Pinus sylvestris L. Scotch Pine

Pinaceae Pine family

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Scotch pine *(Pinus sylvestris),* also called Scots pine, is an introduced species in North America, brought here from Europe probably in colonial days. Although it is used for both pulpwood and sawlogs, its principal value in the United States appears to be as a Christmas tree, as an ornamental, and for erosion control.

Habitat

Native Range

Scotch pine has been widely planted in the United States, especially in the Northeast, Lake States, Central States, and Pacific Northwest. It is now considered naturalized in parts of New England and the Lake States *(29).* The species has also been planted across southern Canada.

Scotch pine is the most widely distributed pine in the world. It grows naturally from Scotland almost to the Pacific Ocean and from above the Arctic Circle in Scandinavia to the Mediterranean. Its altitudinal range is from sea level to about 2440 m (8,000 ft).

Climate

Scotch pine is adapted to a wide variety of climates as indicated by its extremely large natural range. It grows in areas with an annual precipitation exceeding 1780 mm (70 in) and in areas with an annual precipitation as little as 200 mm (8 in). Scotch pine survives in the Verkhoyansk Mountains of eastern Siberia where winter temperatures have been recorded as low as -64" C (–83° F). In some areas it grows where the subsoil is permanently frozen. Scotch pine can also survive high temperatures, and it is found at middle altitudes in the Mediterranean region. The primary distribution of Scotch pine, however, indicates that it is a tree of the continental climates *(18).*

Soils and Topography

In Europe, Scotch pine grows on a wide variety of soil types. In Scotland it is found on the most ancient rocks and also on the most recent glacial deposits. The cool, humid climate of Scotland, along with the nature of the parent material, which is usually siliceous and acidic, frequently results in a deep litter and raw humus layer. The soils exhibit various degrees of podzolization. Scotch pine grows well on these soils but best growth is on freely drained sands and gravels, often on knolls and terraces. These soils have only a thin layer of raw humus and are weakly podzolized. Although Scotch pine grows on peat land in certain areas, usually it is badly stunted *(18).*

Studies of the mineral nutrient content of the foliage of several Scotch pine provenances at three sites in Michigan show that Scotch pine has evolved an efficient mechanism to extract nutrients from the infertile sites to which it is relegated in its native range. Significant differences were found among seed sources in their ability to accumulate nitrogen, phosphorus, sodium, magnesium, and boron. Magnesium was one of the key minerals in Scotch pine nutrition at all three sites. The faster-growing seed sources accumulated higher levels of foliar magnesium *(17).*

Although Scotch pine can grow on soils with pH from 4.0 to 7.0, it grows best on soils in the 4.5 to 6.0 range ***(1).*** In the Lake States, Scotch pine is planted most commonly on level or gently rolling sand plains-chiefly at elevations between 300 m (1,000 ft) and 460 m (1,500 ft). In the Eastern States, it has been planted not only on outwash plains, but also on mountain slopes at elevations from a few meters above sea level to about 820 m (2,700 ft) in the Adirondacks. Scotch pine grows well on the loess soils of northern Idaho and eastern Washington, under rainfall conditions prevailing in the ponderosa pine *(Pinus ponderosa)* zone.

Scotch pine grows most commonly on soils in the orders Spodosols, Entisols, Inceptisols, Histosols, Alfisols, and Mollisols.

Associated Forest Cover

Scotch pine has been naturalized in northern New York. The associated trees are black cherry *(Prunus serotina),* red maple *(Acer rubrum),* sugar maple ***(A. saccharum),*** American beech *(Fagus **grandifolia),*** quaking aspen *(Populus **tremuloides),*** and eastern white pine *(Pinus strobus).*

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Life History

Reproduction and Early Growth

Scotch pine, like many of the hard pines, is intolerant of shade. Seedlings germinating under a dense forest canopy do not survive for long. Although the seedlings will grow very well on fertile soil, they are usually found on the more sandy dry soils because of the lack of competition from other trees and plants.

