Tsuga canadensis (L.) Carr. Eastern Hemlock

Pinaceae Pine family

R. M. Godman and Kenneth Lancaster

Eastern hemlock *(Tsuga canadensis),* also called Canada hemlock or hemlock spruce, is a slow-growing long-lived tree which unlike many trees grows well in shade. It may take 250 to 300 years to reach maturity and may live for 800 years or more. A tree measuring 193 cm (76 in) in d.b.h. and 53.3 m (175 ft) tall is among the largest recorded. Hemlock bark was once the source of tannin for the leather industry; now the wood is important to the pulp and paper industry. Many species of wildlife benefit from the excellent habitat that a dense stand of hemlock provides. This tree also ranks high for ornamental planting.

Habitat

Native Range

The northern limit of eastern hemlock (fig. 1) extends from outliers in northeastern Minnesota and the western one-third of Wisconsin eastward through northern Michigan, south-central Ontario, extreme southern Quebec, through New Brunswick, and all of Nova Scotia. Within the United States the species is found throughout New England, New York, Pennsylvania, and the middle Atlantic States, extending westward from central New Jersey to the Appalachian Mountains, then southward into northern Georgia and Alabama. Outliers also appear in extreme southern Michigan and western Ohio, with scattered islands in southern Indiana and east of the Appalachians in the middle Atlantic States.

The range completely overlaps that of Carolina hemlock *(Tsugu caroliniana),* a closely related species limited to the slopes of the Appalachians from Virginia and West Virginia into Georgia.

Commercial volumes of eastern hemlock have been greatly reduced by harvesting. In Michigan, for example, sawtimber volume decreased 69 percent and growing stock volume decreased 71 percent between 1935 and 1955 *(10).* Both the type area and volume are continuing to decline because of harvesting and failure to regenerate, particularly in the western portion of the range. The remaining saw-timber is concentrated in the Northeast and the Lake States (5).

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Climate

Eastern hemlock is generally restricted to regions with cool humid climates. In the northern areas January temperatures average about -12" C (10° F) and July temperatures about 16" C (60" F). Precipitation ranges from less than 740 mm (29 in) in heavy snowfall areas of the north to more than 1270 mm (50 in) per year, about one-half occurring as summer precipitation. In the more productive areas near the Atlantic coast and southern Appalachians, January temperatures range as high as 6" C (42" F) and annual precipitation exceeds 1520 mm (60 in). The frost-free period is less than 80 days at the northern limits and nearly 200 days in the eastern and southern portions of the range.

Fully stocked stands of eastern hemlock tend to develop similar microclimates because of their dense canopy, dense shading, deep duff layer, and subsequent retention of moisture and uniformly low temperatures. In the few stands in which understories do develop, the type of vegetation tends to be similar to other forest types in the area although fewer species become established (30).

Soils and Topography

The soil requirements for eastern hemlock are not exacting (35). They are universally characterized as being moist to very moist but with good drainage. In the Lake States the species grows on upland sandy loams, loamy sands, and silt loams, often with an abundance of ground or coarse rocky material throughout the upper profile deposited from glacial or fluvial material. In Canada and the northeastern States the soils under eastern hemlock tend to be shallow loams and silt loams, often over granite, gneiss, and slate bedrock (Typic, Lithic, and Entic Haplorthods of the order Spodosols). Typically, most soils are highly acid, particularly in the upper horizons, but some are near neutral. The heavy, slowly decomposing litter fosters podzolization or leaching as the stand increases in age. On sites in which eastern white pine *(Pinus strobus)* is a major component, the soils tend to be of a sandy texture, well mixed with humus, moist, and well drained (Alfic Haplorthods). Scattered patches of hemlock also occur on the finer glacial tills as well (Alfic Fragiorthods), but in general these soils have less hemlock than the coarser soils.

