salmonberry, bracken and salal, may be accomplished by using chemical sprays without damaging the seedlings (59). Control of different species of brush that occur in the coastal forests of British Columbia was investigated by Hetherington (46).

(b) Artificial Regeneration

In British Columbia, there has been less artificial restocking with Sitka spruce than with some other species. This is possibly due to the rather limited areal extent of productive spruce sites, compared to that of other equally or more commercially important trees, and to the greater emphasis that has been placed on the harvesting of these species.

(1) Planting Requirements

Cognizance of seedling growth characteristics and the influence of environmental factors is important for successful reforestation and afforestation. Although successful restocking is dependent on such factors as quality of the planting stock, conditions of site, weather, and freedom from vegetative competition, knowledge of optimum requirements is incomplete. Planting 2-0 and 3-0 Sitka spruce seedlings is usually successful, particularly on moist alluvial soil. Survival of 1-0 seedlings and 1-1 transplants, planted on a variety of sites, has also been satisfactory, but growth of the latter were superior (32). Generally, planting on decayed wood has been avoided, but when this was done with 1-0 seedlings in Oregon, where the growing season precipitation was 10 inches, seedling survival and growth was as good as on mineral soil (9). Planting trials have shown that the altitude of a planting site has less effect on seedling survival and development that has its quality (75).

Competition from brush and minor vegetation is a major factor contributing to seedling mortality, and where competing vegetation is dense, release of the seedlings by chemical or other means is a prerequisite for a successful plantation (70). Investigations in British Columbia (4) have demonstrated that planting wilding stock is a satisfactory alternative to planting 2-0 and 3-0 nursery stock. On well-drained scarified sites in the nursery, seedlings averaged 3.1" at the end of the second growing season and 4.7" one year later; dominants attained heights of 9 inches after 2 years and 15 inches after 3 years. Growth of the wildings often surpassed that of nursery plants, which was attributed to their larger initial size and better vigor. The restocking was accomplished more cheaply with wildings than with nursery stock. In Oregon, better survival was obtained with planted wildings than with planted 3-0 nursery stock, attributed mainly to their greater capability to compete with the dense brush (92).

Nursery Practices

Problems in the nursery most frequently experienced are concerned with seed viability, nutrition, soil quality and excessive weeds.

Large one-year-old Sitka spruce seedlings, adequately provided with nutrients, were reported to have 2.1% N, 0.25% P and 1.2% K based on total plant dry weight; associated needle concentrations were 2.4% N, 0.33% P and 1.27% K (94). Nitrogen deficiency can be recognized by the pale-green color of seedlings; insufficient phosphorous by a slight lack of lustre; inadequate potassium by a purple discoloration; deficiencies in magnesium and copper by a brilliant yellow discoloration and needle tipburn (8), and calcium deficiency by purple-brown foliage (55).

Sandy to sandy-loam soils are suitable seed-bed material (8), and compacting the soil before sowing improves production and accelerates the rate of germination (33). Optimum seedling height is usually obtained with a soil pH of about 4.5, and good density for sowing is considered to be 1,800 viable seeds per square yard (8).

Weeds, a perennial problem in most nurseries, can be controlled before emergence of seedlings with a light vaporizing oil (8) or with Paraquat (1) without causing damage to the seedlings. Those that occur after emergence are usually removed by hand.

Under particular circumstances, it may be desirable to raise seedlings by intensive methods. Four crops of seedlings (1½ inches) were raised in one year by using a heated frame and extended illumination at night (34). The procedure was expensive, and difficulty was experienced in hardening-off the seedlings developed in the winter months.

Damage to Sitka spruce from frost-killed leaders is less serious than for many other species, due to replacement of the killed leader by a lateral branch within one year (81). In the nursery, seedlings which have been damaged by Xiphinema bakeri are more susceptible to injury from frost than those that have not been damaged (88). Where frost damage is prevalent, frost screens provide protection, but they are expensive and not always practicable. Large and well-rooted seedlings, which are most resistant to frost damage, can be grown if seeding is done on fertile soil in early spring and the seeds are not too densely sown (7). Frost damage in nurseries in British Columbia is effectively reduced by sprinkling with water during the danger period, or by fogging if the temperature is too low for sprinkling to be practicable.

