


eastern hemlock Pinaceae *Tsuga canadensis* (L.) Carrière 
symbol: TSCA



Leaf: Evergreen, flat, single needles, 1/2 inch long, tapering to a dull point, primarily two-ranked, shiny dark green above, 2 lines of white stomata below.

Flower: Monoecious; males yellow, small, round; females light green at branch tips.

Fruit: Ovoid light brown cone, 3/4 inch long with rounded, entire scales, maturing in early fall.

Twig: Slender, gray-brown in color; buds are very small.

Bark: Initially gray-brown and smooth then turning scaly; older trees are red-brown with wide ridges and furrows; when cut or broken, purple streaks are obvious.

Form: A medium sized tree with a dense, conical crown, fine branches and a drooping terminal shoot reaching up to 80 feet tall, typically a poor natural pruner.



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Tsuga canadensis is native to North America. Range may be expanded by planting.
[See states reporting eastern hemlock](#) (opens a new window).

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Text written by: John R. Seller, Edward C. Jensen, or John A. Peterson

USDAFS Silvics of North America

Tsuga canadensis (L.) Carr.

Eastern Hemlock

Pinaceae -- Pine family

R. M. Godman and Kenneth Lancaster

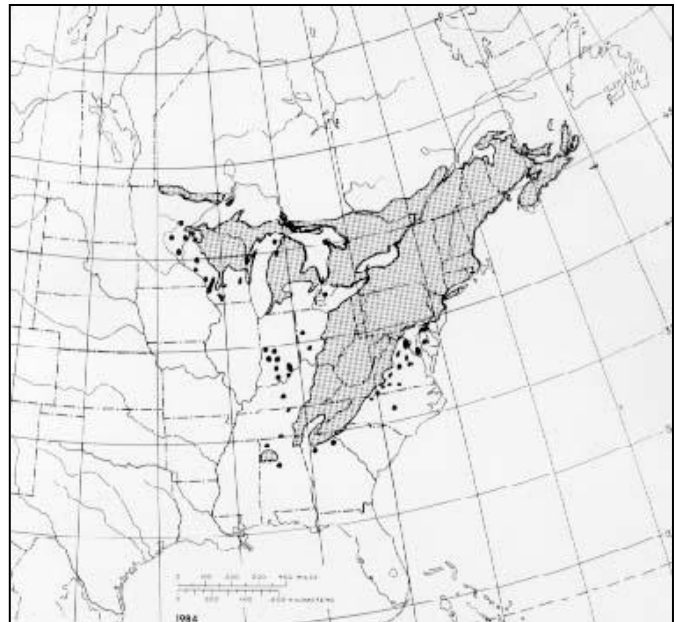
Eastern hemlock (*Tsuga canadensis*), also called Canada hemlock or hemlock spruce, is a slow-growing long-lived tree which unlike many trees grows well in shade. It may take 250 to 300 years to reach maturity and may live for 800 years or more. A tree measuring 76 inches in diameter at breast height (dbh) and 175 feet 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 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 native range of eastern hemlock.

The range completely overlaps that of Carolina hemlock (*Tsuga 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 sawtimber is concentrated in the Northeast and the Lake States (5).

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.

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

Associated Forest Cover

Eastern hemlock 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 33), 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*), starflower (*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; 3-0 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.

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 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 overstory requirements for successful natural regeneration."

Table 1- Average dimensions of dominant eastern hemlock trees at selected locations						
	Southern Appalachians		Michigan		New York	
Age	D.b.h.	Height	D.b.h.	Height	D.b.h.	Height
<i>yr</i>	<i>cm</i>	<i>m</i>	<i>cm</i>	<i>m</i>	<i>cm</i>	<i>m</i>
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	-
<i>yr</i>	<i>in</i>	<i>ft</i>	<i>in</i>	<i>ft</i>	<i>in</i>	<i>ft</i>
40	9.0	53	5.7	42	4.4	39
60	13.1	71	9.4	62	7.4	58
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	-