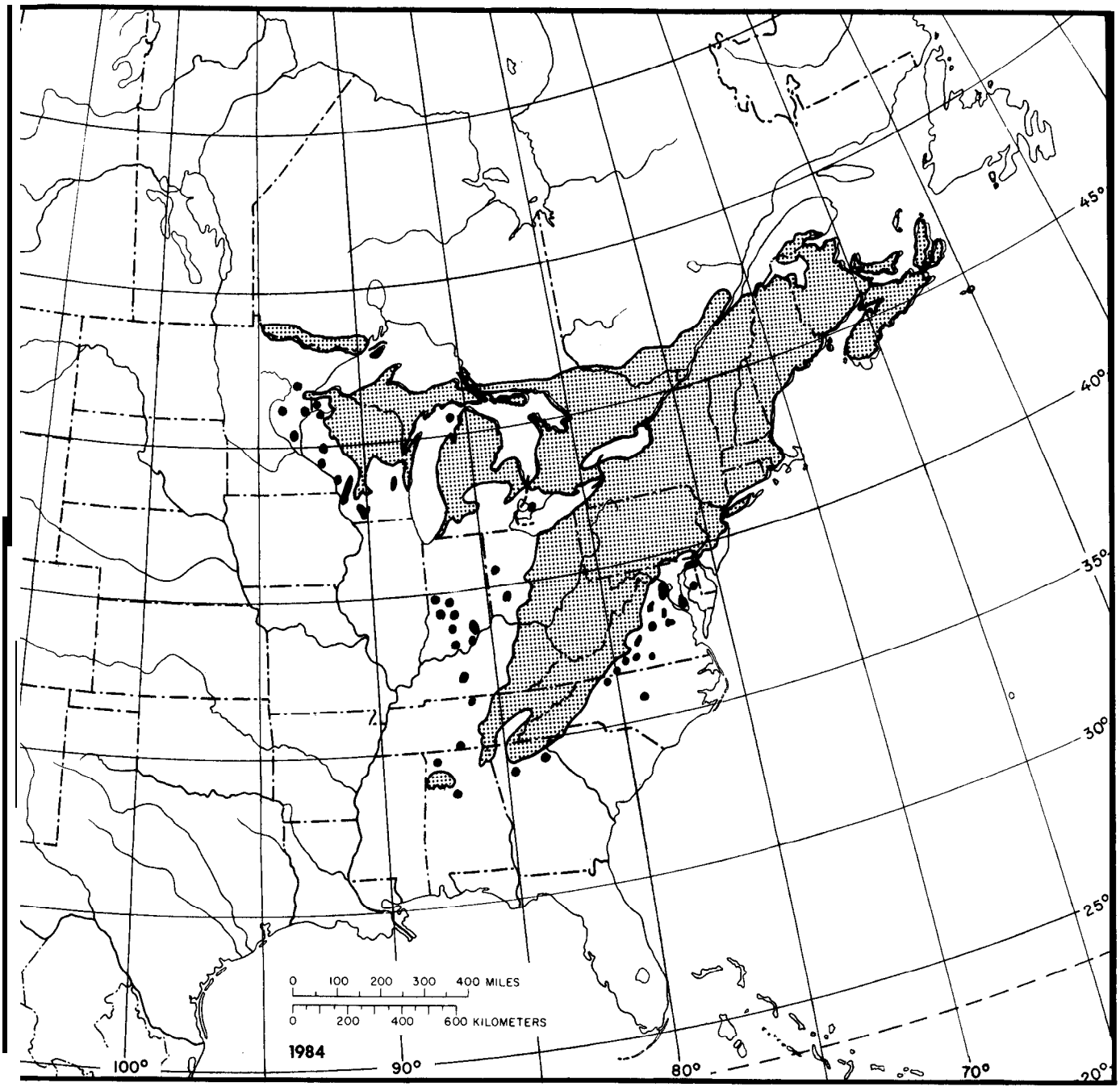

Figure *1-The native range of eastern hemlock.*

Eastern hemlock grows from sea level to about 730 m (2,400 ft) in elevation in the northeastern and northern portions of the range. Most commonly it is found on benches, flats, and swamp borders, provided the peat and muck soils are shallow (Aquic Haplorthods or Aeric Haplaquods). On the Allegheny Plateau, especially in New York and Pennsylvania, most of the hemlock grows between 300 and 910 m (1,000 and 3,000 ft) (35). In the southern Appalachians the most frequent occurrences are at elevations of 610 to 1520 m (2,000 to 5,000 ft) and often are restricted to north and east slopes, coves,

