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Silvical Characteristics of Eastern Hemlock

(Tsuga canadensis)

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by Ashbel F. Hough

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RALPH W. MARQUIS, DIRECTOR

Preface

MUCH of the silvical information on our forest trees is widely scattered and sometimes difficult to find. To make this material more readily available, the Forest Service is assembling information on the silvical characteristics of all the important native forest tree species of the United States. It is expected that this information will be published as a comprehensive silvics manual.

This report presents the silvical characteristics of one species. It contains the essential information that will appear in the general manual but has been written with particular reference to the species in the Northeast. Similar reports on other species are being prepared by this Experiment Station, and by several of the other regional forest experiment stations.

Silvical Characteristics of Eastern Hemlock

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by Ashbel F. Hough

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About the Author ...

ASHBEL F. HOUGH *is a pioneer in U. S. Forest Service research on the Allegheny Plateau, having spent the last 30 years in studies of the ecology, silvics, silviculture, and management of the Allegheny hardwood-hemlock forest region of New York and Pennsylvania. He was graduated from Syracuse University in 1923 and took his Master's degree at Yale in 1927. Formerly in charge of research on the Kane Experimental Forest at Kane, Pa., he is now in the Division of Forest Management Research at the Northeastern Forest Experiment Station headquarters at Upper Darby, Pa.*

The Eastern Hemlock

THE eastern hemlock (*Tsuga canadensis* (L.) Carr.), as its common and scientific names imply, is a native of the eastern United States and adjacent Canada. It is one of the four North American species of this genus. The genus name means "yew-leaved" and is of Japanese origin. In 1763 the species was named *Pinus canadensis* by Linnaeus. The genus was separated from Pinus in 1847 by S. L. Endlicher and the species was named *canadensis* in 1855 by the French botanist Elie A. Carriere. Other common names are hemlock, hemlock spruce, and Canada hemlock *(41)*.

Eastern hemlock is a medium to tall tree that reaches about 125 feet in total height and 36 to 48 inches in diameter. The crown in mature trees is usually pyramidal with graceful horizontal or drooping leader and branches, many branched twigs, and feathery foliage (fig. 1). The needles are flat, petioled, and appear two-ranked; they are about ½ inch long, shiny green above with two white lines below.

The present botanical distribution of eastern hemlock and the commercially or ecologically important portions of its range *(23, 41, 55)* are shown in figure 2. Original stands that sustained commercial operations were found in the Canadain Maritime Provinces and parts of southern Ontario, the New England States, the Lake States, (especially Michigan and Wisconsin). New York, Pennsylvania, West Virginia, and the mountains of the Appalachian region. The range of eastern hemlock overlaps that of the closely related Carolina hemlock (*Tsuga caroliniana* Engelm).

The wood of hemlock is moderately light in weight: 28 to 32 pounds per cubic foot when air dry *(84)*; practically without taste or odor, coarse-grained, moderately hard, relatively weak, easily split, subject to wind-shake, non-durable when exposed to moisture, and low in shock resistance, but has good nail-holding power. The buff to light red-colored heartwood has distinct annual rings with the soft springwood merging gradually into the narrower, harder, and darker summerwood *(5, 84)*. Compression wood is often noted in the early growth rings *(49)*.