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 m³/ha (11,000 fbm) by age 110. On heavier soils, hemlock stands with a mixture of hardwoods reach volumes of 217 m³/ha (15,500 fbm) at 100 years. In pure, older stands gross volumes are reported in excess of 322 m³/ha (23,000 fbm) in Wisconsin and more than 560 m³/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 shelterwood 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 m² (95 ft²) basal area of both hemlock and hardwoods. This same stand with 30 percent or more hemlock would be managed to 29 m² (125 ft²) 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 m²/ha (300 ft²/acre). When thinning heavily stocked stands- 46 m²/ha (200 ft²/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 mortality and contributes to windthrow. In addition, hardwood encroachment interferes with the successful establishment of hemlock. Fully stocked stands with densities less than 46 m²/ha (200 ft²/acre) can be thinned to a minimum of 27 m²/ha (120 m²/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 m²/ha (130 ft²/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 proper 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 *Aureobasidium pullulans* was isolated from 73 percent of the seedcoats. In another test this mold was isolated twice from the embryonic 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. abietiscanadensis*, *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 woodpecker-like 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 fiscellaria*, devours part of the needle after which the remainder turns brown. In nurseries, white grubs of the strawberry root weevil, *Otiorynchus ovatus*, consume the roots, and larvae of the black vine weevil, *O. 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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USDAFS Additional Silvics

Index of Species Information


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Introductory

SPECIES: *Tsuga canadensis*

AUTHORSHIP AND CITATION :

Carey, Jennifer H. 1993. *Tsuga canadensis*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: <http://www.fs.fed.us/database/feis/> [2009, November 2].

ABBREVIATION :

TSUCAN

SYNONYMS :

NO-ENTRY

SCS PLANT CODE :

TSCA

COMMON NAMES :

eastern hemlock
Canada hemlock
hemlock spruce

TAXONOMY :

The currently accepted scientific name for eastern hemlock is *Tsuga canadensis* (L.) Carr. [35]. Fernald [15] recognizes a dwarf form, *T. canadensis* forma *parvula* Vict. and Rousseau, that grows in mats up to 3 feet (1 m) high in Quebec and New England.

LIFE FORM :

Tree

FEDERAL LEGAL STATUS :

No special status

OTHER STATUS :
NO-ENTRY

DISTRIBUTION AND OCCURRENCE

SPECIES: *Tsuga canadensis*

GENERAL DISTRIBUTION :

In the United States, eastern hemlock occurs throughout New England, the mid-Atlantic states, and the Lake States, and extends south in the Appalachian Mountains to northern Georgia and Alabama and west from the mountains into Indiana, western Ohio, and western Kentucky. At its northern limit, eastern hemlock ranges along the southern border of Canada from southern Ontario to Cape Breton Island, Nova Scotia [[20,35](#)].

ECOSYSTEMS :

FRES10 White - red - jack pine
FRES11 Spruce - fir
FRES15 Oak - hickory
FRES18 Maple - beech - birch
FRES19 Aspen - birch

STATES :

AL CT DE GA IN KY ME MD MA MI
MN NH NJ NY NC OH PA RI SC TN
VT VA WV WI NB NS ON PE PQ

BLM PHYSIOGRAPHIC REGIONS :

NO-ENTRY

KUCHLER PLANT ASSOCIATIONS :

K093 Great Lakes spruce - fir forest
K094 Conifer bog
K095 Great Lakes pine forest
K096 Northeastern spruce - fir forest
K097 Southeastern spruce - fir forest
K103 Mixed mesophytic forest
K104 Appalachian oak forest
K106 Northern hardwoods
K107 Northern hardwoods - fir forest
K108 Northern hardwoods - spruce forest

SAF COVER TYPES :

5 Balsam fir
17 Pin cherry
18 Paper birch
19 Gray birch - red maple
20 White pine - northern red oak - red maple
21 Eastern white pine

- 22 White pine - hemlock
- 23 Eastern hemlock
- 24 Hemlock - yellow birch
- 25 Sugar maple - beech - yellow birch
- 26 Sugar maple - basswood
- 27 Sugar maple
- 28 Black cherry - maple
- 30 Red spruce - yellow birch
- 31 Red spruce - sugar maple - beech
- 32 Red spruce
- 33 Red spruce - balsam fir
- 34 Red spruce - Fraser fir
- 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
- 58 Yellow-poplar - eastern hemlock
- 59 Yellow-poplar - white oak - northern red oak
- 60 Beech - sugar maple
- 97 Atlantic white-cedar
- 108 Red maple

SRM (RANGELAND) COVER TYPES :
NO-ENTRY

HABITAT TYPES AND PLANT COMMUNITIES :

Eastern hemlock occurs as a dominant or codominant in coniferous and mixed-hardwood forests. It is often the only conifer present in mixed mesophytic forests of the eastern United States [\[40\]](#).