Current practice in British Columbia is to drill-sow sufficient seeds (approx. 40) to obtain 20 seedlings per lineal foot. Usually this has been done in the fall, as the seedlings are larger than those from spring-sown seeds, but seed loss during the winter months may be so extreme that spring sowing might be preferable. The seed beds are standard sized and raised 3 inches above grade level. Before sowing, the soil is treated with applications of phosphorus and potassium. Eradication of weeds is accomplished by spraying the beds with oil just before the seedlings emerge. After the planting stock is lifted, mainly 2-0 seedlings, they are transported to planting sites in multi-walled bags (6).

Spacing trials with Sitka spruce seedlings near Kalum Lake, B.C. indicated that there were no significant differences in growth, based on the first five-year growth measurements, related to spacing which ranged from 6 feet by 6 feet to 15 feet by 15 feet (3).

(3) Vegetative Propagation

Although vegetative reproduction is uncommon, layering sometimes occurs when the oldest branches of bushy open-grown trees become covered with an accumulation of vegetative debris (26) or soil (31). Sitka spruce can be propagated from cuttings or by grafting. Scions can be rooted in a medium of coarse sand and peat if treated with a solution of indolebutyric acid (42), the degree of success being dependent on clonal variation, photoperiod, air temperature and humidity (35,36). Variations in natural rooting ability occurred, attributable to environment and the physiological condition of the cuttings (60); experimental work with cuttings in cold frames showed rooting to be more prolific between July and September and in February than at other times.

Investigations in Denmark showed that the production of roots on

Sitka spruce cuttings was not significantly influenced by the rooting media (80). Little information is available on grafting Sitka spruce, but good results have been obtained by grafting one-year-old scions to root-stocks by the side veneer and cleft methods (67).

Volume Tables

Various tree-volume tables for Sitka spruce have been published.

Meyer (71) prepared cubic foot and board foot volume tables from data collected in Sitka spruce - western hemlock stands in British Columbia, Washington, Oregon and Alaska. Approximately ten per cent of the data were collected in British Columbia. In the preparation of the tables, adjustments were made for butt swell by relating diameter inside bark at 18 feet to diameter at breast height.

Tables, expressing volume in cubic feet, were published in 1953 for the Puget Sound area in western Washington (78), and minor omissions and corrections were incorporated into them in 1959 (86); board-foot tables for the International and Scribner rule were included in the earlier publication.

Volume tables, in cubic and board feet, were constructed and volume equations computed for old-growth Sitka spruce in southeastern Alaska (11). The weighted volume equation is

$$\frac{Vk}{D^2H} = b_o \frac{1}{D^2H} + b_1 \frac{1}{DH} + b_2 \frac{1}{H} + b_3 \frac{1}{D^2} + b_4 + b_5 \frac{1}{D^4H} + b_6 \frac{Fj}{D^2H}$$

where b_1 = constants for the weighted equation and Fj = 16 or 32-foot form class.

Volume tables, based on D^2H have been constructed for use in British Columbia (37). Volume of trees for different combinations of diameter and height were determined by the equation $V = a + b \frac{D^2H}{100}$. Values for the constants "a" and "b", based on data from U.B.C. research forest at Haney, are shown below for total cubic foot volumes.

a) Immature Sitka spruce (all diameters)

$$V = 5.3 + 0.193 \frac{D^2H}{100}$$

b) Mature Sitka spruce (0-24" d.b.h. and $\frac{D^2H}{100} < 790$)

$$V = 4.2 + 0.203 \frac{D^2H}{100}$$

c) Mature Sitka spruce (25-60" d.b.h. and $\frac{D^2H}{100} < 713$)

$$V = 38.4 + 0.177 \frac{D^2H}{100}$$

d) Mature Sitka spruce (61" d.b.h. +)

$$V = 155.4 + 0.159 \frac{D^2H}{100}$$

Local volume tables are derived from the standard volume equations by utilizing a value for height, calculated from the formula $H = 4.5 + bD + cD^2$. Butt-taper tables (15), published in 1966 as a supplement to these tables, show the relationship between d.b.h. for a given diameter outside bark at different stump heights.

Standard cubic foot volume tables, prepared by J.E. Browne (13), and basic taper curves (17) are currently in use in British Columbia. They are based on measurements of diameter (B.H), diameter at specific intervals between breast height and tip, and total height of trees measured in the province. Total volumes are obtained by means of the following equations, derived by the method of least squares:

a) Immature Sitka spruce (up to 140 years)

$$\text{Log } V = -2.550299 + 1.835678 \text{ Log } D + 1.042599 \text{ Log } H$$

b) Mature Sitka Spruce (over 140 years)

$$\text{Log } V = -2.700574 + 1.754171 \text{ Log } D + 1.164531 \text{ Log } H.$$

Factors based on stump height and top diameter inside bark are used for conversion to merchantable volume. Local volume tables are obtained from reliable height-diameter curves.