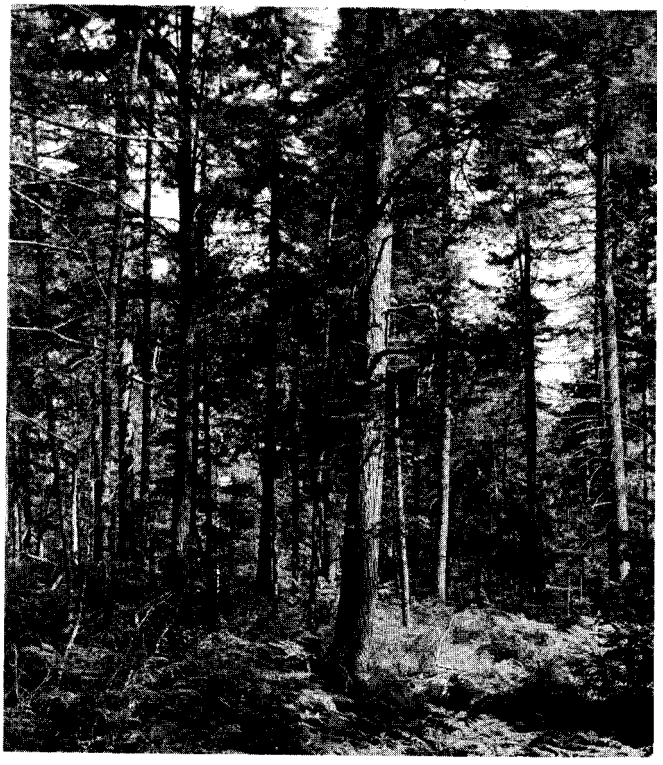

Figure *Z-Eastern hemlock in a red spruce-hemlock selection cut in Maine.*

or cool, moist valleys (35). Outliers tend to be severely restricted by a combination of edaphic and climatic factors.

Associated Forest Cover

Eastern hemlock (fig. 2) is a major component of four forest cover types (9): In the Northern Forest Region, White Pine–Hemlock (Society of American Foresters Type 22), Eastern Hemlock (Type 23), and Hemlock-Yellow Birch (Type 24); in the Central Forest Region, Yellow-Poplar-Eastern Hemlock (Type 58). It is also a common associate in seven types of the Northern Forest Region: White Pine–Northern Red Oak-Red Maple (Type 20), Eastern White Pine (Type 21), Red Spruce-Yellow Birch (Type 30), Red Spruce-Sugar Maple-Beech (Type 31), Red Spruce (Type 32), Red Spruce-Balsam Fir (Type 333, Red Spruce-Fraser Fir (Type 34). Eastern hemlock occurs in the following 18 types but only as a minor species:

5 Balsam Fir
17 Pin Cherry
18 Paper Birch
25 Sugar Maple-Beech-Yellow Birch
26 Sugar Maple-Basswood
27 Sugar Maple
28 Black Cherry-Maple
35 Paper Birch-Red Spruce-Balsam Fir
37 Northern White-Cedar
39 Black Ash-American Elm-Red Maple
44 Chestnut Oak
52 White Oak-Black Oak-Northern Red Oak
53 White Oak
57 Yellow-Poplar
59 Yellow-Poplar-White Oak-Northern Red Oak
60 Beech-Sugar Maple
97 Atlantic White-Cedar
108 Red Maple

Fully stocked stands of eastern hemlock form such a dense canopy that an understory seldom is able to develop. When an understory does exist, the most common herbs are false lily-of-the-valley *(Mianthemum canadense),* star-flower *(Trientalis borealis),* woodfern *(Dryopteris* spp.), common woodsorrel *(Oxalis montana),* goldthread *(Coptis groenlandica),* clubmoss *(Lycopodium* spp.), and sedges *(Carex* spp.). Common mosses are *Dicranum* and *Polytrichum (30,39).*

Life History

Reproduction and Early Growth

Flowering and Fruiting-Flowering in eastern hemlock is monoecious with the flowers in separate clusters on the same branch. Beginning about age 15, male strobili arise from short-stalked light-yellow flower clusters in the axis of needles from the preceding year; they are then surrounded by bud scales to form the male conelet. The shorter ovulate flowers develop on the terminals of the previous year's branchlets and develop into erect conelets. Two ovules occur on each of the bracts. The time of flowering ranges from late April to early June, depending on the locality and season.

Pollen usually is dispersed by the wind beginning about 2 weeks after leaf buds burst, when the bracts on the female conelet are partially open *(28,29,35).* At the close of pollination receptivity, the conelets are in a drooping position and the cone scales reclose. Fertilization is complete in about 6 weeks. During this period the pollen is extremely sensitive to drying, often the cause of seed failure *(28).* Cones reach full size in late August to early September, about the same time as the winter buds begin to form. Cones open fully in mid-October, and seed dispersal extends into the winter. Opened cones may persist on the trees for slightly more than 1 year.