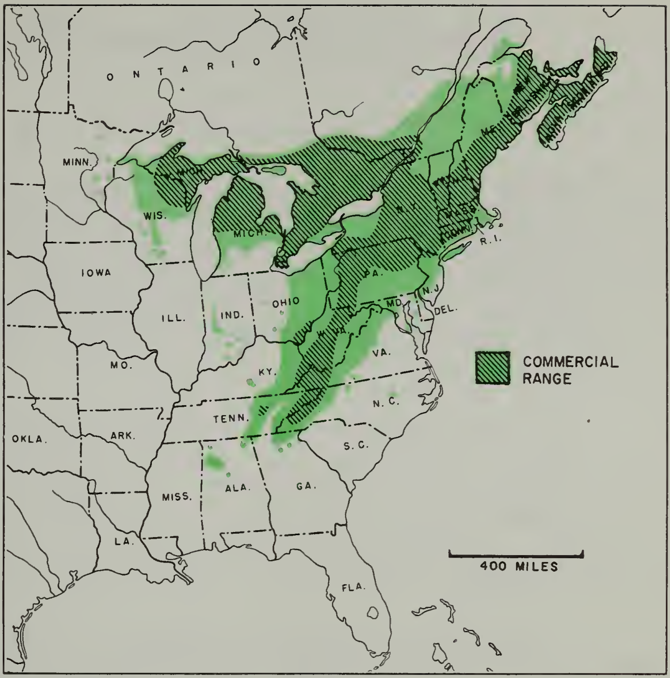
Eastern hemlock is used chiefly for lumber and paper pulp. Minor amounts are used for railroad ties and fuel. Hemlock bark contains 10 to 13 percent tannin and in the past was an important source of tanning material. At one time the tanback was much more valuable than the lumber, and hemlock trees were felled for bark alone, the trunks being left to rot in the woods *(10)*. Under today's economic conditions most of our tanning materials are imported, and little domestic hemlock bark is used for this purpose *(5, 70)*.

Hemlock lumber is used mostly in building construction, including houses and barns, and the like. It is also used in prefabricated housing and panels, for grain doors in freight cars, pallets, and furniture. Smaller amounts are

Figure 1.--*Gracefully drooping branches and feathery foliage are characteristic of the eastern hemlock.*

Figure 2. *The natural range of eastern hemlock.*

DISTRIBUTION MAP BY ELBERT L. LITTLE, JR. U.S. FOREST SERVICE



used for patterns and flasks, general millwork, signs, and flooring.

The peak of eastern hemlock lumber production was reached in 1906 with a cut of 3,431,000,000 board-feet or about 9 percent of the total lumber cut in that year in the United States. The cut declined gradually from 1906 to 1932, reaching a low of 138 million board-feet during the Depression. Production has averaged about 500,000,000 board-feet during the decade 1940-50. Most of the eastern hemlock lumber cut today comes from the Lake States. The same is true for the annual pulpwood cut, which amounts to about 400,000 cords (equivalent to 120,000,000 board-feet), mostly from Wisconsin and Michigan *(5)*.

In addition to its use in commerce, hemlock is a valuable ornamental plant, hedge shrub, Christmas tree, and watershed cover, and it provides food and cover for wildlife *(10, 46, 86)*. Swartley[1] in 1939 listed 63 horticultural varieties or clones. This evergreen adds beauty and variety to our hardwood forests at all seasons of the year.

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[1] Swartley, J.C. Canada hemlock and its variations. Unpublished thesis, 381 pp., illus., 1939. Cornell University Library, Ithaca, N.Y.

Habitat Conditions

CLIMATIC & MICROCLIMATIC

The climate throughout the commercial range of hemlock is predominantly humid and cool, with moisture adequate at all seasons. The botanical range also includes some warmer regions at lower elevations in the Middle West and Appalachians. Local areas of relatively high precipitation in the Adirondacks and southward are also favorable to hemlock *(78)*.

At the limits of its range, hemlock is found in localities with as low as 28 inches average annual precipitation, and only 16 to 18 inches average growing-season precipitation. Throughout the chief commercial range the average annual precipitation is 32 to over 56 inches, with 20 to over 32 inches falling during the growing season *(83)*.

Temperatures range from January averages of 10°F. in the north to 42°F. in the south. Growing-season temperatures are indicated by July averages of 60°F. in Maine and Canada to 78°F. in parts of the southern Appalachians. Length of growing season varies from 80 days or less in the north to 200 days along the Atlantic Coast, the Middle West, and points south *(83)*.

Hemlock in groups or stands possesses the silvical characteristic of producing an exceptionally dense canopy. As a result the microclimate beneath hemlock differs from the regional or open-station climate and from that of adjacent hardwood stands, especially during the growing season *(13, 19, 20, 21, 22, 35, 52, 61, 69)*. Hemlock stands develop similar microclimate even though growing in different latitudes, elevations, physiography, and local sites. Beneath a hemlock canopy the microclimate is cooler and there is less evaporation during the growing season than in adjacent hardwood stands of similar age on similar topography. Hemlock forests 300 miles apart have a closer resemblence, with respect to evaporation as measured by use of atmometers, than hemlock and hardwood stands 300 yards apart *(52)*.