British Columbia Forest Service standard volume tables (13), showing total volume for each two-inch/ten-foot height class are shown in Tables A-B. Total Tables C-D show merchantable volume factors. Total volumes by one-inch diameter and one-foot height have been prepared as a supplement to the standard volume tables (14). Adjustments for decay, waste and breakage (16) are shown in Table E (appendix). Tables are prepared for use in compilation of variable-plot or prism cruises (74). They show the ratio of gross volume in cubic feet of the entire stem inside bark to the basal area outside bark in square feet at breast height for two-inch diameter classes and 10-foot height classes.

Yield Tables

Yield tables for the Sitka spruce - western hemlock forest type, published in 1937 (71), were based on data collected in British Columbia, Washington, Oregon and Alaska for site indices between 60 and 200 feet. Included are tables showing for all trees, by 10 year - 20 foot site classes, the number of trees per acre, basal area, cubic foot volume, board-foot volume and cords per acre, and a table showing deviations from normal yield table values by stand composition.

Extracts from unpublished tables (19), which are applicable to stands in British Columbia, are shown as tables F and G (appendix). They were prepared from measurements in spruce, spruce-hemlock, spruce-fir, spruce-balsam and spruce-deciduous stands in British Columbia. The predominant species in all stands is Sitka spruce. Volumes, in cubic feet per acre, at culmination ages are shown for different diameter (B.H) levels for good, medium, poor and low sites. Definition of the sites has been prepared as a table (18) and is shown in the appendix as Table H.

Management Practices

Management practices for optimum timber production of Sitka spruce must take into consideration that the species grows vigorously and is shade intolerant. Ring-width patterns in trees from the Queen Charlotte Islands have shown that a constant vigorous rate of growth can be maintained up to 170 years; even at advanced ages, good radial growth response occurs when the trees are released from suppression (30). Timber production per acre is dependent on the aggregate crown surface of the whole crop, which is influenced by such factors as thinning treatment, quality of site and height of the stand (57).

The economical justification of thinning in managed stands is related to degree of thinning and quality of the stand (48). It has been shown that in managed stands there is a straight line relationship between mean crown diameter in feet and stem diameter in inches (47). MacBean (66), in discussing silviculture and cutting methods in British Columbia, states that knowledge of silvical requirements of Sitka spruce is limited but that surveys suggest that regeneration takes place slowly and that burning may be beneficial when shrubs and underbrush are heavy.

Thinning to produce high quality timber in a short rotation should favor crown development of final crop trees; epicormic branching is a characteristic for Sitka spruce, and care should be exercised that it is not encouraged by drastic exposure to light. In plantations, the effect of side-shade that suppresses branches and potential knot size of dominants starts about 7 years after planting (68). This continues until the bottom of the crown of the dominant over-tops the suppressed; a similar but more prolonged relationship occurs between co-dominant and dominants. When side shading no longer benefits the dominants, understory trees can be left until they are eliminated naturally or harvested if the operation is economically feasible.

Bradley et al. (12) published Forest Management Tables for the management of Sitka spruce plantations. Planted stands are classified into yield classes, based on mean annual volume increment. Three main types of tables provide guidance for thinning. Thinning Control Tables express the appropriate annual thinning yield that can be obtained from each yield class. The annual volume is multiplied by the intended thinning cycle to obtain the total volume to be removed in a particular thinning operation. Production Forecast Tables convert inventory data of gross land area into net yield potential by using an arbitrary reduction of 15 per cent. Assumptions of thinning intensity used in these two tables and the type of thinning are incorporated into Normal Yield Tables. These give stand statistics for total production, the crop after thinning and the yield from thinning.

Yield tables for different spacings of Sitka spruce were used by Wardle (96) to illustrate problems pertinent to forest management, and to stress the importance of deciding on a standard by which different management practices could be compared. The cost of adopting different spacings in Sitka spruce plantations is related to resulting values. Logging methods, falling, loading, settings and yarding, booming and rafting, scaling and forest land tenure are described in detail by Hutchison (50).