During the last century, Scottish foresters have had serious difficulties establishing Scotch pine regeneration under mature pine stands. This difficulty appears to be partly due to grazing by deer and domestic animals. Successful regeneration has been achieved, however, with the uniform or shelterwood compartment system, which also appears to be successful in the Scandinavian countries *(18).*

The best regeneration is found in stands with the following characteristics: large seed supply, open or light tree canopy, light understory ground cover, and exposed mineral soil or no continuous layer of raw humus *(18).*

In the United States in the Northeastern and Lake States, Scotch pine reproduction is extremely abundant on the more sandy sites. As soon as the parent stand reaches seed bearing age, it begins to spread outward into firebreaks and along open roadsides. In many areas reproduction is so plentiful as to present a mat of seedlings, and this aggressive reproductive habit has concerned foresters who preferred to grow other conifer species on these sites. A recent event in New York may change this reproductive potential of Scotch pine. When scleroderris canker *(Gremmeniella abietina)* is present in the Scotch pine overstory, the advance reproduction can be completely eliminated (15). As this disease has advanced across northern New York, the "mats" of Scotch pine reproduction have become seas of dead seedlings. New seedlings continue to germinate under the parent stand but become infected and die within 1 or 2 years. Scleroderris canker is present in Scotland but it is not known whether this disease is related to the reproduction problems there.

Flowering and Fruiting-Although Scotch pine is primarily a monoecious species, some shoots, branches, and even entire trees are predominantly of one sex. Male flower primordia are formed in late summer at the base of the bud that will make the next year's growth. During the winter their presence can be noted as a slight swelling, and the preferred male catkins are easily visible if a bud is dissected. About 2 weeks after growth begins in the spring, the male catkins enlarge to 0.6 to 0.7 cm (0.2 to 0.3 in) long and shed pollen. At this time they are yellow.

The male catkins are borne at the base of the twigs, replacing leaf clusters. They are most common in the lower part of the crown and on short lateral twigs. Because they replace leaves, an excess of pollen production can lead to sparse foliage. A Pennsylvania breeder who selected for early flower production for two generations obtained a variety that produced plentiful pollen but few needles and it was worthless as a Christmas tree.

Female flower primordia are also formed in late summer but are microscopic. They are borne at the tips of buds for the next year's growth. There may be one, two, or three on a single bud. They first become visible after the buds expand in the spring. The primordia enlarge into female flowers or strobili about 2 weeks after growth begins in the spring, at a time when the new growth has completed 75 percent of its elongation for the season. Because of this, shearing of the outside branches such as is practiced by Christmas tree growers removes all female flowers. Indeed, trees sheared in June will not produce seed for the next 3.5 years.

Flowering occurs in late May or early June. On any one tree nearly all pollen is shed and nearly all the female flowers are receptive during the same 2- or 3-day period. In any one stand most trees flower within a day or two of each other. Trees of different provenances may differ in blooming time by several days, however; trees of northern provenances bloom the earliest.

Pollen production tends to be concentrated on short lateral twigs in the lower half of a tree crown. Female flowers are borne on the most vigorous shoots. They tend to be concentrated on upper branches but may occur in any part of the crown receiving full sunlight.

Pollination occurs in early summer, at a time when the female strobili are from 0.6 to 0.7 cm (0.2 to 0.3 in) long. Shortly after pollination, the scales of the female strobili thicken, and the pollen grains germinate and send out a short pollen tube. At this time the female strobili become reflexed instead of pointing forward. For the next 12 months the germinated pollen remains dormant and the female strobili grow little. A little more than a year after pollination, the germinated pollen grains renew growth and fertilize the ovules. In June, soon after fertilization, the conelets rapidly elongate and reach full size by early summer. Seeds mature and cones ripen in early October. The cones require alternating periods of dry and wet weather to open and shed few seed until early winter. Indeed, many seeds are retained on the tree until early spring.

Seeds from any one tree can be sorted visually by color into those that are full and those that are empty-empty seeds are much lighter in color (often nearly white) than full ones. On any one tree the full seeds are fairly uniform in color and size, but both traits vary considerably from tree to tree. Trees from the same stand may produce seeds ranging from tan to almost black and from all one color to speckled. Seed size varies in a geographic pattern-seeds from the extreme northern latitudes are half the size of those from the southern part of the range.