SOIL FACTORS

The zonal soils on which hemlock occurs throughout most of its botanical range are the podzolic, brown podzolic, and gray-brown podzolic groups. Hemlock is found also on humid-region azonal lithosols or shallow soils, such as peat and muck, and groundwater podzols or half-bog soils in Maine, the Lake States, and adjacent Canada. At the southern extreme of its range hemlock is locally found on the gray-brown podzolic, lithosols, and red and yellow podzolic lateritic zonal soil groups of the Appalachians *(82)*.

From Canada and the Lake States into the Middle Atlantic region, the soils that support hemlock have developed largely from glacial or fluvial materials; below the glacial limits the parent materials may be residual, colluvial, or alluvial. The species is very adaptable; in the Northeastern States and Canada it grows on rocky, acid soils *(32, 33)* and on loams and silt loams of circumneutral reaction. In the Lake States it occurs on upland loams and sandy loams as well as on moist benches, flats, and swamp borders that are less well-drained and heavier in texture *(17, 89)*. In the Appalachian Mountains, hemlock grows best on deep fertile loams of alluvial or colluvial origin, though it is found also on shallow and rocky soils *(23, 61)*. The high acidity of hemlock litter fosters leaching or podzolization of the upper soil layers when the species predominates over long periods under a cool moist climate *(63, 64)*. Because of the high acidity and slow decomposition of the litter, the upper soil horizons under hemlock stands tend to be strongly acid. Even where the soils are derived from basic geologic materials, the upper layers commonly will be acid.

PHYSIOGRAPHIC

Although hemlock generally tends to be more abundant and to thrive better on the moister than on the dryer sites, it may be found on nearly all physiographic situations in its commercial range except near timberline *(8)*, in swamps, and in some coastal areas. At its northeastern limits in Canada, it is absent from a narrow coastal strip on the north shore of the Bay of Fundy and along the Atlantic coast of Nova Scotia. It is absent also from the highlands of northwestern New Brunswick and Cape Breton Island.

On the Northern Peninsula of Michigan, hemlock goes to the top of the Porcupine Mountains at 2,000 feet elevation *(7, 12, 17)*; probably proximity to Lake Superior is a favorable factor in this area near the northern limit of the species' range. In the southern Appalachians, hemlock is found mostly in the 2,000 to 5,000-foot elevation belt *(38)*. It occurs on all topography from 1,000 to 3,000 feet on the dissected Allegheny Plateau *(7, 8, 36)*.

It is in the westward and southern extensions of its range that physiographic and associated factors restrict the occurrence of hemlock to the greatest degree. In such areas of below-optimum climate, hemlock is confined to moist, cool, valleys, north and east slopes, coves, benches, and sides of ravines or hollows under cliffs *(23, 39, 68)*. In the lower Piedmont of North Carolina a relict stand of hemlock has persisted on north-facing bluff topography because of certain soil and physiographic factors *(61)*. Studies of hemlock outliers in Indiana *(13, 19, 20)* and in North Georgia and Alabama *(51)* likewise show the importance of physiography near the limits of the species' range.

BIOTIC

Hemlock is found in both the northern and central forest regions *(47)*, and in a large number of individual cover types *(71)*. The relationships of region, life zone (plant and animal), natural tree associations, and cover-type groups, is shown in the following tabulation:

Life zone & forest region	Natural forest formations or tree associations	SAF cover-type groups	Geographic extent	Relative importance of hemlock component
Canadian or Northern Forest	Spruce-fir	30-36	Canada, Lake States, New England, New York (mountains), West Virginia and south in Appalachian Mountains	Minor to fairly important.
	Northern hardwoods-hemlock; Allegheny hardwoods-hemlock; (Beech-birch-maple-hemlock)	22-29 & 60	Canada, Lake States, New England, New York Pennsylvania, Ohio, West Virginia and south in Appalachian Mountains below the spruce-fir	Very important; typical region of original and present hemlock forest.
Carolinian or Central Forest	Mixed oak-hickory; yellow-poplar	52-59	Southern Lake States, Southern New England, Central New York, New Jersey, Pennsylvania, Maryland, West Virginia, Ohio, & Kentucky, and south to northern Alabama & Georgia	Minor in most of area but may be locally important.
	Shortleaf pine-Virginia pine-oak	75-79	New Jersey, Delaware, Maryland, West Virginia, North Carolina, eastern Kentucky, eastern Tennessee, and south to northern Alabama & Georgia. Generally on drier sites than mixed oak-hickory-yellow poplar	Very minor; local on favorable cove sites.