Damage

a) Disease

Sitka spruce is subject to decay loss from a large number of fungi which gain entrance to the tree through roots, tree scars, branch stubs and dead tops. A study of mature and overmature trees on the Queen Charlotte Islands revealed that 31 species of fungi caused decay in living trees, although only a few were of major importance (10). Young trees were relatively free from decay and, although loss increased with age, a definite relationship was not apparent between extent of decay and tree vigor.

Red ring rot caused by Fomes pini is a serious heart rot, particularly on high quality sites, as has been indicated in Washington and Oregon (99). This fungus attacks both heartwood and sapwood, frequently causing tree mortality. Lentinus kauffmanii, causing brown pocket rot, and Polyporus sulphureus, causing brown cubical trunk rot, are other important decay organisms. The volume of wood destroyed by L. kauffmanii is less than from other fungi, but it is important because of its common occurrence in high quality basal logs. Other diseases have been described by Foster and Wallis (38). Although the species is subject to infection from Armillaria mellea, Poria weirii and Fomes annosus, the most important root and butt rot is the brown cubical buttrot caused by Polyporus schweinitzii. Spores from this fungus enter the tree through basal scars, causing decay and making the tree prone to wind breakage.

Sitka spruce is subject to needle disease. Brown felt blight caused by Herpotrichia juniperi, which develops under the snow, sometimes kills young trees if attacks are repeated. Other defoliating agents that affect tree growth are: Lirula (Lophodermium) macrospora and Chrysomyxa ledicola (38). The two most important cone rusts that damage seed are

Chrysomyxa monesis, which alternates with single delight (Moneses uniflora (L.) Gray), and Chryxomyxa priolata, whose alternate host is wintergreen (Pyrola sp.) (38).

b) Insects

Sitka spruce in British Columbia is attacked by a number of insects, but damage from most of them is usually not serious. The most important insect pest is Pissodes sitchensis (45), although it has not been found on the Queen Charlotte Islands. This insect kills the terminal shoots of trees between 10 and 30 feet in height. Height growth is retarded and the tree frequently develops a forked top or crooked stem; repeated attacks sometimes result in an associate tree species assuming dominance within the stand and the ultimate exclusion of the spruce. The Cooley spruce gall aphid (Adelges cooleyi) frequently attacks young seedlings, causing the formation of cone-shaped galls on terminal shoots; damage to natural regeneration on the Queen Charlotte Islands has been attributed to the weevil, Steremnius carinatus (61). The spruce aphid (Neomyzaphis abietina (Wilk) has caused damage to ornamentals. The other important damaging insect is the Sitka spruce beetle (Dendroctonus obesus (Mann)) (69). The species is also subject to attack by several defoliators (Lepidoptera), but all are of minor importance (69). Damage to the terminal buds of Sitka spruce on the Queen Charlotte Islands is caused primarily by Epinetia n. sp., Zeiraphera nr ratzeburgiana and the gall midge, Rhabdophaga sp nr ratzeburgiana (25).

Appendix

TABLE A

STANDARD CUBIC-FOOT VOLUME TABLE FOR IMMATURE SITKA SPRUCE (UP TO 140 YEARS)
BRITISH COLUMBIA FOREST SERVICE, FOREST SURVEYS AND INVENTORY DIVISION, 1962