Seed Production and Dissemination-Cones of eastern hemlock are the smallest in the genus, from 13 to 19 mm (0.5 to 0.75 in) long; 35.2 liters (1 bushel) of cones weigh about 15.4 kg (34 lb), and yield from 0.64 to 0.68 kg (1.4 to 1.5 lb) of seed. The number of cleaned seeds ranges from 56,250 to 163,290/kg (25,500 to 74,070/lb). Seeds from eastern and southern areas are usually larger than those from northern and western regions. The seeds of eastern hemlock are slightly larger than those of western hemlock ***(Tsuga heterophylla)*** but are smaller than those of either Carolina or mountain hemlock *(T. **mertensiana)*** (36). The single seeds are about 1.6 mm (0.06 in) long with a slightly longer terminal wing.

Seeds ripen about the time the cones change from yellowish green to purple brown. Dispersal of the seeds begins when the cones turn deeper brown indicating a reduction in moisture content. Most seeds fall within tree height because of the small wings. Additional distribution may occur from drifting on crusted snow. Some seeds may remain in the cones through the winter but usually they are sterile, having developed without an embryo (35). In healthy, vigorous seeds, the embryo extends the full length of the seed.

Eastern hemlock is one of the most frequent cone producers among the eastern conifers. Good or better cone crops occur 61 percent of the years, based on 32 years of observation in Wisconsin *(13,29,37)*. Successive good or better cone crops did occur for one 5-year period and successive poor cone crops for a maximum of only 2 years. Excellent cone production has been reported for trees more than 450 years of age (35).

Seedling Development-Despite the high frequency of cone crops and the long duration of cone production by individual trees, the viability of eastern hemlock seed is usually low. Germinative capacity commonly is less than 25 percent (36). In one locality only 2.1 viable seeds were produced per cone, 2.2 were destroyed by insects, and the remaining 8.0 seeds were empty (29).

Eastern hemlock seed is partially dormant at maturity and must be stratified about 10 weeks at or slightly above freezing temperatures for best germination. Unstratified seed must be exposed to light to break the partial dormancy Under natural conditions the chilling requirements are met during the winter and the spring germination seldom is delayed because of seed dormancy *(35)*. Germination is epigeal.

The temperature requirements for germination of eastern hemlock are more exacting than for other species in the genus. A constant temperature of 15" C (59" F) is about optimum for germination. High germination percentages usually occur at temperatures ranging from 7" to 18" C (44" to 64" F), depending on the seed source *(29,35)*. These temperatures are nearly identical to those required for yellow birch ***(Betula alleghaniensis),*** the most common associated species in the northern region, and help to explain the association of two species differing so much in tolerance. Achieving desirable temperatures for germination under natural conditions is difficult because eastern hemlock seeds require from 45 to 60 days to reach their peak in germinative energy. Contrary to common belief, the species requires a warm, moist site for stand establishment rather than the cool, moist conditions that usually develop as stands mature.

Eastern hemlock seeds are easily damaged by drying. In one study 60 percent of the seeds were severely damaged after only 2 hours of drying, and 80 percent died or did not recover after 6 hours of drying (35). Drying of the seedling after germination caused heavy root mortality that could not be overcome once moisture conditions improved.

Natural stands of eastern hemlock nearly always contain a large component of relatively even-aged trees but consistently have a stocking of older age classes and larger diameter trees that provided shelter during the regeneration period *(17,33,35,39)*. Consequently, new stands of eastern hemlock and yellow birch can be established under a high density overstory (from 70 to 80 percent crown cover) using the shelterwood regeneration system. The site must be prepared, however, by thorough mixing of organic and mineral soil or by prescribed fire to expose a partially decomposed layer *(6,12,14,18,26,32,34, 35,38)*. Under this system, optimum conditions are created for germination and seedling establishment. Without these conditions most eastern hemlock regeneration is restricted to rotten logs, stumps, and mounds that normally have warmer surfaces and better moisture retention than the forest floor.

The rigid overstory and seedbed requirements for successful natural regeneration of eastern hemlock were evident in a direct seeding study in northwestern Pennsylvania. "No hemlock germinated on prepared spots in the open (hemlock rarely germinates and becomes established in open areas) and only a few germinated under a light overstory because of the moisture stress created under these conditions." Germination was good, however, on prepared sites under a pole-size stand, especially on north slopes *(20)*.