Publications listing eastern hemlock as codominant or dominant are as follows:

The natural forests of Maryland: an explanation of the vegetation map of Maryland [\[7\]](#)

A multivariate analysis of forest communities in the western Great Smoky Mountains National Park [\[9\]](#)

The vegetation of Wisconsin [\[10\]](#)

The principal plant associations of the Saint Lawrence Valley [\[11\]](#)

Field guide: forest habitat types of northern Wisconsin [\[32\]](#)

A classification of the deciduous forest of eastern North America [\[42\]](#)

The natural communities of South Carolina [\[45\]](#)

Forest associations in the Harvard Forest [\[55\]](#)

Vegetation of the Great Smoky Mountains [\[65\]](#)

MANAGEMENT CONSIDERATIONS

SPECIES: *Tsuga canadensis*

WOOD PRODUCTS VALUE :

Eastern hemlock wood is of low value because of brittleness and abundant knots [26]. It is used for pulp, light framing, sheathing, roofing, subflooring, and boxes and crates [20].

IMPORTANCE TO LIVESTOCK AND WILDLIFE :

Dense stands of eastern hemlock provide excellent wildlife habitat [20]. Cove forests in the southern Appalachian Mountains provide nesting habitat for many species of birds. The black-throated blue warbler, black-throated green warbler, and blackburnian warbler are especially abundant in virgin eastern hemlock cove forests [25].

Large eastern hemlocks can be climbed by small black bear cubs. In northeastern Minnesota, black bear mothers and cubs spent more than 95 percent of the time in April and May within 600 feet (183 m) of either an eastern hemlock or an eastern white pine (*Pinus strobus*) larger than 20 inches (51 cm) in d.b.h. [50].

Eastern hemlock has high cavity value for wildlife [12]. Large hollow trees are commonly used as dens by black bears [49].

The seeds are eaten by birds and mammals [13], and in the winter the foliage is browsed by white-tailed deer, moose, and snowshoe hares [2,59].

PALATABILITY :

In the winter, eastern hemlock browse is moderately preferred by moose and highly preferred by white-tailed deer [2,10]. In the summer, white-tailed deer prefer hardwood sprouts and seedlings to eastern hemlock [44]. The seeds of eastern hemlock are not as preferred by white-footed mice, red-backed voles, and meadow voles as red pine (*Pinus resinosa*) and white pine seeds [1].

NUTRITIONAL VALUE :

NO-ENTRY

COVER VALUE :

Eastern hemlock provides cover to ruffed grouse, wild turkey, fishers, and other wildlife [4,20]. It provides excellent thermal protection and snowfall interception for moose and white-tailed deer in the winter [2,17].

VALUE FOR REHABILITATION OF DISTURBED SITES :

NO-ENTRY

OTHER USES AND VALUES :

From 1880 to 1930, eastern hemlock was extensively harvested for its bark which is a source of tannin [64].

Eastern hemlock is planted as an ornamental [20].

OTHER MANAGEMENT CONSIDERATIONS :

Multiple removal cuttings are the best method for regenerating eastern hemlock. Suddenly released seedlings often die, and a series of removals releases hemlock more slowly [28]. On moist sites, a two-cut shelterwood system leaving about 50 percent cover may be adequate. On drier sites, a three-cut system is appropriate, initially leaving 70 to 80 percent crown cover and 50 percent after the second cut [62]. If too few residual trees are left, they may die when exposed, and they are subject to windthrow [28]. Scarification of seedbeds and removal of competing hardwoods may be necessary [20]. Eastern hemlock regeneration must be at least sapling size when released if it is to compete successfully with uncontrolled hardwoods [29]. Single tree selection is also an effective method to harvest and regenerate eastern hemlock [62].

Effective reproduction may be absent in areas with high deer populations [3,10]. Regeneration in the Porcupine Mountains in Michigan has declined over the last several decades because of white-tailed deer browsing in the winter [17]. In the Allegheny National Forest in Pennsylvania, the eastern hemlock-northern hardwoods forest type covered 83.4 percent of the land in 1800 and only 15.8 percent in 1986. Extensive harvesting, fire, and overbrowsing are responsible for the decline [64].

Numerous insects attack eastern hemlock, but only a few are of economic importance cause sporadic or local mortality [62]. Mortality usually occurs following complete defoliation by insects [43,62].

Eastern hemlock seedlings are sensitive to damping-off fungi, root rots, and stem and needle rusts [20].

Eastern hemlock appears to be resistant to ozone [21].

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

SPECIES: *Tsuga canadensis*

GENERAL BOTANICAL CHARACTERISTICS :

Eastern hemlock is a native, evergreen conifer with heavily foliated and upsweeping branches. At maturity, it is commonly 60 to 70 feet (18-21 m) tall and 24 to 48 inches (61-122 cm) in d.b.h. One of the largest eastern hemlock recorded was 175 feet (53 m) tall and 76 inches (193 cm) in d.b.h. It reaches ages in excess of 800 years. Eastern hemlock roots are shallow and widespreading [20,26].