Seed Production and Dissemination-In-dividual trees in Michigan, under favorable growth conditions, begin to produce male and female flowers at from 5 to 8 years, although the average is between 10 and 15 years (26). Scotch pine continues to produce viable seeds until at least age 200, although seed quality and size are greatly reduced at this age *(18).*

Good seed crops are produced at intervals of from 3 to 6 years with light crops in most intervening years. The number of cleaned seeds per kilogram ranges from 74,500 to 244,700 (33,800 to 111,000/lb). If properly stored, the seeds remain viable for 15 years. One kilogram (2.2 lb) of average size cones produces approximately 3,300 seeds (21).

Scotch pine cones begin to open in late October, and seed dispersal continues into December. At times, large quantities of seed are dispersed onto snow cover. Seed dispersal for natural restocking of cutover areas is normally limited to between 50 and 100 m (164 to 328 ft) from the parent tree. Maximum seed dispersal is much greater, however. In northern New York, the establishment of second-generation natural Scotch pine seedlings up to at least 1 km (0.6 mi) from the seed source is the rule rather than the exception (29).

Seed crops in New York and Nebraska have been damaged primarily by coneworm larvae *(Dioryctria* spp.). Tip moths *(Rhyacionia* spp.), which destroy shoots bearing newly formed or developing conelets, are common in Scotch pine seed orchards.

Seedling Development-Seeds tested in the laboratory differ in their degree of dormancy according to geographical seed source, individual tree selection, and seed maturity. Most, however, will germinate immediately if placed in warm, moist conditions. Germination is epigeal *(21).* Artificial light has been shown to increase germination by 83 percent for some seed sources (4).

Field germination is best under full or partial sunlight. Seedling establishment is best when adequate moisture is available and some shade is present. In northern New York, Scotch pine has established itself rapidly on abandoned old fields on very light soils.

At present, almost all the Scotch pine plantations in North America are from planted nursery stock. Two-year-old stock averages from 8 to 20 cm (3 to 8 in) in height. Early nursery practice was to grow the seedlings very close together-from 2,150 to 3,230/m^2 (200 to 300/ft^2) of seedbed. The result was a tall, spindly seedling that bent to the ground when subjected to wet snow during the first winter. These young trees developed a crook at the base. As they developed, the growing tip overcompensated for this crook resulting in an S-shaped stem. The trees eventually returned to a vertical growth habit, but the crook remained. When nursery stock is grown at lower density, 540 seedlings per square meter (50/ft^2), the resulting stock is sturdier and is able to resist snow bending during its early years.

The idea that certain varieties (especially Riga) are always straight wherever grown and that other varieties (such as German and Belgian) are generally crooked is too simple and not always true. Form is as much a matter of site as of variety. On some sites most trees grow crooked whereas on other sites trees of any variety are usually straight. Scotch pine inherently grows straight unless the leader is damaged, when it is apt to be very crooked. The tendency for a variety to be straight or crooked depends on its susceptibility to a particular pest or other damaging agent, and on the presence of that pest or damaging agent in that locality. For example, when the Zimmerman moth *(Dioryctria zimmermani)* is present in high numbers, Greek trees, which are generally not attacked, are straight, while Belgian trees, which are very susceptible, are very crooked. Where pine grosbeaks are present in large numbers, the Belgian trees, which are resistant to this pest, are straight whereas trees of the Riga variety are likely to be crooked.

Poor quality sites seem to have a larger number of pests and a larger number of poorly formed trees than good quality sites.

Scotch pine produces one whorl of branches per year. A fast-growing tree may have branches 0.8 m (2.5 ft) apart resulting in a thin crown. To promote closer branching and denser crowns for Christmas tree production, the trees are sheared by removing the tips of all the new shoots. Following shearing, the leaf fascicles near the cut ends develop adventitious buds. These buds are not formed if shearing is done during late summer.

Scotch pine seedlings grow rapidly in their early years. In Nebraska, after 8 field seasons, trees ranged in height from 2.5 to 5.0 m (8.2 to 16.4 ft) depending on the seed source. Trees from central

European seed grew fastest while those from Scandinavian and Siberian origins grew slowest *(10)*. On good sites throughout the Lake States and the Northeast, trees of the fast-growing varieties can grow 0.8 m (2.5 ft) per year.

In Michigan shoot growth begins in early May in the central part of the State and in mid-May in the Upper Peninsula. The new shoots elongate rapidly and achieve 90 percent of their growth within 3 weeks.