Under ideal growing conditions, seedlings of eastern hemlock develop slowly. First-year seedlings may grow only 25 to 38 mm (1 to 1.5 in) in height and the

roots extend less than 13 mm (0.5 in) into the soil. These conditions provide moisture in the upper soil horizon throughout the growing season. "Because of their stable moisture requirements, seedlings are very sensitive to high temperatures and drying of the surface soil during the establishment period. Once the root system has reached a soil depth not radically affected by surface drying, usually after the second year, the seedlings grow more rapidly without interference of overhead shade. Seedlings are fully established when they are 0.9 to 1.5 m (3 to 5 ft) tall and at that time, can be released completely from overhead competition without fear of mortality."

Eastern hemlock seedlings are subject to damping-off as well as root rot fungi *(23,35)*. The fungi may be present in the soil or within the seed before it is dispersed. At least seven species of fungi are known to attack the seed, and several other species cause damping-off. Treatment of seeds with fungicides is frequently ineffective in controlling diseases and also delays or reduces germination. The high incidence of seedling disease combined with low seed viability suggest that supplemental seeding would enhance natural seeding under most conditions.

Vegetative Reproduction-None of the hemlocks sprout and only rarely layer. Vegetative propagation by cuttings and grafting are limited to ornamental production (35). Stem cuttings are easily rooted but auxin treatments will enhance the response under greenhouse conditions. Natural root grafts have been reported in northern Wisconsin.

Most of the stock used in planting, both under forest conditions and as ornamentals, is grown from seed. Nursery grown seedlings grow slowly; 3-O stock ranges from 13 to 23 cm (5 to 9 in) tall. Survival and height growth of planted hemlock, unlike natural regeneration, tend to be good both in the open and under partial overstories. Trees in a study in the Alleghenies grew significantly faster on north slopes under overstories of intermediate densities.