RAUNKIAER LIFE FORM :

Phanerophyte

REGENERATION PROCESSES :

Trees begin producing seed when they are 20 to 30 years old. Eastern hemlocks older than 450 years still produce large seed crops. This species bears cones every year, and large crops are frequent, usually every 3 to 4 years. The small winged seeds are dispersed by gravity and wind; most fall within one-tree-height distance from the source [20,54].

The seeds are partially dormant and germinate best when stratified for about 10 weeks at or slightly above freezing. Germination occurs at a range of temperatures; seeds from the northern portion of its range germinate at lower temperatures than seeds from the southern portion [20,54]. Seeds do not remain viable if they do not germinate the first spring after seedfall [38].

Seeds germinate best on moist substrates, such as rotten wood, mineral soil, mineral soil mixed with humus, well-decomposed litter, and moss mats [14,62]. The number of seedlings established on rotten logs and stumps increases as the wood decays and the moss cover increases. Seedlings commonly establish on "tip-up mounds" formed by fallen trees [10]. Seedlings grow slowly and cannot tolerate full sunlight until fully established, usually when they are 3 to 5 feet (0.9-1.5 m) tall [20].

Eastern hemlock regeneration appears to be periodic and is influenced by fire, windthrow, drought, and stand conditions. A young dense stand may exclude regeneration for many years because of severe root competition in the upper soil layers, dense low shade, and dry acidic litter [27,56]. Hemlock regeneration is present in the understory of stands with a parent overstory density of up to 140 square feet per acre (32 sq m/ha) but is most abundant when eastern hemlock comprises 80 to 100 square feet per acre (18-23 sq m/ha) of the overstory [31].

Eastern hemlock does not sprout and layers only rarely [20].

SITE CHARACTERISTICS :

At its western and southern limits, eastern hemlock is confined to moist cool valleys, moist flats, northern and eastern slopes, coves, benches, and ravines. In the northern part of its range, it tolerates drier and warmer sites. Eastern hemlock also occurs at swamp borders provided peat and muck soils are shallow [14,20,40,65].

Favorable eastern hemlock sites are moist to very moist with good drainage. Eastern hemlock grows in a wide variety of acidic soils; textures include sandy loams, loamy sands, and silty loams with gravel of glacial origin in the upper profile [14,20].

While generally considered a moisture-demanding species, eastern hemlock grows on dry sites protected from fire, such as rocky ledges [22]. Two types of eastern hemlock have been described: one grows in mesophytic habitats and one on subxeric slopes [30]. The types cannot be termed ecotypes, however, because of incomplete habitat differentiation. Eastern hemlock growing on "subxeric" slopes may actually be receiving moisture from seeps [51].

In the northeastern United States, eastern hemlock grows at elevations ranging from sea level to 2,400 feet (730 m). In the southern Appalachian Mountains it grows from 2,000 to 5,000 feet (610-1,520 m). In the Allegheny Plateau region of New York, Pennsylvania, and Ohio, it grows from 1,000 to 3,000 feet (300-910 m) [13,20,34].

Understory associates are scarce because of acidic infertile humus, low light, and cool conditions [14,34]. Shrub and small tree associates that occur in canopy gaps include sweet birch (*Betula lenta*), striped maple (*Acer pensylvanicum*), mountain maple (*A. spicatum*), hobblebush (*Viburnum alnifolium*), mapleleaf viburnum (*V. acerifolium*), mountain winterberry (*Ilex montana*), rhododendron (*Rhododendron* spp.), mountain-laurel (*Kalmia latifolia*), and witch hazel (*Hamamelis virginiana*). Herbs can include Canada mayflower (*Maianthemum canadense*), star flower (*Trientalis borealis*), common woodsorrel (*Oxalis montana*), and goldthread (*Coptis groenlandica*). Other associated species include clubmosses (*Lycopodium* spp.), bracken (*Pteridium aquilinum*), woodfern (*Dryopteris* spp.), and sedges (*Carex* spp.). Common mosses include *Dicranium* spp. and *Polytrichum* spp. [14,20,32,45,65].

SUCCESSIONAL STATUS :

Obligate Climax Species

Eastern hemlock is very shade tolerant [5]. Seedlings survive in as little as 5 percent of full light [14]. Individuals are able to survive several hundred years of suppression, and many show numerous growth

releases and suppressions [6]. Saplings less than 2 inches (5 cm) in d.b.h. may be more than 100 years old [10].

