Western Hemlock – Sitka Spruce

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The western hemlock–Sitka spruce forest type (2), as recognized by the Society of American Foresters (type 225), is composed of stands in which western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) comprise a majority of the stocking. Also included at various locations may be small admixtures of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), Pacific silver fir (*Abies amabilis* Dougl. ex Forbes), western redcedar (*Thuja plicata* Donn ex D. Don), Alaska-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach), mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.), red alder (*Alnus rubra* Bong.), black cottonwood (*Populus trichocarpa* Torr. and Gray), vine maple (*Acer circinatum* Pursh), and bigleaf maple (*Acer macrophyllum* (Pursh)) (2).

Tree species within the type change with latitude. Douglas-fir is an important associate in Oregon and Washington; Western redcedar is important in British Columbia and extends into southeast Alaska. Pacific silver fir becomes an associate north of the Columbia River and extends north through British Columbia and into Alaska. Alaska-cedar and mountain hemlock become associates north of central Vancouver Island. Shore pine (*Pinus contorta* Dougl. ex Loud. var. *contorta*) is an associate on some sites from Oregon to Alaska. Red alder and black cottonwood are important hardwood associates in seral stands throughout the range; bigleaf maple is common only in the southern latitudes of the type.

The type occupies a coastal strip 2,000 miles (3220 km) long from southern Oregon to south central Alaska (11). Its greatest extent is in southeast Alaska where it reaches a width of 130 miles (210 km) including a narrow mainland strip and offshore islands.

Northwestward, along the Gulf of Alaska, the type narrows greatly, limited by steep mountains and glaciers, widening again to include islands within Prince William Sound. In British Columbia, the Queen Charlotte Islands lie entirely within the type, and a narrow strip extends along the mainland and on the west coast of Vancouver Island with stringers along major streams. In Washington and Oregon, the type occupies a narrow coastal strip and extends inland along streams and rivers.

The type occurs at sea level throughout its range, extending to elevations of 3,000 feet (910 m) in British Columbia and southeast Alaska. North and west from southeast Alaska, upper limits gradually lower to 1,500 feet (460 m) around Prince William Sound. Toward the south the type reaches elevations of 1,800 feet (550 m) along the Oregon coast, and as high as 3,000 feet (910 m) in especially moist situations on the Olympic Peninsula, Wash. (11).

Soils vary by latitude. In the Coast Ranges of Oregon and Washington, Inceptisols and Ultisols are the most widespread. Northward through British Columbia and Alaska, Spodosols and Histosols are more prevalent. Throughout the type, Entisols are found along streams.

From the Olympic Peninsula northward, glaciation has affected soil development. Soils tend to be less well developed northward. In Alaska, most Spodosols have low clay content; colloidal organic and iron compounds are the main source of cation exchange and water retention. They have relatively high moisture retention capacity and relatively high rates of water transmission. A substantial proportion of nutrients is concentrated in the surface organic layers. Even in the deeper soils, tree rooting is generally shallow, and, therefore, destruction or serious disturbance of the upper soil layers is likely to have adverse effects on tree growth (11).

The type is confined to an area of maritime climate with abundant moisture throughout the year, relatively mild winter temperatures, and cool summers. Lack of a pronounced summer drought is an important factor affecting vegetation. Length of growing season and total solar energy received during the growing season decrease northward and account for much of the variation in productivity, soil development, and species composition within the type (3).

Total annual precipitation tends to be high throughout the type, apparently little influenced by latitude; 60 to 150 inches (1525 to 3810 mm) is common with up to 300 inches (7620 mm) in some localities. Local topography greatly influences precipitation. Average depth of snowfall during the winter decreases southward, ranging from 134 inches (3400 mm) at Cordova, Alaska, to 5 inches (125 mm) at Otis, Oreg. Summer precipitation tends to be greater toward the north. Along the southern Alaska coast, frequent cloudiness, light summer drizzle, and fog are common. Toward the south where summer precipitation is less frequent, damp maritime air helps to maintain moist conditions.