Insects have not been a serious problem under nursery conditions, although a pine shoot moth *(Rhyacionia adana)* has injured some new Scotch pine shoots in several Michigan nurseries (22). The most serious nursery problem of Scotch pine seedlings is *Lophodermium* needlecast, usually attributed to *L. pinustri* but now assigned to *L. seditiosum*. This disease has killed or seriously damaged millions of Scotch pine seedlings in at least 40 tree nurseries in the Northeast, Lake States, Pacific Northwest, and Canada. Nursery stock infected with *Lophodermium* has also been shipped from nurseries to outplanting sites where further damage has occurred in the young plantations (8).

Vegetative Reproduction-In nature, Scotch pine does not reproduce vegetatively. It is not difficult, however, to graft scions from the larger trees onto potted understock of Scotch pine. In a Swedish study, cuttings from young seedlings (50 to 100 days old) rooted readily, but cuttings from shoots of 3-year-old plants rooted poorly *(19)*.

Sapling and Pole Stages to Maturity

Growth and Yield-Scotch pine shows tremendous variation in yield, both by site and by geographic seed source. In seed source tests, some varieties grew 2.5 times as fast as others on the same site (28). The average height of 150-year-old trees in Scotland is from 13.7 to 16.8 m (45 to 55 ft). On well-drained sites, an occasional tree as tall as 22.9 m (75 ft) is found *(18)*.

In a Michigan study in which dominant crop trees were released, the released trees averaged 13.7 m (45 ft) in height and 18 cm (6.9 in) in d.b.h. at 21 years (fig. 1). The plantation was grown from seed from Magdeburg, Germany, and the soil is a fox sandy loam on a well-drained site *(13)*. A 32-year-old, unthinned Scotch pine plantation in the same area averaged 19 cm (7.3 in) in d.b.h. and 18.6 m (61 ft) in height. This seed source was probably central Europe. A Scotch pine plantation in northern New York averaged 26.0 m (85.5 ft) tall and 48 cm (19 in) d.b.h. at age 74 to 77 years. The largest tree in this stand was 29.0 m (95.25 ft) tall and 51 cm (20.2 in) in d.b.h. One of the earliest Scotch pine plantations in the United States was planted in 1879 near Boonville, NY. The seed source was probably southern Germany (9). Although no stand data are available, the largest tree still standing in 1981 was 26.8 m (88 ft) tall and 66 cm (26 in) in d.b.h.