White-tailed deer on depleted ranges may severely browse hemlock during the winter months. Repeated browsing can stunt or kill small seedlings and saplings *(76)*. Damage is especially pronounced in hemlock thickets in valley bottoms used as winter shelter by deer. The Canada porcupine wounds larger trees by gnawing bark and sometimes kills smaller ones by branch-pruning *(74)*. Red squirrels, mice, chipmunks, and some birds eat hemlock seed *(46, 86)*. Some damage is done by the snowshoe rabbit or varying hare during population peaks *(18, 28)*.

Two species of hemlock loopers, *Lambdina fiscellaria fiscellaria* and *L. athasaria athasaria*, may defoliate hemlock and sometimes cause sporadic or local tree mortality *(87)*. Of 24 insects having hemlock as a host, these two loopers and the hemlock borer, *Melanophila fulvoguttatta*, which usually attacks only weakened trees, are the only species of economic importance *(11)*.

Disease organisms of economic importance in causing death or decay losses in living trees are relatively few for eastern hemlock *(6)*. Heart rot is caused by the red ring rot fungus *Fomes pini (62)*, the velvet top fungus *Polyporus schweinitzii*, the brown butt rot *Polyporus balsameus*, and the white root conk *Poria subacida*. Occasionally damage is done to weakened trees by the honey fungus or shoestring rot *Armillaria mellea (67)*. Rarely found on living hemlock are the red belt fungus *Fomes pinicola*, the rusty conk *Polyporus gilvus*, and *Polyporus borealis*. Access points for fungi are afforded by porcupine scars, sunscald wounds *(90)*, and radial stress cracks due to wind and frost.[2]

Life History

SEEDING HABITS

Flowering & Fruiting

Differentiation of male and female flower buds begins about July 1 (New York and Pennsylvania); the males are well-formed by the end of July and the females by October. Flowers appear from April to early June, depending on lati-

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[2] Hough, A.F. The forests of the Allegheny Plateau; their ecology and silviculture. Unpublished manuscript, 383 pp., 1941. Northeast. Forest Expt. Sta.

Figure 3 --*Cones of eastern hemlock. Mature cones open when dry and close when wet, so seed dispersal is intermittent, occurring only in dry weather.*

tude, elevation, and seasonal advance *(23)*. Male and female flowers are found on the same general branch but usually on different shoots, the male being in leaf axils of 2-year-old, or rarely 3-year-old, shoots and generally in clusters *(3, 16)*. Pollination is by wind *(56)*.

Seed Production & Dissemination

After fertilization the female flower develops into a mature cone 1/2 to 3/4 inches long, by September or October (fig. 3). Only about 20 scales in the central part of the cone bear seed.[3]

The small winged seeds are shed during the fall and winter following cone maturity (fig. 4). The cone scales are hygroscopic, which causes them to open when dry and close when wet. Seed dispersal therefore is intermittent,

[3]Prentiss, Albert N., and Griffith, Edward M. The hemlock (Tsuga canadensis). Its history, biology, and economy. Unpublished manuscript, 1908. Copy on file in National Archives, Washington, D.C.

occurring only in dry weather and particularly during dry windy periods.[3] This favors wide dispersal. Judging from studies of western hemlock, dispersal up to 4,500 feet might be expected in a 20-mile wind *(37)*. The bulk of the seed of course falls closer to the mother tree.