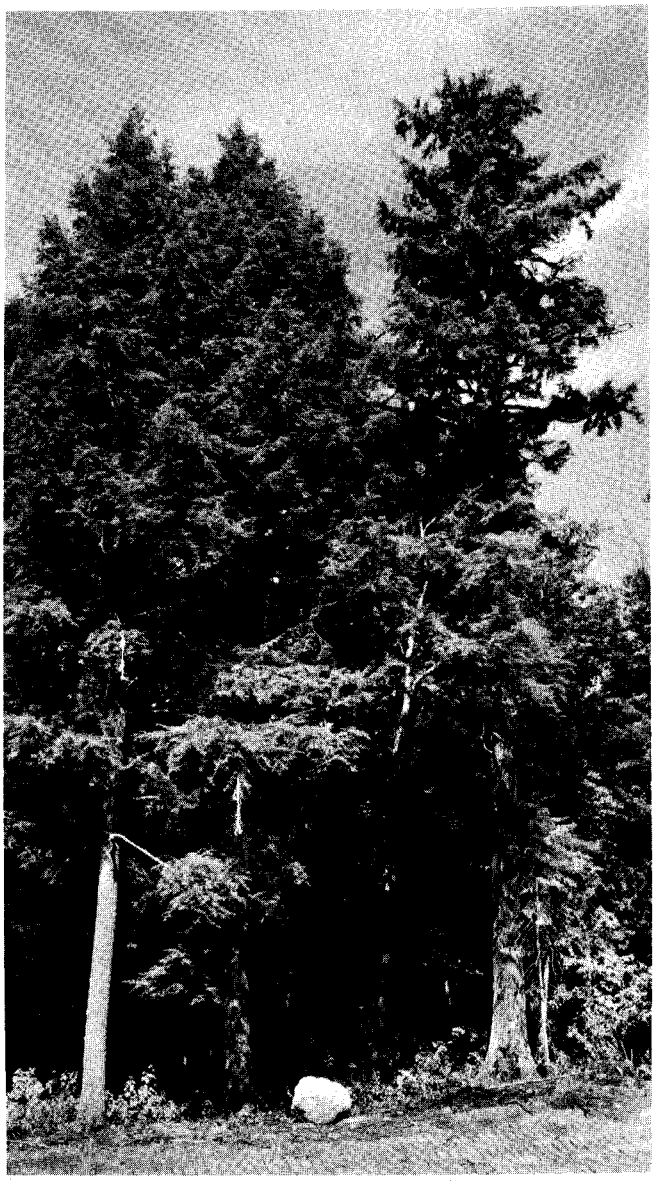

Figure 3-A *large forest-grown eastern hemlock.*

Sapling and Pole Stages to Maturity

Growth and Yield-Because early growth of eastern hemlock is so slow, trees less than 2.5 cm (1 in) in d.b.h. may be as old as 100 years and 5 to 8 cm (2 to 3 in) saplings may be 200 years old (34). Growth during the pole stage also tends to be slow, mainly because of crowding and overstory suppression. One 26 cm (10.3 in) tree in a dense stand, for example, was 359 years old. Other trees of the same age in the dominant portion of the stand ranged from 61 to 91 cm (24 to 36 in) in d.b.h. Although many trees may be suppressed for as long as 200 years, they retain good stem form and live crown ratios.

Mature eastern hemlock trees (fig. 3) attain relatively large diameters and height as well as retaining excellent stem form. The record age is reported to be 988 years, largest diameter 213 cm (84 in), and maximum height 49 m (160 ft) (34). In typical stands, however, ages approaching 400 years, diameters of 89 to 102 cm (35 to 40 in), and heights in excess of 30 m (100 ft) are most common (table 1). "Accurate site index curves are not available for hemlock because most dominant trees have been suppressed during their early years, a result of the species' rigid

Table l-Average dimensions of dominant eastern hemlock trees at selected locations

Age	Southern Applachlans		Michigan		New York	
	D.b.h.	Height	D.b.h.	Height	D.b.h.	Height
yr	*cm*	*m*	*cm*	*m*	*cm*	*m*
40	23	16	14	13	11	12
60	33	22	24	19	19	18
80	43	26	33	23	27	22
100	52	30	41	26	35	26
120	62	33	49	28	43	28
140	71	35	57	29	52	30
160	81	37	65	30	61	31
180	91	38	—	—	70	—
200	100	39	—	—	78	—
yr	*in*	*ft*	*in*	*ft*	*in*	*ft*
40	9.0	53	5.7	42	4.4	39
60	13.1	71	9.4	62	7.4	56
80	16.9	86	12.8	76	10.5	73
100	20.6	98	16.1	85	13.8	84
120	24.3	107	19.4	91	17.1	91
140	28.0	114	22.6	96	20.4	97
160	31.9	120	25.7	100	23.9	102
180	35.7	125	—	—	27.4	—
200	39.5	129	—	—	30.9	—

overstory requirements for successful natural regeneration."

Yields of eastern hemlock tend to be higher than in most forest types except for white pine and red pine *(Pinus resinosa).* In New England, hemlock stands have about twice the volume of oak stands at 80 years of age but only from 50 to 60 percent of the volume of white pine stands at the same age *(35).* In northeastern Wisconsin on a typical loam podzol, well stocked hemlock and yellow birch stands attain volumes of 154 m^3/ha (11,000 fbm) by age 110. On heavier soils, hemlock stands with a mixture of hardwoods reach volumes of 217 m^3/ha (15,500 fbm) at 100 years. In pure, older stands gross volumes are reported in excess of 322 m^3/ha (23,000 fbm) in Wisconsin and more than 560 m^3/ha (40,000 fbm) in New England, but cull percent tends to increase rapidly in large diameter trees *(31,35).*

Rooting Habit-To a great extent, site conditions determine the rooting habits of eastern hemlock. When the watertable is near the surface, root systems are shallow. On better drained sites, deeper rooting patterns may be observed.

Reaction to Competition-Eastern hemlock is the most shade tolerant of all tree species *(3,15,35).* It can survive with as little as 5 percent of full sunlight, but under severe suppression only partial growth rings form and some may be missing entirely from the lower bole areas. In one study, from 10 to 40 rings were missing for a 120-year period of suppression. The tree is capable of withstanding suppression for as long as 400 years.

At all ages, however, eastern hemlock responds to release in both height and diameter growth. Growth rates in excess of 6.4 cm (2.5 in) per decade are possible following release either from side or overhead suppression. Excessive release often results in reduced growth and mortality and has been a contributing factor to partial uprooting or windthrow because of shallow rooting. Trees originating on logs or stumps often develop stilted root systems and also are susceptible to windthrow *(19).*

Even-aged or uneven-aged (selection) management systems can be successfully used to manage hemlock, but with certain limitations on the selection system. In the Lake States, the selection system has not always been successful and is not recommended for upland sites. In the East, the selection system has been used successfully on a limited basis, but the even-aged system is preferred and most frequently used.