D.B.H. (Inches)	TOTAL HEIGHT (FEET)																									Basis (Number of Trees)
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	
	TOTAL VOLUME OF ENTIRE STEM INSIDE BARK (CUBIC FEET)																									
2	0.1	0.2	0.8	0.5	0.6	0.7	0.8																			5
4	0.4	0.8	1.2	1.7	2.1	2.6	3.0	3.5	3.9	4.4																21
6	0.8	1.7	2.6	3.5	4.5	5.4	6.3	7.3	8.2	9.2	10.2															32
8	1.4	2.9	4.4	6.0	7.6	9.1	10.7	12.3	14.0	15.6	17.2	18.8	20.5													48
10			6.7	9.0	11.4	13.8	16.2	18.6	21.0	23.5	25.9	28.4	30.9	33.3	35.8											60
12			9.3	12.6	15.9	19.3	22.6	26.0	29.4	32.8	36.2	39.7	43.1	46.6	50.1											47
14			12.4	16.7	21.1	25.6	30.0	34.5	39.0	43.5	48.1	52.6	57.2	61.8	66.4	71.1										59
16			15.9	21.4	27.0	32.7	38.4	44.1	49.8	55.6	61.4	67.3	73.1	79.0	84.9	90.8										41
18			19.7	26.6	33.5	40.5	47.6	54.7	61.9	69.1	76.3	83.5	90.8	98.1	105	113	120									40
20			23.9	32.2	40.7	49.2	57.8	66.4	75.1	83.8	92.5	101	110	119	128	137	146	155								30
22						58.6	68.8	79.1	89.4	99.8	110	121	131	142	152	163	173	184	195	206						17
24						68.7	80.7	92.8	105	117	129	142	154	166	179	191	204	216	229	241						27
26						79.6	93.5	107	121	136	150	164	178	193	207	221	236	250	265	279						16
28						91.2	107	123	139	155	172	188	204	221	237	254	270	287	303	320	337	353				16
30						103	122	140	158	176	195	213	232	250	269	288	307	325	344	363	382	401	420			10
32									178	198	219	240	261	282	303	324	345	366	388	409	430	452	473	495		5
34									199	222	245	268	292	315	339	362	386	410	433	457	481	505	529	553		7
36									221	246	272	298	324	350	376	402	429	455	481	508	534	561	587	614		4
38									244	272	301	329	358	387	415	444	473	502	531	561	590	619	649	678		3
40									268	299	330	362	393	425	456	488	520	552	584	616	648	680	713	745	777	1
42												396	430	464	499	534	569	604	639	674	709	744	779	815	850	2
44												431	468	506	544	581	619	657	696	734	772	810	849	887	926	1
46												467	508	549	590	631	672	713	755	796	838	879	921	963	1005	
48												505	549	594	638	682	727	771	816	861	906	951	996	1041	1086	
50												545	592	640	687	735	783	831	880	928	976	1025	1073	1122	1171	
52												585	636	687	739	790	842	893	945	997	1049	1101	1154	1206	1258	
54												627	682	737	792	847	902	957	1013	1069	1124	1180	1236	1292	1349	
56												671	729	788	846	905	964	1024	1083	1142	1202	1262	1322	1382	1442	
58												715	778	840	903	966	1029	1092	1155	1218	1282	1346	1410	1474	1538	
60												761	828	894	961	1028	1095	1162	1229	1297	1364	1432	1500	1568	1636	492

Data collected in the Coastal regions of British Columbia. Underlined figures indicate extent of basic data.
Table shows total volume of entire stem, inside bark, including stump and top, without allowance for defect, trim, or breakage.
Table volumes obtained by means of logarithmic equation derived by method of least squares: $\log V = -2.550299 + 1.835678 \log D + 1.042599 \log H$.
Standard error of estimated volume for single trees: $\pm$ 9.5 per cent.
Aggregate difference: 0.65 per cent high.

TABLE 8

STANDARD CUBIC-FOOT VOLUME TABLE FOR MATURE SITKA SPRUCE (OVER 140 YEARS)
BRITISH COLUMBIA FOREST SERVICE, FOREST SURVEYS AND INVENTORY DIVISION, 1962