Seedlings are able to establish under the canopy of mature individuals. Eastern hemlock establishes under dense sugar maple canopies and can replace that species [39]. Eastern hemlock uniquely modifies semipermanent soil properties, such as acidity, which favors its reproduction. Opportunities to establish in a mature forest increase over time as nurse logs and tip-up mounds accumulate [51].

The general designation of eastern hemlock as a climax species has been questioned [22,41]. In some old-growth eastern hemlock stands, the smaller size classes of hemlock are being replaced by American beech (*Fagus grandifolia*) and sugar maple [41]. Because of this lack of regeneration, Hemond and others [22] suggest that eastern hemlock requires disturbance to perpetuate itself.

In contrast, other authors suggest that disturbance is responsible for the lack of regeneration in mature hemlock forests [3,6,51]. White-tailed deer populations have increased since presettlement times because logging of virgin forests opened up habitat, predators declined, and the deer were protected. Deer often consume all eastern hemlock seedlings and saplings in the winter. Where deer populations are low, eastern hemlock appears to be able to reproduce in its own shade and become a component of a self-perpetuating homogenous climax forest [3].

Eastern hemlock requires partial shade for establishment and is a late colonizer of disturbed sites [24]. In the Pisgah Forest in southwestern New Hampshire, 80 percent of old-growth eastern hemlock established within 37 years of disturbance. Hardwoods grew rapidly into the canopy while eastern hemlock grew slowly as shade-tolerant saplings. Eastern hemlock extended into the canopy following subsequent disturbance [23].

The understory population of eastern hemlock readily takes advantage of canopy gaps. Eastern hemlock increased in importance as American chestnut (*Castanea dentata*) declined from chestnut blight [8]. It is currently replacing American beech where that species is succumbing to beech bark disease [53]. Eastern hemlock is not successful in regenerating in canopy gaps in areas such as the New York Botanical Forest, where the occasional light arson fire, trampling, and other urban stresses kill seedlings. In addition, the removal of fallen logs in the forest decreases the amount of adequate substrate for germination [52].

The slow invasion of oak-dominated sites by eastern hemlock appears to be related to heavy leaf litter and the absence of favorable seedbed conditions [22].

SEASONAL DEVELOPMENT :

Eastern hemlock male strobili open and pollen is dispersed in late April to early June, depending on locality. This is usually 2 weeks after the leaf buds open. Fertilization is complete in about 6 weeks, and cones reach full size in late August or early September. The cones open in mid-October, but seed dispersal may extend into the winter [20]. Cones close in wet weather and open again in subsequent dry weather, prolonging seed dispersal. Germination occurs in the spring [10].

FIRE ECOLOGY

SPECIES: *Tsuga canadensis*

FIRE ECOLOGY OR ADAPTATIONS :

Eastern hemlock is very susceptible to fire because of its thin bark, shallow roots, low-branching habit, and heavy litter deposits [20,51]. It is possibly the most fire-sensitive mesophytic tree species in its range [51].

Eastern hemlock usually escapes fire because it occurs in moist habitats and is often associated with hardwoods which do not readily burn. If a fire starts in a cutover area, a windfall area, or an area with dead standing timber, it may carry into a northern hardwoods forest if there is strong wind [18]. In Michigan, the average return time for severe crown fires in the hemlock-white pine-northern hardwoods type is estimated to be about 1,400 years [63]. In northeastern Maine, the average return interval for fire in spruce-fir forests in which eastern hemlock is a minor component is about 800 years [37].

Vogl [61] considers eastern hemlock a fire-initiated species rather than a fire-independent species because it benefits from fire-prepared seedbeds. However, suggestions that fire promotes regeneration of eastern hemlock are not well documented. Given the difficulties in accurate age estimates because of heart rot, Rogers [51] suggests that even-aged eastern hemlock forests that regenerated after fire may actually be uneven-aged.

POSTFIRE REGENERATION STRATEGY :

Tree without adventitious-bud root crown
Secondary colonizer - off-site seed

FIRE EFFECTS

SPECIES: *Tsuga canadensis*

IMMEDIATE FIRE EFFECT ON PLANT :

Low-severity fire readily kills seedlings and saplings of eastern hemlock, and may also kill larger trees. A low-severity ground fire in a northern hardwoods community in south-central New York killed 93 percent of the eastern hemlock saplings. Sixty percent of the mature eastern hemlock died or were badly injured as a result of the fire [58]. The presence of fire scars indicates that larger trees have thick enough bark to survive low-severity surface fires [18,36].

DISCUSSION AND QUALIFICATION OF FIRE EFFECT :

NO-ENTRY

PLANT RESPONSE TO FIRE :

Eastern hemlock appears to invade burned sites over time. In the Pisgah Forest in southwestern New Hampshire, 80 percent of old-growth hemlock germinated within the first 37 years after a major fire in 1665 [23].