Good seed crops occur every 2 or 3 years in mature stands *(23)*. Trees fruit when 20 to 40 years old in the open and at 30 to 50 years in moderate light *(50)*. Suppressed trees under a dense canopy do not fruit--regardless of age. Mature, dominant, old-growth trees continue to produce cones abundantly up to 450 or more years of age *(36)*.

The number of cleaned seeds per pound varies from 132,000 to 360,000, with an average of 187,000 *(85)*.

VEGETATIVE REPRODUCTION

Hemlock does not sprout naturally. Vegetative propagation by layers, shoot cuttings, or grafting is not practiced as a rule except for horitcultural uses. Horticulturists successfully graft clonal varieties to propagate ornamentals. Bud or shoot grafts are used. Layering in nature is very rare, though it has been noted in a few cases.[4] In general, hemlock roots readily from shoot cuttings properly treated. Use of auxins increases success *(77)*.

[4]Schreiner, E. J. Personal communication, 1956.

Figure 4.
The small winged seeds are shed during the fall and winter after cone maturity.

SEEDLING DEVELOPMENT

The germination of eastern hemlock seed commonly is low (20 to 30 percent), but usually can be increased to 40 to 60 percent by stratification in moist sand or peat moss for 60 to 100 days at 30 to 40°F. *(1, 2, 3, 4)*. In nursery culture, fall sowing is recommended because dry storage at room temperatures causes rapid loss in viability. Storage in sealed containers at low temperatures (41°F.) retained viability for 4 years (46 percent) but practically no seed germinated at 6 years *(3)*.

Natural dissemination of seed, from September through the winter, results in cold moist stratification on the ground or forest floor. Seed germinates from March or April in the South until late June or even July in the North. Germination follows the epigeous pattern *(85)*.

Hemlock germination and initial survival are most successful on shaded, moist, cool sites. Given such site conditions, the prerequisites for good germination are seed stratification and suitable temperatures. There is good evidence that germination is influenced by length of day *(59)*, and also by the interaction of photoperiod and temperature *(60, 72)*. Favorable seedbeds are moist, well-decomposed litter, rotted wood, mineral soil, and moss mats on soil or on rocks *(17, 36)*. Mineral soil, however, is less favorable than the other media for initial survival because the tiny seedlings are susceptible to washing-out or mudding-under in heavy rains, and to frost-heaving.

Detailed observations on the location of establishment of all hemlock on 10 acres of virgin forest in Pennsylvania showed that 76 percent of trees 1 inch d.b.h. and larger originated on soil of normal relief, 16 percent on upturned mineral soil, 5 percent on rotted wood, and 3 percent on large rocks. More trees originated on rotted wood and mineral soil on dry sites than on well-watered sites.[2]

Seedling development during the first growing season is slow, the shoot reaching a length of 1.0 to 1.3 inches by autumn. The three seed leaves are replaced by a rosette of 8 to 12 needles about half the size of the needles on older trees. The root system at the end of the first season consists of a short taproot and a few laterals; depth of taproot penetration may be as much as 5 inches, but often is no more than 1 inch.[3] Root development in succeeding years is primarily in the laterals, and the taproot soon loses its identity.

Early survival of hemlock seedlings depends upon continuous availability of moisture in the upper soil horizons through the growing season, and upon adequate light. Trenching experiments under forest canopies have shown that moisture is the more critical factor except perhaps in the densest shade. Under average canopies, when plots were freed from the moisture-depleting effects of roots from the overstory trees, hemlock seedlings and many other plants thrived despite the shade *(79)*. The importance of soil moisture shows up particularly on dry sites or in regions of relatively low rainfall. There is considerable evidence that, in these places, hemlock establishment is periodic, occurring in substantial numbers only during years of greater than normal rainfall *(19, 20, 24, 25, 26, 36, 42, 61)*.

Hemlock seedlings have a very low light requirement. In fact, establishment is much better in shade than in full sun, one reason being that in sun the soil often dries out below the depths reached by the shallow seedling roots. In medium to heavy shade, soil desiccation is reduced much more than seedling vigor; with light as low as 20 percent of full sunlight, hemlock seedlings commonly will grow with sufficient vigor to maintain their roots below the level of surface soil drying *(42)*.[5]

Full sunlight is detrimental to seedling establishment, by causing direct heat injury. Heat lesions on the young stems may result from exposure to the sun on any kind of seedbed, but are most severe on dark-colored, organic seedbeds of poor conductivity. Here, even brief exposure can build up surface temperatures to as high as 165°F. With young, unlignified seedling stems, such temperatures are lethal *(58, 80)*.