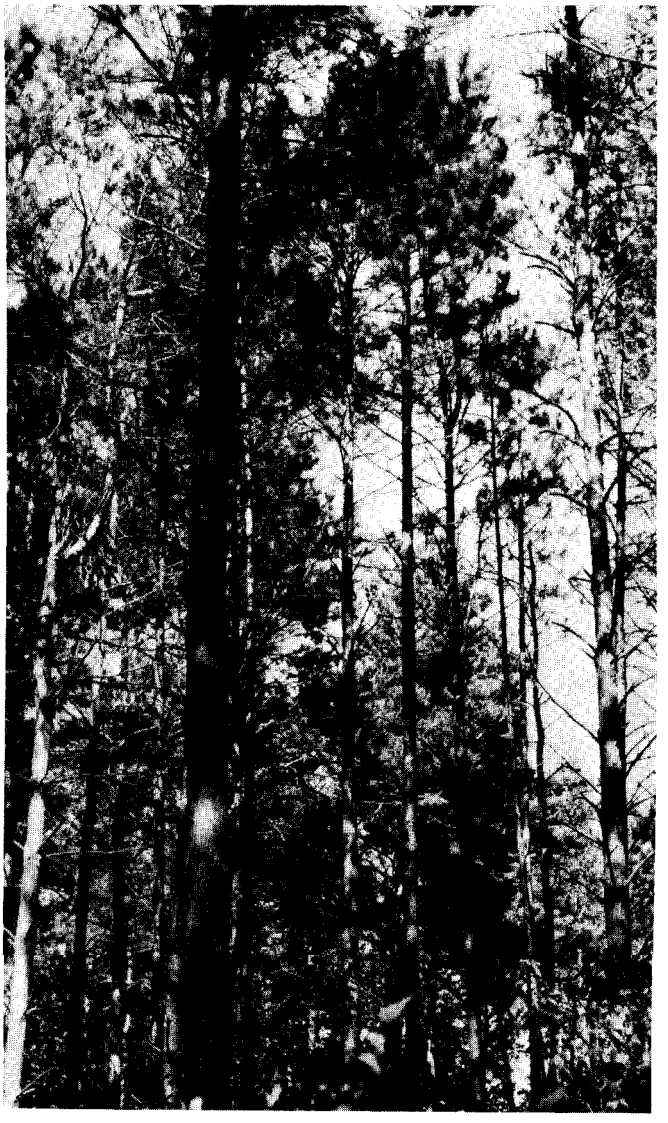

Figure 1-A *stand of Scotch pine grown from seed from a German source.*

Thinning a Scotch pine plantation in southern Michigan increased diameter growth but reduced total volume production *(12)*. At 42 years the unthinned portion of the stand averaged 23 cm (9.2 in) in d.b.h. and contained a volume of 263.8 m^3/ha (3,768 ft^3/acre). Basal area was 36.0 m^2/ha (157 ft^2/acre). The area receiving five light thinnings at 5-

year intervals to a basal area of 19.5 to 21.8 m^2/ha (85 to 95 ft^2/acre) had an average d.b.h. of 30 cm (11.8 in) but volume was only 155.2 m^3/ha (2,217 ft^3/acre) and basal area was 25.7 m^2/ha (112 ft^2/acre). The heaviest thinning with five thinnings at 5-year intervals to a basal area of 14.9 to 17.2 m^2/ha (65 to 75 ft^2/acre) produced an average d.b.h. of 34 cm (13.3 in) with 117.5 m^3/ha (1,679 ft^3/acre) of volume and 20.7 m^2/ha (90 ft^2/acre) of basal area.

Rooting Habit-Scotch pine frequently, but not always, develops a taproot. One study in Europe found 64 percent of the trees with taproots. Often, the lateral roots turn and grow down vertically, acting as a taproot. Taproots are more common on sandy soils than on moraine or gravel soils. The average depth of taproots is from 1.5 to 3.0 m (4.9 to 9.8 ft). The bulk of the root system consists of horizontal roots close to the surface. The majority of these horizontal roots are within 20 cm (7.8 in) of the surface. The horizontal root system is smaller on good soils than on poor soils. The depth of the horizontal root system is also related to soil moisture-it is deeper on the drier soils. On vigorous trees, the length of the longest horizontal roots ranged from 4.5 m (14.8 ft) for lkyear-old trees to 17.1 m (56.0 ft) for 52-year-old trees. Root systems on rocky soils are usually shorter than on sandy soils. The size of the stem and the length of horizontal roots are closely interdependent. A small tree will have a small root system regardless of the tree age, and the root system of a large Scotch pine may cover an area of 0.125 ha (0.3 acre) (5).

Reaction to Competition-Scotch pine, like red pine, is intolerant of shade. Overtopped saplings eventually are lost to suppression. Where Scotch pine has been intermixed with red or white pine at planting, the Scotch pine grows so much more aggressively during the first few years that its roots crowd out roots of the other species leaving only Scotch pine.

Many open-grown trees in poorly stocked stands are bushy and crooked with large-diameter branches. This habit appears to be due more to stand stocking than to genetic factors.

Much of the experience with Scotch pine in the United States has been in Christmas tree plantations. In these stands, the trees are usually planted at a spacing of 2 by 2 m (6.6 by 6.6 ft) and are harvested within 8 to 15 years. Early growth in these plantations can be doubled by removing grass and weed competition either by mowing or by using chemical herbicides.

In Norway and Sweden, Scotch pine is normally managed under a uniform or shelterwood system, in compartments of about 4 ha (10 acres). The regeneration cut is made to coincide with a heavy seed year. This can be predicted 1 year in advance because the cones take 2 years to mature. At the time of regeneration, the number of overstory trees is reduced to approximately 50/ha (20/acre) by one or two fellings to provide the required light conditions for young seedlings and to reduce root competition for water and nutrients. The seed trees normally are felled when the reproduction is well established—usually within 5 to 10 years *(18)*.