DISCUSSION AND QUALIFICATION OF PLANT RESPONSE : The Research Project Summary [Early postfire effects of a prescribed fire in the southern Appalachians of North Carolina](#) provides information on prescribed fire and postfire response of plant community species, including eastern hemlock, that was not available when this species review was originally written.

FIRE MANAGEMENT CONSIDERATIONS :
NO-ENTRY

REFERENCES

SPECIES: *Tsuga canadensis*

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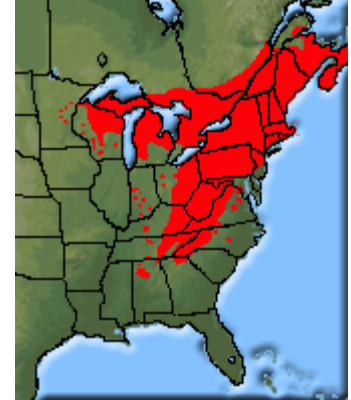
Landowner Factsheet

forest and range.org

eastern hemlock

Tsuga canadensis

Eastern hemlock is a long-lived conifer of cool eastern climates. It offers valuable shade and shelter to wildlife, and it often planted ornamentally due to its versatility and beauty. The future of eastern hemlock is in question due to the spread of the hemlock woolly adelgid, an accidentally introduced sap-feeding insect.



Light ☀️ ☁️ ☁️ ☁️ ☁️

Growth 🌳 🌳 🌳 🌳 🌳

Water 🌊 🌊 🌊 🌊 🌊

Size ● ● ● ● ●

Timber Value 💰 💰 💰 💰 💰

Eastern hemlock is used for light framing, roofing, sheathing, subflooring, boxes, crates, and pulpwood.

Wood Grain

Wildlife Value 🦌 🦌 🦌 🦌 🦌

Eastern hemlock provides shade to aquatic ecosystems and shelter to wildlife, especially deer, during the winter. Large hollow trees are commonly used as dens by black bears.

Attracts: voles, squirrels, snowshoe hares, deer, ruffed grouse, turkey, warblers

Regeneration methods

Superior shade tolerance allows for regeneration by the shelterwood and group selection methods. Eastern hemlock responds well to release from competition from above and below.

Important Problems

- hemlock woolly adelgid

Early Detection tips

white cottony substance on lower needle surfaces; declining foliage color and density

Fun facts

- Hemlocks were once used for structural timbers, as the wood has tremendous nail-holding ability. Hemlock bark was once harvested for tannins. Hemlocks can live in deep shade suppression for as long as 400 years - dominant, healthy specimens can live as long as 800 years.
- *Tsuga* Japanese name. *canadensis* of Canada.

[Home](#) - [Tsuga canadensis I.D. Fact Sheet](#) - [US Forest Silvics](#) - [Additional silvics](#) - [VT Dendro](#)

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questions, comments, and criticisms: email John.Peterson@vt.edu

PLANTS Profile

Tsuga canadensis (L.) Carrière eastern hemlock

Symbol: TSCA
Group: Gymnosperm
Family: Pinaceae
Duration: Perennial
[Growth](#): Tree
[Habit](#):
[Native](#): L48 N
[Status](#): CAN N

Click on the image below to enlarge it and download a high-resolution JPEG file.



Robert H. Mohlenbrock. USDA NRCS. 1995. *Northeast wetland flora: Field office guide to plant species*. Northeast National Technical Center, Chester. Courtesy of [USDA NRCS Wetland Science Institute](#). [Usage Requirements](#).