Hemlock seedlings are subject to damping-off and root-rot fungi, both in natural seedbeds and in the nursery *(58)*. In a hardwood forest, the slow-growing seedlings also are subject to smothering under hardwood leaf fall during the first 3 to 5 years of their life.

SAPLING STAGE TO MATURITY

The cool, moist conditions and shade that favor hemlock seedling establishment are equally favorable for the subsequent development of the seedlings and saplings. However, as root systems become well established and stems become woody, the young trees can withstand considerable ex-

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[5] Ostrom, C. E. Hemlock regeneration studies. Unpublished manuscript, 1941. Northeast. Forest Expt. Sta.

posure. They may thrive in small forest openings or along a woods edge in fairly strong light, provided the soil is moist and taller trees are close by to temper drying winds. The species has relatively low mineral nutrient requirements.

Hemlock is remarkably tolerant of low light intensities. As little as 5 percent of full sunlight will enable older seedlings to live, though growth will be negligible *(9, 27)*. In natural stands advance-growth hemlock often undergoes periods of suppression ranging from 25 to over 200 years *(36)*. Under a hemlock-beech forest a seedling may take 40 to 60 years to reach a height of 6 feet, while those growing under somewhat lighter canopies may require only 20 to 30 years to reach the same height *(30)*. Despite suppression, such understory saplings for the most part are well formed, with fairly full crowns. The competitive ability of hemlock in a virgin stand is better over a long time period (200 to 400 years) than that of any associated tree species *(29, 36)*.

Under severe suppression, hemlock saplings may not form a growth ring, or at least not a complete ring, every year. In one study in a virgin stand, cross-dating showed 10 to 40 rings missing at root-collar level over a 123-year period of suppression *(81)*.

Hemlocks less than 1 inch d.b.h. are sometimes over 100 years old and 2- to 3-inch saplings may be as much as 200 years old. One 10.3-inch tree in a dense virgin stand examined by the author was 359 years old; neighboring trees of about the same age but of dominant crown class were 24 to 36 inches in diameter *(36)*.

Vigorous seedlings and saplings in light to medium shade may grow 8 to 12 inches per year in height[3]; in full sun, with ample soil moisture, the growth may be 18 inches or more. Understory saplings respond well to release; after removal of the overstory they may put on 4 inches of diameter increment per decade. Such released trees continue rapid growth and often become dominant *(34)*. According to Marshall *(45)*, hemlocks with a history of suppression and release make better final growth than those free to grow from the start.

The vigor and rapidity of response to release is related to crown development of the individual tree: those with fairly full crowns at the time of release often respond the first year *(34)*; in those with a live-crown ratio between 33 and 50 percent, the response may be delayed a few years; those with a live-crown ratio of 25 percent or less

Figure 5.--*A mature stand of hemlock in western Maryland. Hemlock grows to 125 feet in height and 48 inches in diameter.*

usually are very slow to respond.[6] Hemlocks under hardwoods commonly have better crowns and respond to release more promptly than those that have grown under other hemlocks.

At maturity, hemlock may reach large size and great age. The record for age is 988 years; for d.b.h., 84 inches; and for total height, 160 feet *(23, 53)*.[3, 7] These trees were in original old-growth stands. Even at the critical northern, western, and southern limits of its range, hemlock grows to commercial size *(7, 12, 13, 23, 51, 68)*.[3]

Hemlock is relatively shallow rooted *(23)*.[3] Consequently, on a given site, it tends to be more subject to drought injury than some associated species. Severe droughts may cause appreciable mortality *(31, 48, 67, 73)*. Its shallow rooting habit also is a factor predisposing to uprooting by wind *(17, 36, 75)*. Windthrow occurs most frequently on wet sites and on shallow or slow-draining soils that become waterlogged during heavy rains. Trees that have become stilt-rooted, after having started on boulders, old logs, or stumps, are highly vulnerable to windthrow.