D.B.H. (Inches)	TOTAL HEIGHT (FEET) 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	Basis (Number of Trees)
	TOTAL VOLUME OF ENTIRE STEM INSIDE BARK (CUBIC FEET)																												
2	0.1	0.2	0.4	0.5	0.6																								
4	0.3	0.7	1.2	1.7	2.2	2.7	3.2	3.7	4.3	4.8																			7
6	0.7	1.5	2.4	3.4	4.4	5.4	6.5	7.6	8.7	9.9	11.0																		14
8	1.1	2.5	4.0	5.6	7.3	9.0	10.8	12.6	14.4	16.3	18.2	20.2	22.1																18
10		3.7	5.9	8.3	10.8	13.3	15.9	18.6	21.3	24.1	27.0	29.8	32.8	35.7	38.7														29
12		5.1	8.2	11.4	14.8	18.3	21.9	25.6	29.4	33.2	37.1	41.1	45.1	49.2	53.3	57.4													31
14		6.7	10.7	15.0	19.4	24.0	28.7	33.6	38.5	43.3	48.7	53.9	59.1	64.6	69.8	75.3													44
16		8.4	13.5	18.9	24.6	30.4	36.3	42.4	48.7	55.0	61.5	68.1	74.7	81.4	88.3	95.2	102												40
18		10.4	16.7	23.3	30.2	37.3	44.7	52.2	59.9	67.7	75.6	83.7	91.9	100	108	117	125	134											36
20		12.5	20.0	28.0	36.3	44.9	53.7	62.8	72.0	81.4	91.0	101	110	120	131	141	151	161											34
22					42.9	53.1	63.5	74.2	85.1	96.2	107	119	131	142	154	166	178	191	203	216									26
24					50.0	61.8	74.0	86.4	99.2	112	125	139	152	166	180	194	208	222	237	251									25
26					57.5	71.2	85.2	99.5	114	129	144	159	175	191	207	223	239	256	272	289	306								24
28					65.5	81.0	97.0	113	130	147	164	182	199	217	236	254	272	291	310	329	349	368							29
30					74.0	91.5	109	128	147	166	185	205	225	245	266	287	308	329	350	372	393	415	437						30
32									164	186	207	230	252	275	298	321	344	368	392	416	441	465	490						35
34									183	206	231	255	280	306	331	357	383	409	436	463	490	517	545						36
36									202	228	255	282	310	338	366	395	423	453	482	512	542	572	602						25
38									222	251	280	310	341	371	402	434	466	498	530	563	596	629	662	696	730				15
40									243	275	307	340	373	406	440	475	509	543	580	616	652	688	724	761	798				18
42											334	370	406	443	480	517	555	593	632	671	710	749	789	829	870	910			19
44											363	401	441	480	520	561	602	644	685	728	770	813	856	900	944	988			15
46											392	434	476	519	563	607	651	696	741	787	833	879	926	973	1020	1068			16
48											422	468	513	560	606	654	701	750	798	848	897	947	997	1048	1099	1151			11
50											434	502	551	601	651	702	754	805	858	911	964	1017	1072	1126	1181	1236			14
52												538	591	644	698	752	807	859	919	975	1032	1090	1148	1206	1265	1324	1383	1443	21
54												575	631	688	745	804	862	922	982	1042	1103	1165	1226	1289	1351	1415	1478	1542	23
56												513	673	733	795	857	919	983	1046	1111	1176	1241	1307	1374	1440	1508	1570	1644	13
58												652	715	780	845	911	978	1045	1119	1181	1250	1320	1390	1461	1532	1604	1676	1748	8
60												692	759	828	897	967	1038	1109	1181	1254	1327	1401	1475	1550	1626	1702	1778	1855	9
62													804	877	950	1024	1099	1175	1251	1328	1406	1484	1563	1642	1722	1803	1884	1965	13
64													850	927	1004	1083	1162	1242	1323	1404	1486	1569	1652	1736	1821	1906	1991	2078	11
66													897	978	1060	1143	1226	1311	1396	1482	1569	1656	1744	1832	1922	2011	2102	2193	4
68													946	1031	1117	1204	1292	1381	1471	1562	1653	1745	1838	1931	2025	2120	2215	2311	5
70													994	1085	1175	1267	1360	1453	1548	1643	1739	1836	1933	2032	2131	2230	2330	2431	3
72																1331	1429	1527	1626	1726	1827	1929	2031	2135	2239	2343	2448	2554	5
74																1397	1499	1602	1706	1811	1917	2024	2131	2240	2349	2459	2569	2680	6
76																1464	1571	1679	1788	1898	2009	2121	2234	2347	2461	2576	2692	2809	1
78																1532	1644	1757	1871	1987	2103	2220	2338	2458	2576	2696	2818	2939	4
80																1601	1719	1837	1956	2077	2198	2321	2444	2568	2693	2819	2946	3073	5
82																1672	1795	1918	2043	2169	2295	2423	2552	2682	2812	2944	3076	3209	1
84																1745	1872	2001	2131	2262	2395	2528	2662	2797	2934	3071	3209	3348	4
86																1818	1951	2085	2221	2358	2495	2634	2774	2915	3057	3200	3344	3489	1
88																1893	2031	2171	2312	2455	2598	2743	2889	3035	3183	3332	3482	3632	3
90																1969	2113	2259	2405	2553	2703	2853	3005	3157	3311	3466	3622	3778	1
92																2046	2196	2347	2500	2654	2809	2965	3123	3282	3441	3602	3764	3927	2
94																2125	2281	2438	2596	2756	2917	3079	3243	3408	3574	3741	3909	4078	
96																2205	2366	2529	2694	2859	3027	3195	3365	3536	3708	3881	4056	4231	2
98																2286	2454	2622	2793	2965	3138	3313	3489	3666	3845	4024	4205	4387	
100																2369	2542	2717	2894	3072	3251	3432	3615	3798	3983	4169	4357	4545	
																													736

Data collected in the Coastal regions of British Columbia. Underlined figures indicate extent of basic data.
Table shows total volume of entire stem, inside bark, including stump and top, without allowance for defect, trim or breakage.
Table volumes obtained by means of logarithmic equation derived by method of least squares: $\log V = -2.700574 + 1.754171 \log D + 1.164531 \log H$.
Standard error of estimated volume for single trees: $\pm$ 12.5 per cent.
Aggregate difference: 0.21 per cent low.