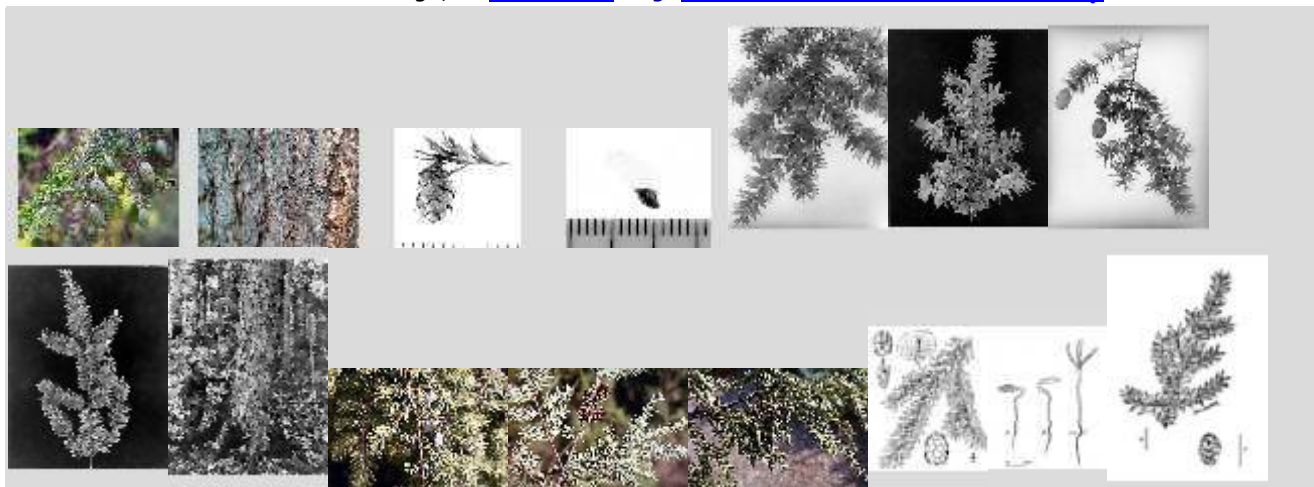
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Plant Guide
[\(pdf\)](#) [\(doc\)](#)
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Images:

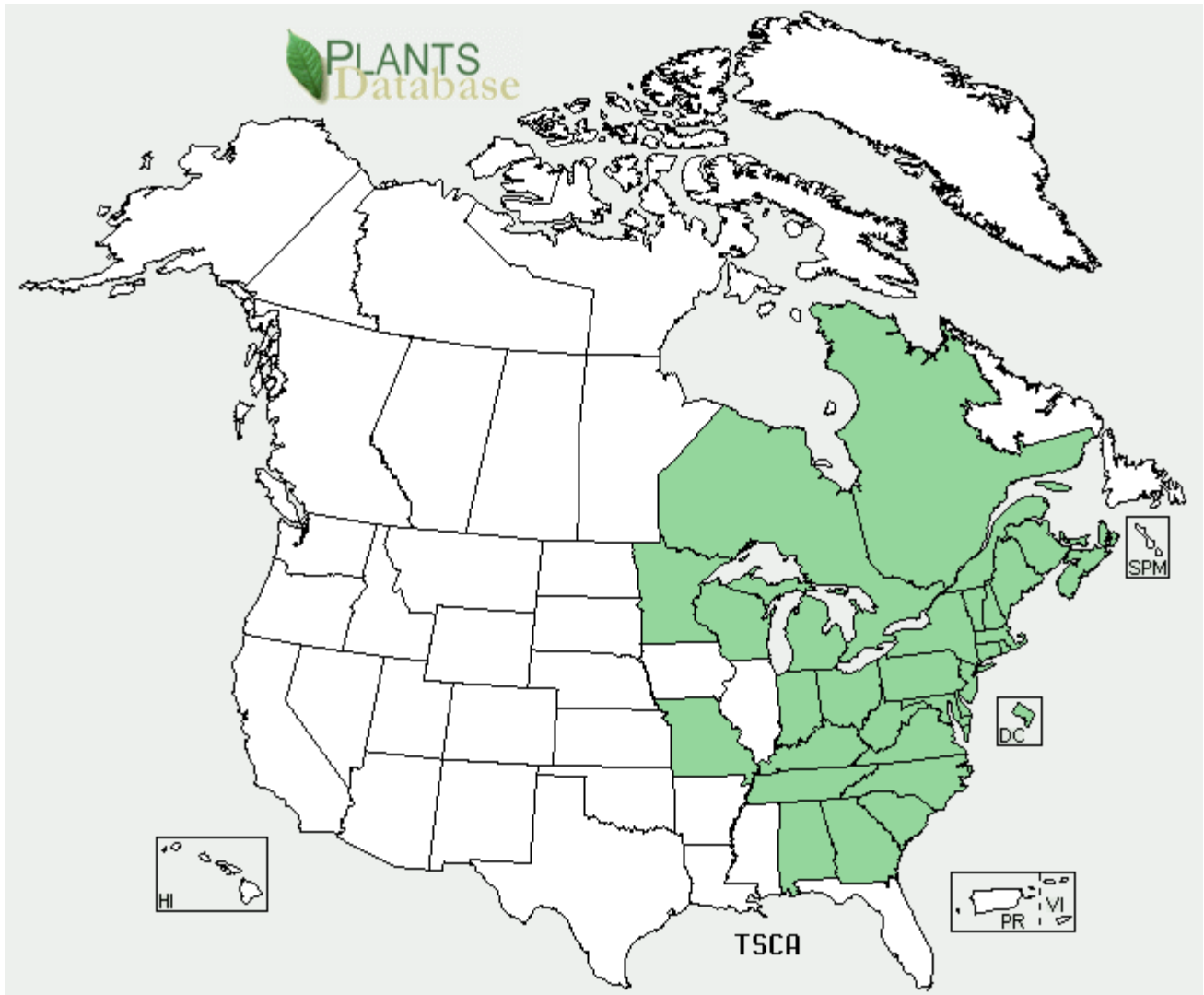
Tsuga canadensis (L.) Carrière

Click on a thumbnail to view an image, or [see all the Tsuga thumbnails at the PLANTS Gallery](#)



Distribution:

Tsuga canadensis (L.) Carrière



[View Native Status](#)

■ Present □ Absent

See U.S. county distributions (when available) by clicking on the map or the linked states below:

USA ([AL](#), [CT](#), [DC](#), [DE](#), [GA](#), [IN](#), [KY](#), [MA](#), MD, [ME](#), [MI](#), [MN](#), [MO](#), [NC](#), [NH](#), [NJ](#), [NY](#), [OH](#), [PA](#), [RI](#), [SC](#), [TN](#), [VA](#), [VT](#), [WI](#), [WV](#)), **CAN** (NB, NS, ON, PE, QC)

Related Taxa:

Tsuga canadensis (L.) Carrière

View [9 genera in Pinaceae](#), [5 species in Tsuga](#)

Classification:

Tsuga canadensis (L.) Carrière

Click on a scientific name below to expand it in the PLANTS Classification Report.

- Kingdom [Plantae](#) – Plants
- Subkingdom [Tracheobionta](#) – Vascular plants
- Superdivision [Spermatophyta](#) – Seed plants
- Division [Coniferophyta](#) – Conifers
- Class [Pinopsida](#)
- Order [Pinales](#)
- Family [Pinaceae](#) – Pine family
- Genus [Tsuga](#) [Carrière](#) – hemlock

Species *Tsuga canadensis* (L.) Carrière – eastern hemlock

Wetland Indicator Status:

Tsuga canadensis (L.) Carrière

Nat. Ind.	Reg. 1	Reg. 2	Reg. 3	Reg. 4	Reg. 5	Reg. 6	Reg. 7	Reg. 8	Reg. 9	Reg. 0	Reg. A	Reg. C	Reg. H
FACU	FACU	FACU	FACU	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

[Interpreting Wetland Indicator Status](#)

More Accounts and Images:

Tsuga canadensis (L.) Carrière

- ∞ [photographs](#) from CalPhotos.
- ∞ [species account](#) from USDA Forest Service Fire Effects Information System (FEIS).
- ∞ [species account and distribution map](#) from Flora of North America (FNA).
- ∞ [species account](#) from ARS Germplasm Resources Information Network (GRIN).
- ∞ [taxonomic account](#) from Integrated Taxonomic Information System (ITIS) for ITIS Taxonomic Serial Number 183397.
- ∞ [species account](#) from Kemper Center for Home Gardening.
- ∞ [species account](#) from Lady Bird Johnson Wildflower Center Native Plant Information Network (NPIN).
- ∞ [species account](#) from Native American Ethnobotany (University of Michigan - Dearborn).
- ∞ [1 propagation protocol](#) from Native Plants Network.
- ∞ [photographs and distribution](#) from University of Tennessee Herbarium.
- ∞ [species account and photographs](#) from University of Wisconsin - Stevens Point Freckmann Herbarium.

Related Web Sites:

Tsuga canadensis (L.) Carrière

[Plant Identification Resource \(Auburn University\)](#)
[University of Connecticut Plant Database](#)
[Floridata Plant Profile](#)
[eImage Images](#)
[Image Search](#)
[Selecting Trees for your Home \(University of Illinois\)](#)
[Missouri Botanical Garden Plant Finder](#)
[Plant Fact Sheet \(NCSU\)](#)
[Five Conifers of North America](#)
[Ohio State University Plant Dictionary](#)
[Ohio State University Pocket Gardner](#)
[Department of Conservation and Natural Resources](#)
[Conifers of North America](#)
[Plants For A Future](#)
[FA FS Fact Sheet \(University of Florida\)](#)
[FA FS Softwoods of North America](#)
[FA FS Silvics of North America](#)
[Virginia Tech Dendrology](#)
[Trees of Wisconsin \(University of Wisconsin-Green Bay Herbarium\)](#)
[University of Wisconsin Freckmann Herbarium](#)