Storm winds often sweep in from the Pacific Ocean during the fall and winter, causing frequent wind damage. In Oregon and Washington, the greatest damage is from south and southwest winds of approaching storms. Gale-force winds are most common in October and November. In southeast Alaska the most damaging winds are from the southeast and occur most frequently from September through November. Management strategies have been developed to reduce wind damage in the forest, such as selecting windfirm cutting boundaries, shaping cutting units to minimize the length of cutting boundaries exposed to storm winds, and laying out cutting strips perpendicular to prevailing storm winds with progressive cutting of strips toward the wind (11).

Both western hemlock and Sitka spruce are prolific seed producers. In Oregon and Washington, both species produce some seed most years with heavy crops every 3 to 4 years. In Alaska, a heavy crop occurs every 5 to 8 years. The seed is small and is carried long distances by the wind. Western hemlock is an especially heavy seed producer, and even relatively poor seed crops usually produce enough seed to insure natural restocking (16). Seed production generally is adequate for establishment of regeneration even on large clearcuts, so few areas fail to regenerate from lack of seed. Failures more often are due to competing vegetation (11).

Western hemlock and Sitka spruce seed will germinate and seedlings will grow on both organic and mineral soil seedbeds. Establishment and subsequent growth, however,

are better on soils with a high percentage of organic matter. In Alaska, soils stripped of surface organic material may be unsuitable because underlying soil horizons contain few nutrients to support growth. Exposure of mineral soil also provides a good seedbed for red alder and brush species, which compete with conifers (6).

Shade improves seedling establishment where low moisture or high temperature is limiting. Both duff-covered soil and rotten wood can be good seedbeds under light shade, but too much shade can prevent seedling establishment. Toward the south, exposed organic seedbeds tend to dry out more readily and few seedlings become established on them. On the other hand, soils are deeper and better developed than in Alaska and have more nutrients available in lower soil horizons to support good tree growth (11).

Western hemlock is more tolerant of shade than is Sitka spruce and dominates reproduction in old-growth forests (4). Both species are capable of rapid growth increases if shade is removed.

Soil and ground water conditions are important in determining the success of tree species. Lodgepole pine (*Pinus contorta* var. *latifolia*.), Douglas-fir, and red alder roots can grow in soils with high bulk densities. These soils prohibit the growth of Sitka spruce, western redcedar, and western hemlock. Pacific silver fir ranks between these two groups (9). Red alder, western redcedar, Sitka spruce, and western hemlock are more tolerant of high water tables than is Douglas-fir (8).

Western hemlock–Sitka spruce is one of the world's most productive forest types. Yield tables are available for unthinned even-aged stands of mixed hemlock and spruce in Oregon, Washington, and Alaska. They show that many stands in the southern part of the type's range produce over 200 cubic feet of wood per acre per year (14 m^3/ha/yr) (1, 7, 12). Productivity decreases with increasing latitude (3). Stand volumes can be impressive. One plot in a 147-year-old stand in coastal Oregon contained, on an area basis, 76 spruce and 13 hemlock per acre (188 spruce and 32 hemlock/ha). Total volume was 34,000 cubic feet per acre (2380 m^3/ha). Spruce averaged 210 feet (64 m) in height and 34 inches (86.4 cm) in diameter at breast height (d.b.h.) (4).

Even-aged management is practiced throughout the western hemlock–Sitka spruce type. The optimum rotation age for management of hemlock–spruce depends on the objectives of the landowner. Many hemlock–spruce forests on industrial lands are managed on an economic rotation that varies from about 40 years in accessible, intensively managed areas, to well over 100 years in less accessible areas.

The white pine weevil (*Pissodes strobi* (Peck)) is the most serious enemy of young Sitka spruce in Oregon, Washington, and British Columbia. It is not a problem on the Queen Charlotte Islands nor in southeast Alaska. Within its range, the weevil is more damaging to widely spaced trees on drier sites located inland. Close spacing and the planting of Sitka spruce in small blocks offers the most practical means of minimizing damage in plantations (5). Weevil damage limits the suitability of many sites for future management of Sitka spruce.