Damaging Agents-Scotch pine in North America is subject to a number of agents that can severely damage or kill the trees. Some of these agents are not present in Europe and Asia and, as a result, the species has not yet had an opportunity to develop genetic resistance.

Fire and wind can damage the trees. Young stands have thin bark and are heavily damaged by fire. Older trees with thicker bark are moderately resistant. Scotch pine has more branches per whorl than red or white pine and this large number of branches makes the tree weak at the nodes. During severe wind storms, trees may snap off at the nodes 3 to 6 m (10 to 20 ft) above the ground.

Wildlife and insects are also damaging. The pine grosbeak feeds on the terminal and lateral buds of Scotch pine causing numerous small crooks. Trees of Scandinavian provenances are heavily attacked. In Christmas tree plantations, this feeding can cause major economic losses; a single year's feeding can reduce the tree harvest by 50 percent. This is a minor problem to timber growers, however (2). On occasion, porcupine seriously damage Scotch pine plantations by girdling young trees, causing dead tops.

The pine root collar weevil *(Hylobius radicis)* is a major cause of tree death in young plantations in the Lake States. The weevil girdles the tree at the base, killing it within 3 to 4 years. The damage is especially severe on dry sandy soils. The fast-growing central European trees are particularly susceptible (26). In Michigan, on low quality sites, mortality frequently reaches 70 to 80 percent.

The pine root tip weevil *(Hylobius rhizophagus)* causes serious damage in Michigan on Scotch pine Christmas trees grown from stump culture. These trees result from leaving the lower limbs on cut trees to grow into a second tree crop. The pine root tip weevil larvae feed on the roots and root tips, resulting in reduced height growth and flagged shoots, and eventual death. In some cases the pine root tip weevil and the pine root collar weevil attack some

Scotch pine stands simultaneously, causing more mortality than expected from either insect alone (7).

The European pine sawfly *(Neodiprion sertifer)* causes moderate damage in Christmas trees and ornamental plantings. Heavy defoliation reduces growth from 10 to 20 percent. The fast-growing Scotch pine variety *uralensis* shows some resistance to this insect while the slow-growing variety *iberica* is most susceptible (27).

If Scotch pine is pruned in midsummer, the Zimmerman pine moth may be attracted to the fresh pitch. The larvae feed in the cambial region, causing masses of coagulated pitch and frass to collect. Feeding by several larvae at the same whorl may kill the tree top or the entire tree. Partially girdled stems frequently break at the weakened area during storms *(28)*.

The white pine weevil *(Pissodes strobi)* burrows into terminal shoots and kills them. This insect is very damaging to trees on light soils but causes only minor damage on better sites (28). The eastern pine shoot borer *(Eucosma gloriola)* also burrows in the pith of new growth. In Michigan plantations, this insect is universal but causes only minor damage.

The pine spittlebug *(Aphrophora parallela)* is a serious pest in many Scotch pine Christmas tree plantations. Heavy infestations of spittlebugs may cause twig, branch, and tree mortality. In one 19-year-old Scotch pine plantation in southern Michigan, the pine spittlebug has apparently acted as the vector for the fungus disease *Sphaeropsis sapinea;* mortality is now 25 percent and is continuing.

Lophodermium needlecast caused by the fungus *Lophodermium seditiosum* is the most serious disease of Scotch pine Christmas tree plantations. The major loss is due to premature defoliation resulting in unsalable Christmas trees. In general, the longer needle provenances are resistant to this disease. The problem is minor in forest stands (8).

Scotch pine is also a host for brown spot needle disease of southern pines *(Scirrhia acicola).* This disease, like *Lophodermium,* causes premature defoliation and is primarily limited to Christmas tree plantations. The long needle provenances are also more resistant to this disease *(16).*

Western gall rust *(Endocronartium harknessii)* is common on Scotch pine in the Lake States and the Northeast. Individual trees may have several hundred galls. In most cases damage is limited to branch mortality and growth loss.

As described earlier, Scotch pine is susceptible to scleroderris canker. This disease is present in many areas in Europe, and as a result, certain Scotch pine provenances show some resistance. Scotch pine is more resistant to scleroderris canker than red pine, and in some areas, red pines have been eliminated from the stand while Scotch pines are still alive. Scleroderris canker can be spread on cut Scotch pine Christmas trees. Therefore, State quarantines have been established to prevent the movement of this disease into noninfected areas *(15).*

When southern seed sources of Scotch pine are planted too far north of their normal range, severe foliage winter injury develops. This winter injury causes both branch and tree mortality. In the Lake States, a large number of Christmas tree plantations have been destroyed by this problem.