TABLE C

MERCHANTABLE VOLUME FACTORS FOR IMMATURE SITKA SPRUCE

D.B.H. CLASS	CLOSE UTILIZATION	INTERMEDIATE UTILIZATION	ROUGH UTILIZATION
2			
4	.33		
6	.77		
8	.89	.13	
10	.93	.52	
12	.95	.72	.06
14	.95	.81	.35
16	.95	.86	.54
18	.96	.89	.67
20	.96	.90	.74
22	.96	.91	.79
24	.96	.92	.83
26	.96	.92	.85
28	.96	.93	.86
30	.96	.93	.87
32	.96	.93	.87
34	.96	.93	.88
36	.96	.93	.88
38	.96	.93	.88
40	.96	.93	.88
42	.96	.93	.89
44	.96	.93	.89
46	.96	.93	.89
48	.96	.93	.89
50	.96	.93	.89
52	.96	.93	.89
54	.96	.93	.89
56	.96	.93	.89
58	.96	.93	.89
60	.96	.93	.89

Factor x total volume of entire stem equals merchantable volume to stump and top limits shown.

Close Utilization Stump height of 1 foot, top diameter inside bark of 4 inches.

Intermediate Utilization: Stump height of 1.5 feet, top diameter inside bark of 8 inches.

Rough Utilization Stump height of 2 feet, top diameter inside bark of 12 inches.

TABLE D

MERCHANTABLE VOLUME FACTORS FOR MATURE SITKA SPRUCE

D.B.H. CLASS	CLOSE UTILIZATION	INTERMEDIATE UTILIZATION	ROUGH UTILIZATION
2			
4	.36		
6	.76		
8	.89	.14	
10	.93	.58	
12	.95	.74	.05
14	.95	.81	.32
16	.96	.86	.52
18	.96	.89	.66
20	.96	.90	.74
22	.96	.91	.80
24	.96	.92	.83
26	.96	.92	.86
28	.96	.93	.87
30	.96	.93	.88
32	.96	.93	.89
34	.96	.94	.90
36	.96	.94	.90
38	.96	.94	.91
40	.96	.94	.91
42	.96	.94	.92
44	.97	.94	.92
46	.97	.94	.92
48	.97	.95	.92
50	.97	.95	.93
52	.97	.95	.93
54	.97	.95	.93
56	.97	.95	.93
58	.97	.95	.93
60	.97	.95	.93
62	.97	.95	.93
64	.97	.95	.94
66	.97	.95	.94
68	.97	.95	.94
70	.97	.95	.94
72	.97	.95	.94
74	.97	.96	.94
76	.97	.96	.94
78	.97	.96	.94
80	.97	.96	.94
82	.97	.96	.95
84	.97	.96	.95
86	.97	.96	.95
88	.98	.96	.95
90	.98	.96	.95
92	.98	.96	.95
94	.98	.96	.95
96	.98	.96	.95
98	.98	.96	.95
100	.98	.96	.95

Factor x total volume of entire stem equals merchantable volume to stump and top limits shown.

Close Utilization: Stump height of 1 foot, top diameter inside bark of 4 inches.

Intermediate Utilization: Stump height of 1.5 feet, top diameter inside bark of 8 inches.

Rough Utilization: Stump height of 2 feet, top diameter inside bark of 12 inches.

TABLE E

NET VOLUME (LOSS) FACTORS

To Reduce Gross Merchantable Volumes to Net Merchantable Volumes for

Decay or for Decay, Waste and Breakage

Zone 1 & 2 Species Sitka spruce

MATURE FOREST

DIAMETER LIMIT (D.b.h.)	TREE CLASS 0		TREE-CLASS I		TREE CLASS II			
					SUSPECT 1		SUSPECT 2	
	DECAY	DECAY, WASTE & BREAKAGE	DECAY	DECAY, WASTE & BREAKAGE	DECAY	DECAY WASTE & BREAKAGE	DECAY	DECAY, WASTE & BREAKAGE
5.1-7.0"	.990	N.A.	.990	N.A.	.990	N.A.	.990	N.A.
7.1-9.0"	.990	N.A.	.990	N.A.	.980	N.A.	.880	N.A.
9.1-11.0"	.980	.910	.990	.930	.970	.910	.870	.770
11.1" plus	.950	.880	.980	.930	.950	.880	.850	.740