The western blackheaded budworm (*Acleris gloverana* (Walsingham)) is an important defoliator of western hemlock and Sitka spruce in coastal forests of Oregon, Washington, British Columbia, and Alaska. Another defoliator, the hemlock sawfly (*Neodiprion tsugae* Middleton), attacks western hemlock. In this order, these are the two most destructive forest insects in coastal Alaska. Other defoliators include the western hemlock looper (*Lambdina fiscellaria lugubrosa* (Hulst)), and the Saddleback looper (*Ectropis crepuscularia* (Denis and Schiffermuller)) (5).

The thin bark and shallow roots of hemlock and spruce make them particularly susceptible to logging injury, which leads to decay, especially in hemlock. Losses from decay fungi are high, especially in the old-growth forests of Alaska. Conversion from old to young growth has great potential for reducing decay, but root rots that reduce growth and vigor then become important. Spread of *Heterobasidium annosum* (Fr.) Bref. from old stumps to new seedlings can lead to damage in hemlock plantations. Extent of damage is correlated with frequency and intensity of thinnings (13). Hemlock dwarf mistletoe (*Arceuthobium tsugense* (Rosend.) G. N. Jones), an important disease of western hemlock, can best be controlled by clearcutting (11).

Fire danger is of less concern here than in drier forest types. The greater concern is in the southern part of the range, particularly inland in the transition zone toward hemlock or Douglas-fir forests. Slash burning to reduce fire hazard has been common wherever conditions were dry enough to permit burning, but the trend now is away from slash burning. Fire does not play an important role in the management of coastal Alaska's forests, and slash burning has not been practiced there (6).

Regeneration of hemlock–spruce forests can be attained with any silvicultural system or combination. The choice depends on profit to the landowner and the need to integrate timber harvest with other forest values.

Clearcutting is by far the most common silvicultural system used in harvesting western hemlock–Sitka spruce stands (11). It is recommended where timber production is the primary use. Logging costs are lower than with other systems. Exposure to the sun raises soil temperature, which speeds decomposition of mor, thereby improving the productivity of northern sites. Clearcutting favors regeneration of Sitka spruce by destroying advance hemlock regeneration and by creating more favorable conditions for post-logging reproduction of spruce. Eliminating residual overstory trees infected with dwarf mistletoe prevents infection of western hemlock in the new stand. Clearcutting also facilitates residue management and fire protection and eliminates the risk of blowdown in residual stands. The chance of blowdown along cutting boundaries is increased but can be reduced through proper design of cutting units.

Natural seedfall is generally adequate for regeneration, and most young stands are dense. Direct seeding has been done to supplement a poor seed crop, alter species composition, or regenerate areas left without a natural seed source, but is not effective if regeneration failures are caused by competing vegetation. Restrictions on use of rodent control chemicals, high cost of seed, and development of improved nursery and planting techniques have made planting a better regeneration method (11).

Planting is often done to reduce the time required for natural regeneration on problem sites, to increase the percentage of Sitka spruce in stands, or to replace Sitka spruce with Douglas-fir in areas subject to weevil damage. Handplanting is required because hillsides usually are too steep for machine planting; flat bottomland is too wet; and where old-growth stands are logged, heavy logging residues create obstacles, even if broadcast burning is done. Both bare-root and container-grown stock are used. Where animal damage is a problem, measures such as use of plastic mesh tubes, chemical repellants, and modification of animal habitat may be necessary to protect seedlings (11).

Clearcutting may be less esthetic than other harvesting systems, although size, shape, and arrangement of clearcuts can be altered to reduce the visual effect. On National Forests in Alaska, openings are limited to 100 acres (40 ha) or less except under specific circumstances. After clearcutting, sev-

eral years may elapse before the site is again fully utilized for timber production, and competing vegetation tends to take over the site more quickly than with the shelterwood or selection systems. In extensive swampy areas, clearcutting may reduce transpiration enough to cause an undesirable rise in the water table. In the northern portions of the hemlock–spruce type where winter snows are deep, clearcutting extensive areas of old growth can impair the quality of deer habitat (14).