Many of these problems in Scotch pine plantations are the result of planting this species on very poor sites or planting the wrong seed source. Scotch pine has the inherent ability to produce excellent, straight-boled stands under the proper conditions. Hundreds of Scotch pine plantations throughout the Lake States and the Northeast are equal to or better than the best red pine stands. When Scotch pine is planted on very poor sites, however, or when improper seed sources are used, damage by insects is so severe as to make the final stand useless for timber production.

Special Uses

Scotch pine is the most widely planted pine introduced in North America. It is also the preferred large-volume Christmas tree in the United States—approximately 30 percent of the 35 million Christmas trees harvested annually are Scotch pine *(20)*.

Because it survives on poor droughty sites, Scotch pine has been used to control erosion in many areas. However, the poor vigor of many of these stands on dry, infertile sites has made them susceptible to serious insect attack and many of them have little potential to produce timber (28).

Scotch pine has also been used to a large extent in ornamental plantings. It grows better than red pine on compacted clay soils frequently found around homesites. Because Christmas tree plantations are a ready source of trees, many trees are removed from these plantations as ornamental stock. Many Scotch pine have also been planted along roadsides throughout the Lake States.

Scotch pine is similar in fiber and wood characteristics to red pine and is usable for both pulpwood and saw logs.

Genetics

Population Differences and Races

In Europe, seed source studies on Scotch pine go back almost 200 years, and the literature on genetic variation is large. In the United States, an international seed source trial was conducted in 1938. This trial included trees grown from seed collected in Scandinavia and north-central Europe. In 1961, seeds from 162 natural stands and 24 plantations in Europe and Asia were outplanted in 12 test plantations in Michigan. The results of these seed source studies show the extreme importance of beginning with the correct seed source. The fastest-growing varieties from central Europe grew 2.5 times as tall and produced 15 times as much wood as the slowest-growing variety. In Michigan, the variety *carpatica* from eastern Czechoslovakia was most suitable for timber production because of its fast growth and good stem form. ***The*** next best was variety ***huguenensis*** from Belgium, Vosges Mountains of France, and adjacent West Germany. These varieties may perform poorly in other parts of the United States, however. Information on performance of many seed sources is now available for most of the Lake States and the Northeast *(3,6,14,23,27,28)*.

The diversity within Scotch pine is extremely great. A conservative estimate of the number of geographic varieties ranges from 19 to 22. There is also considerable variation within named varieties. Sources differ in many characteristics including seed size, germination, dormancy, and color; cone color; tree form; growth; structure of root system; flowering characteristics; needle color and length; susceptibility to cold, heat, and drought; and resistance to insects and disease. Seed size increases from North to South. In general, southern sources grow faster than northern sources. The more southern sources are more susceptible to low temperatures. The needles of trees from Siberian and Scandinavian seed sources turn yellow in winter while those from Spain, southern France, and the Balkans remain green *(18,21)*.

The only standard names applied to the various geographic varieties are the Latin names published by Ruby and Wright in 1976 *(11)*. Unfortunately, those names are not in common use among seed dealers and nursery managers. Hence, a grower who wants var. *aquitana* from southern France must know that it also goes by the names French Highland, Aquitaine, French Blue, French Green (this name also applies to another variety), and Royal French Blue. Therefore, it is best when ordering nursery stock to specify the region from which the seed should come, that is, Central Mass of southern France, northern Italy, etc. Generally speaking, seed or seedlings ordered in this manner will come true to form. The names Austrian Hill and Riga should be used with particular caution, however, as they may be applied to trees of very different genetic composition.

Hybrids

Hybrids between recognized varieties can be made but are not common. In the Michigan seed source study, one seed source from northern France was evidently a hybrid because it produced trees with characteristics intermediate between varieties ***huguenensis*** and ***uquitunu*** (28). Scotch pine can be hybridized with Japanese red pine *(P. densiflora)* and Austrian pine *(P. **nigrcz**).*

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