A 2- or 3-cut shelter-wood system is the best even-aged method for regenerating eastern hemlock. It is effective because it promotes seed germination and early seedling development by reducing moisture stress. However, the site must be properly scarified and all competing understory hardwoods removed to develop satisfactory seedbed conditions before or immediately after the first and sometimes the second cut.

In mixed stands of hardwoods and hemlock, where the proportion of hemlock is 15 percent or more, it is feasible to manage for hemlock, but at various residual stocking levels. Hemlock does not require as much growing space as hardwoods, so residual stocking is greater in stands where hemlock predominates. For example, a stand of trees averaging 25 cm (10 in) in diameter that contains 15 to '29 percent hemlock would be marked to favor hemlock at a residual stocking of about 22 m^2 (95 ft^2) basal area of both hemlock and hardwoods. This same stand with 30 percent or more hemlock would be managed to 29 m^2 (125 ft^2) of basal area. If less than 15 percent hemlock, the stand should be managed for the hardwood type represented.

Many fully stocked stands of eastern hemlock have basal areas in excess of 69 m^2/ha (300 ft^2/acre). When thinning heavily stocked stands-46 m^2/ha (200 ft^2/acre)—no more than one-third of the total basal area should be removed at one time. Excessive cutting results in reduced growth and increased mor-

tality and contributes to windthrow. In addition, hardwood encroachment interferes with the successful establishment of hemlock. Fully stocked stands with densities less than 46 m^2/ha (200 ft^2/acre) can be thinned to a minimum of 27 m^2/ha (120 m^2/acre) without jeopardizing the residual stand (22).

Acceptable standards for implementation of the uneven-aged system, based on field experience, include a residual stocking of 30 m^2/ha (130 ft^2/acre) in stands predominantly hemlock (50 percent or more); a stand structure (diameter distribution) of 35 percent poles 13 to 25 cm (5 to 10 in) d.b.h., and 65 percent sawtimber 30 cm (12 in) and larger. These guidelines will ensure a balanced growth between poletimber and sawtimber size classes. In addition, a continuous flow of ingrowth will occur and regeneration is assured if prope ' care is given to seedbed requirements.

Damaging Agents-Seeds of eastern hemlock are sensitive to damage from several molds, particularly ***Botrytis*** spp., that reduce or delay germination (23). Some molds are borne internally while others colonize the seeds during germination. In one study, the fungus ***Aureobasidum pullulans*** was isolated from 73 percent of the seedcoats. In another test this mold was isolated twice from the embyronic tissue and 13 times from the seedcoat. Generally, molds are less injurious than desiccation during the germination and seedling stages.

The most damaging agents to young seedlings, other than desiccation, are damping-off fungi and root rots *(16)*. ***Pythium*** spp. and ***Rhizoctonia*** spp. flourish in wet, poorly drained soils and in well-drained soils, respectively, and are common on eastern hemlock. At least three root rots—***Cylindrocladium scoparium, Rhizina undulata*** (common on burn areas), and ***Fusarium moniliforme-are*** common on eastern hemlock. *F. moniliforme* has been isolated from embryonic tissue and seedcoats as well as in the soil *(16,23)*.

Several diseases affect the needles and twigs of eastern hemlock. The rust caused by *Melampsora farlowii* is one of the most damaging. It causes shoot blight and curls and attacks the cone often resulting in cone abortion. Three rusts caused by ***M. abietis-canadensis, Pucciniastrum hydrangeae,*** and *P. vaccinii* spp. affect only the needles. Single needle browning throughout the crown is caused by *Fabrella* ***tsugae.*** Lower foliage in very wet and shady areas often has a grayish mat appearance on both the needles and twigs caused by ***Rosellinia herpotrichioides. Dimerosporium tsugae*** occasionally forms a black, sooty growth on the needles.

Living heartwood of eastern hemlock is attacked by *Tyromyces* ***borealis,*** particularly in the northeast, leaving white flecks in the wood. ***Pholiota adiposa*** is fairly common in the Lake States and causes a cavity along the pith axis. Other rots are the trunk rot caused by ***Haematostereum sanguinolentum;*** a brown, red ring rot caused by ***Phellinus pini***; and a red heart rot caused by *P.* ***robustus.*** The red-varnish-topped fungus, ***Ganoderma tsugae,*** is the most common decayer of stumps and old logs.