Hemlock and spruce lend themselves to shelterwood cutting because both species can become established under a suitable forest canopy. Shelterwood cuttings resemble heavy thinnings, and use of this method logically follows a series of commercial thinnings in immature stands.

The shelterwood system may be preferable to clearcutting where it is essential to maintain a continuous tree cover, to reduce visual change, to reduce erosion, or to minimize encroachment of unwanted intolerant vegetation. Shade can be controlled, thus providing some control of species composition in the regenerating stand. In order of decreasing shade, seedlings of western hemlock, Sitka spruce, Douglas-fir, and red alder are able to become established (10). Logging costs are higher with shelterwood cutting because several entries are made into the stand. There is increased danger of wind damage to the residual stand. Overstocking of western hemlock regeneration can be expected, and growth rate of seedlings is slower under shade (11). The system is not appropriate for stands infected with dwarf mistletoe or for old-growth stands where trees are large and defective.

The selection system has not been tested in the western hemlock–Sitka spruce type, but in theory it appears to have merit. With the selection system, a high uneven-aged forest cover could be maintained, resulting in less visual change and greater stability of environmental conditions. It may have application in scenic areas where both forest cover and commercial timber production are desired, and may be a useful system for maintaining good deer habitat in the northern portion of the type. The system might be used to discriminate against unwanted intolerant plant species by restricting the size of openings.

Disadvantages of the selection system are that frequent entries must be made into the stand to remove trees individually or in small groups, thus increasing logging costs and the chance of logging damage. Risk of wind damage also increases. A more extensive road system needs to be maintained to secure the same volume of timber as obtained by use of other systems, and this could result in increased erosion. It would be the least desirable system where timber production is a major goal.

Converting older, even-aged stands with trees of fairly uniform, large diameters, or stands having several age classes to uneven-aged stands with a progression of diameter classes, would be a lengthy process. The selection system would not be desirable for hemlock stands infected with hemlock dwarf mistletoe.

The seed-tree system offers little advantage for use in hemlock–spruce forests. Overdense regeneration usually occurs even without seed trees; and on problem sites, additional seed offers no guarantee of regeneration success. Exposed trees tend to blow down, and it is costly to harvest them at a later date. From the standpoint of wildlife management, the seed-tree system might be used to provide snags for nesting or perching sites. Selection of seed trees could be based on their suitability for wildlife habitat as well as for seed production (11).

Both hemlock and spruce respond well to release, and growth rates increase immediately after thinning (15). Early precommercial thinning is recommended where stands are overdense. Height growth of Sitka spruce and western hemlock are nearly equal during the period of most rapid growth, but spruce grows more rapidly in diameter. Consequently, thinning from below tends to favor spruce.

Commercial thinning is becoming more common, but conventional logging methods have not proved satisfactory, and economics has limited thinning opportunities in hemlock. Cable yarding is often preferable to use of tracked or wheeled vehicles and is the only practical means on steep slopes. In Alaska, commercial thinning has been limited because of the predominance of old-growth stands, poor accessibility, and limited markets for small material.

Multiple use management of resources is practiced to various degrees in the western hemlock–Sitka spruce type depending on forest ownership, suitability of the land, and relative demands for various resources. Timber is a major resource; recreation, scenery, wildlife, and fish are important resources as well. Hemlock–spruce forests provide habitat for game and nongame animals and watershed protection for spawning and rearing habitat for anadromous fish. They provide recreational opportunities and scenery rarely found in any other forest type.

Clearcutting will doubtless continue to be by far the most economical and practical silvicultural system for use where timber production is a major objective of management. The shelterwood and selection systems could become more widely used in situations where the use or protection of other resources is paramount.

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