YOUNGER IMMATURE FOREST

DIAMETER LIMIT (D.b.h.)	TREE CLASS 0	
	DECAY	DECAY, WASTE & BREAKAGE
5.1-7.0"	1.000	N.A.
7.1-9.0"	1.000	N.A.
9.1-11.0"	1.000	.940
11.1" plus	1.000	.940

OLDER IMMATURE FOREST

TREE CLASS I		TREE CLASS II	
DECAY	DECAY, WASTE & BREAKAGE	DECAY	DECAY, WASTE & BREAKAGE
1.000	N.A.	1.000	N.A.
1.000	N.A.	1.000	N.A.
1.000	.940	1.000	.940
1.000	.940	1.000	.940

TREE CLASS 0 - All living trees regardless of pathological condition.
TREE CLASS I - All living trees bearing no visible signs of decay.
TREE CLASS II - SUSPECT 1 - Living trees bearing one or more of the following pathological indicators: scars, fork and/or crook, frost crack, mistletoe, large rotten branches and dead or broken top.
SUSPECT 2 - Living trees bearing a conk or blind conk plus any of the above indicators.
Pathological Age - Classes (Coniferous). Immature (1-80 yrs); Older immature (81-120 yrs) Mature (121 +yrs)

TABLE F

Volume/Age Curve index showing culmination age, yield and M.A.I. at culmination age for the 7.1"+ and 11.1"+ D.B.H. levels

Growth Type	Site	Vol/Age Curve No.	D.B.H. Limit					
			7.1"+			11.1"+		
			Yield at Cul. Age Cu. ft/acre	Cul. Age Years	M.A.I. at Cul. Age Cu. ft/acre	Yield at Cul. Age Cu. ft/acre	Cul. Age Years	M.A.I. at Cul. Age Cu. ft/acre
Spruce types -	G	1082-A	7700	42	183	8650	54	160
9,10,11	M	1083-A	7600	57	133	7975	71	112
	P	1084-A	5325	119	45	5475	154	36
	L	1245-A	3075	145	21	2900	194	15

All volumes shown are net for decay only - close utilization (4" top)

TABLE G

Volume/Age curve index showing culmination age, yield and M.A.I. at culmination age for the 9.1"+ and 13.1"+ D.B.H. levels.

			D.B.H. Limit					
			9.1"+			13.1"+		
Growth Type	Site	Vol/Age Curve No.	Yield at cul. age cu. ft/acre	Cul. age Years	M.A.I. at cul. age cu. ft/acre	Yield at cul. age cu. ft/acre	Cul. age Years	M.A.I. at cul. age cu. ft/acre
Spruce types-	G	1082-B	8075	47	172	9400	65	145
9,10,11	M	1083-B	7850	63	125	8225	82	100
	P	1084-B	5375	137	39	5625	177	32
	L	1245-B	3175	183	17	2825	218	13

All volumes shown are net for decay only - close utilization (4" top)

TABLE H

SITE TABLE

COAST - CEDAR, HEMLOCK MIXTURES, BALSAM & SPRUCE

Height in Feet

Revised March, 1966

Age yr	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
20	P	M	G	G	G	G													
30	L	P	M	M	M	G	G												
40	L	P	P	P	M	M	M	G											
50		L	P	P	P	M	M	M	G										
60			L	P	P	P	M		M	G									
70			L	P	P	P	M			M	G								
80				L	P		P	M			M	G							
90				L	P			P	M			M	G	G					
100					L	P		P	M				M	G					
110					L	P			P	M			M	G					
120					L	P			P	M			M	G					
130						L	P			P	M			M	G				
140						L	P			P	M			M	G				
150						L	P			P	M			M	G				
160							L	P		P	M				M	G			
170							L	P			P	M			M	G			
180							L	P			P	M			M	G			
190							L	P			P	M			M	G			
200							L	P			P	M			M	G			
210							L	P			P	M			M	G			
220							L	P			P	M				M	G		
230								L	P		P	M				M	G		
240								L	P		P	M				M	G		
250								L	P		P	M				M	G		
260								L	P			P	M			M	G		

L = Low P = Poor M = Medium G = Good

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