Numerous fungi are associated with the root system but rarely develop conks or kill trees. The most common are the shoestring fungus, *Armillaria* ***mellea,*** and the velvet top fungi, *Phaeolus* ***schweinitzii,*** *Tyromyces balsameus*, and ***Heterobasidion annosum.*** At least two mycorrhiza are known to occur on the roots ***(16).***

Although at least 24 insects attack eastern hemlock, few are economically important. The most important is the hemlock borer, ***Melanophila*** *fulvoguttata*, which attacks weakened trees. Symptoms usually consist of woodpeckerlike holes in the bark, galleries filled with dark excrement, and yellowing shoot tips (27). Spruce budworm, ***Choristoneura fumiferana,*** defoliates and kills hemlock after defoliating all the balsam fir in the stand.

The hemlock looper, *Lambdina fiscellaria fiscel-* ***Zaria,*** devours part of the needle after which the remainder turns brown. In nurseries, white grubs of the strawberry root weevil, ***Otiorhynchus ovatus,*** consume the roots, and larvae of the black vine weevil, ***0. sulcatus***, feed on the needles *(40)*. In the eastern States the hemlock scale, *Abgrallaspis ithacae*, damages young shade trees, and the gypsy moth, ***Lymantria dispar,*** kills understory trees.

Numerous animals feed on eastern hemlock and often cause serious damage, marked loss of vigor, or even death. White-tailed deer readily browse this species although it has been ranked seventh in winter food preference. In some regions, patches of regeneration have been eliminated following heavy browsing in years when deer populations are high. Although deer have been blamed for the absence of eastern hemlock in many localities, no regeneration occurred under similar conditions in fenced areas; thus, overstory-site-temperature requirements are presumably more critical *(2,6,8)*.

Snowshoe hares and New England cottontails frequently browse eastern hemlock. Mice, voles, squirrels, and other rodents also feed on seeds and small seedlings both under natural stands and in nurseries *(1)*. Porcupines occasionally gnaw the bark on larger trees causing serious wounds and top-kill (4). Sapsuckers have been associated with ring shake in some areas *(19,21)*.

Small eastern hemlock trees are highly susceptible to wildfire but prescribed burns are beneficial for securing natural regeneration. The thick bark of older trees is resistant to light burns but saplings are usually destroyed. Root injury often occurs from high intensity fires because of heavy litter accumulation.

Drought is probably the most serious damaging agent to eastern hemlock, especially during the seedling stage. Winter drying caused by excessive transpiration on warm, windy days has caused severe needle injury.

In later stages of stand development, heavy cuttings predispose trees to windthrow because of their shallow rooting habit. Older trees are susceptible to radial stress cracks and ring shake, particularly in partially cut stands *(19)*. Eastern hemlock is sensitive to salt spray or drift and sulfur fumes and is one of the species most often struck by lightning *(16,25)*.

Special Uses

Lumber production from eastern hemlock reached its peak between 1890 and 1910. Primary uses were in light framing, sheathing, roofing, subflooring, boxes, crates, and general millwork. Much of the present production is used in pulping or newsprint and wrapping papers, but the demand for hemlock lumber appears to be increasing again.

Currently, eastern hemlock stands are considered essential for shelter and bedding of white-tailed deer during the winter. In regions of marked reductions in type area, many public agencies have restricted cutting until reliable methods of regenerating the stand become operational (6). The type also is considered important as cover for ruffed grouse, turkeys, and many other animals.

Eastern hemlock often is planted as an ornamental because of its relative freedom from insects and disease, good foliage color, and adaptability to shearing. Some effort is being made to plant the species under forest conditions because it is so important to wildlife.

Tannin from the bark of eastern hemlock formerly was extracted for use in processing leather. Now synthetic and important products are used and a once prosperous industry has been eliminated (19).

Genetics

Seedlings grown from 30 seed sources throughout the range showed a pattern of clinal variation in photoperiodic response. However, many species change abruptly when isolated on the basis of physiographic features (35).

Comparison of an outlier source with one from Wisconsin indicated that races of eastern hemlock differ in physiological and morphological characteristics associated with locality (7). No further studies have been reported on the genetics of eastern hemlock and no superior trees have been selected.

The primary effort in genetic research is propagation of variants for ornamental purposes. At least 280 clones are recorded as being variants, ranging from prostrate to weeping forms *(11)*.

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