Wind also causes radial stress cracks and windshake (cracks between growth rings) in some larger-size hemlocks; these defects often are associated with heart rot.[2] Unlike many of its associates, hemlock is not much damaged by glaze storms because of its drooping flexible branches *(15)*.

When mature hemlocks are suddenly exposed, as by logging or windthrow of nearby trees, they often undergo injury and some mortality *(17)*. Probable factors are sunscald *(90)*, damage to feeding roots by increased soil temperatures, and attack by the hemlock borer, which is attracted by weakened trees *(11, 25, 26, 67)*.

Young hemlocks are highly vulnerable to damage and death by fire; older trees may survive the lighter surface fires by virtue of their thick bark, but the roots are easily injured by any fire that burns deeper than the loose surface litter. Hemlock has been almost eliminated from many areas in the past by forest fires. Now, with more intensive fire control, the species is holding its own or is increasing throughout much of its range.[8]

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[6] Nienstaedt, Hans. Personal communication, 1956.

[7] Hartline, D. S. Personal communication, 1939; this concerned a 969-year-old hemlock mentioned by T. M. Cope in 'The wilderness of old North Mountain' in Amer. Forests 42: 412-434, 1936.

[8] Olson, Jerry S. Personal communication, 1956.

Hemlock is often associated with white pine in stands that have originated after fire, windthrow, or other catastrophic disturbance *(36, 43, 44, 53)*, thus exhibiting some traits of a pioneer species. In contrast to the pine, however, the tolerant hemlock can also start under established forest stands and slowly advance to a dominant position without benefit of a major disturbance, in this way behaving as a climax species *(24, 29)*. On favorable sites, commonly in association with beech and sugar maple, it forms climatic climax associations capable of self-perpetuation *(7, 22, 29)*. In such stands the shrubby and herbaceous vegetation is notably sparse.

On the edge of its range in Indiana and in the lower Piedmont of North Carolina, hemlock occupies sites intermediate between the climax beech-maple or beech and the oak-hickory type *(19, 20, 21, 61)*. Fossil pollen profiles from the northeastern United States indicate that hemlock was an important species during periods of Atlantic Climate in the post-glacial era *(7, 14)*.

Special Features

Hemlock bark has been used in dye works as a source of a brown dye prior to the development of synthetic dyes *(10)*. Oil of hemlock is distilled from the needles and twigs for medicinal use *(5, 10, 66)*. The oleoresin of hemlock from wounded tissues, knots, or needles, has been used by the American Indians and early settlers as a drug for external poultices known as "Canada pitch". A turpentine-like material from hemlock resin has been used as a rubbing compound for aching muscles. Hemlock bark extract provides a powerful astringent. A paste of the boiled bark of young hemlock has been used by the Indians as a wound dressing *(10)*.

For use as ornamentals, many eastern hemlock varieties are cultivated in North America *(65)*, the British Isles, and Central Europe, Hemlock was introduced into England as early as 1736 *(10)*.

The drooping character of the terminal shoot of eastern hemlock, which swings freely in the wind and gradually turns up as the result of compression-wood production as the season advances, differs from the growth pattern of most orders of temperate conifers. Stresses between normal wood and compression wood were induced by gentle bending of frozen leaders and may be the start of shearing failures known as ring shakes *(49)*.

Racial Variations

No distinct races in eastern hemlock have been recognized by taxonomists. In view of the wide geographical distribution of the species, it is highly probable that climatic-geographic races do exist. Heritable differences in characteristics of seed germination and development of seedlings from regions of long growing season and short growing season have been reported *(57, 59, 60, 72)*.

The horticultural varieties are sometimes given scientific names, usually trinomials; but these are ornamental forms, or seed-variation clones, and are not the natural sub-species or varieties of the botanist. STANDARDIZED PLANT NAMES lists 62 such horticultural types by common name *(40)* following Swartley[1] and others.

The so-called "white" and "red" hemlocks distinguished by lumbermen on the basis of wood characteristics in virgin timber are regarded as variations related to site and growth rate, rather than to genetic differences *(54)*.

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