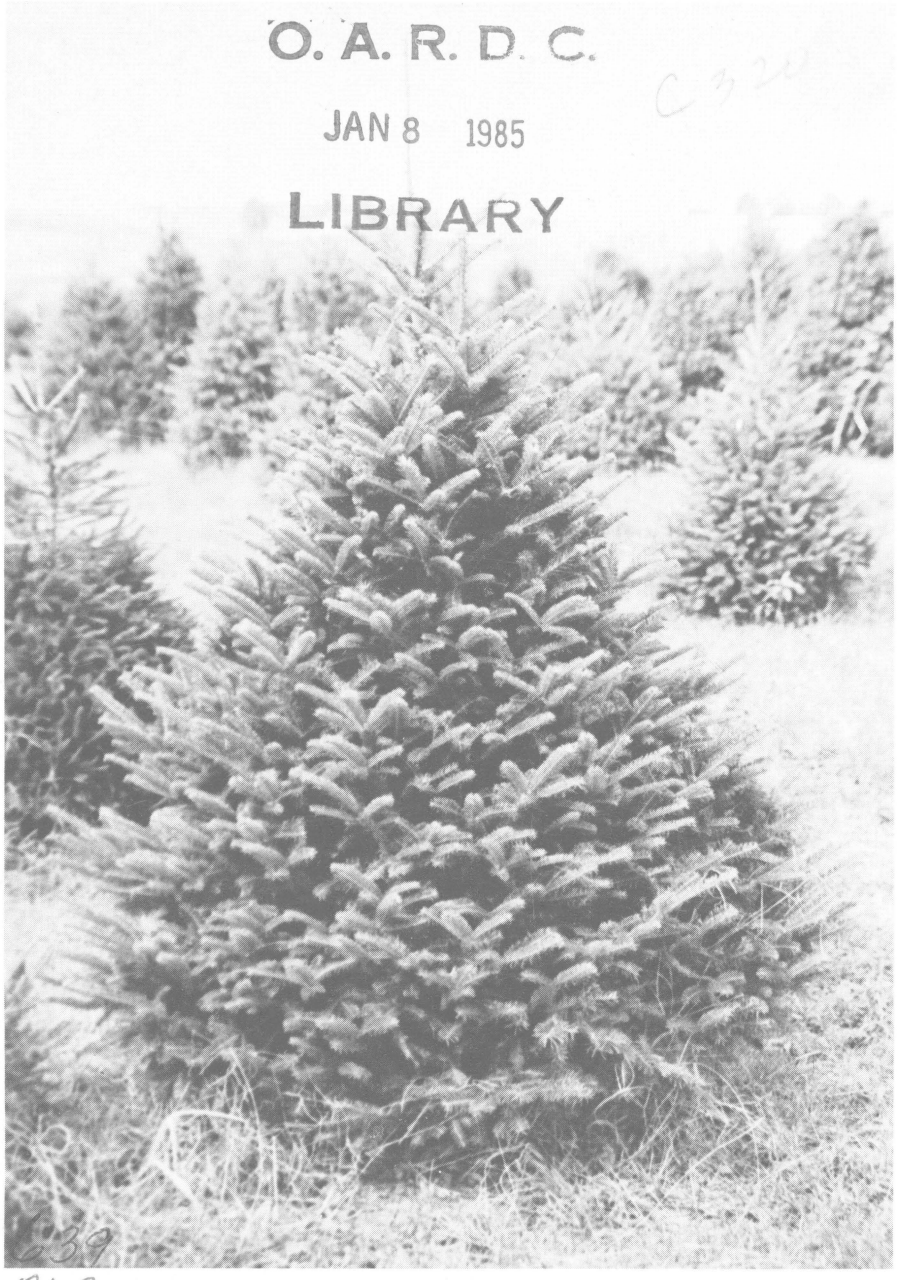
Bulletin 670
Agdex 300/17

OHIO CHRISTMAS TREE PRODUCERS MANUAL



OSU Cooperative Extension Service
The Ohio State University

Authors

James H. Brown
Professor and Associate Chairman
Forestry, OARDC

William F. Cowen, Jr.
Professor and Extension Forester
The Ohio State University

Randall B. Heiligmann
Associate Professor, Forestry
The Ohio State University

Contents

7/84—2M

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914 in cooperation with the U.S. Department of Agriculture, J. Michael Sprott, Director of Cooperative Extension Service, The Ohio State University.

Christmas tree production is an important industry in Ohio, and the potential for expansion of the industry is good. Ohio's large urban population, as well as its proximity to other heavily populated states, places it in a very advantageous position for the production and marketing of Christmas trees. In addition, much land in the state is well suited for growing Christmas trees, and in many instances their production can provide income from areas that might otherwise remain unproductive.

Accurate information on the number of Christmas tree growers, number and type of trees produced and total sales by Ohio growers is presently not available. However, estimates by the Ohio Christmas Tree Growers, Inc., a statewide growers organization, indicate that the supply of high quality, Ohio-grown trees is not sufficient to meet demands of wholesalers and retailers. It is probable that less than 20 percent of Christmas trees sold in Ohio are actually grown in the state. The remainder are imported from surrounding states, the West Coast and Canada.

Returns from growing Christmas trees vary greatly, depending on the particular combination of cultural, marketing and management practices carried out by the individual Christmas tree grower. However, studies show that sales of high quality trees produced using sound management practices should bring returns comparable to those from many other agricultural products.

Intensive cultural work is needed to produce high quality Christmas trees. Operations include selection and evaluation of planting sites, species and seed source selection, proper planting techniques, weed control, fertilization where needed, insect and disease control and shearing and shaping to improve form and density. Unless these operations are carried out properly, trees are usually of low quality and cannot be sold on the competitive market at premium prices. Sometimes they cannot be sold at all.

In sections that follow, guidelines are presented for producing high quality Christmas trees in Ohio.

Planning and Development of the Christmas Tree Enterprise

Careful and thorough planning before establishment of the Christmas tree crop is extremely important for efficient management of Christmas tree plantations. This can be equally true for the beginner just getting into or considering getting into the Christmas tree business, as well as the experienced grower who has been raising trees for several years. Similarly, careful planning can be important whether directed at the initial establishment of Christmas trees on a new area or at replanting a site from which a crop of trees has been removed.

CHOICE OF LANDS FOR CHRISTMAS TREE FARMS

In the past, Christmas tree operations were often relegated to marginal or so-called "wastelands" that were too steep, infertile, dry or eroded for efficient use for most agricultural purposes (Fig. 1). However, as emphasis has shifted to production of high quality trees, there has been greater need for more intensive cultural practices such as shearing, mowing, chemical weed control, spraying for insects and diseases and fertilization. This, coupled with increases in size of many Christmas tree operations, has required increased mechanization. Thus, the "wastelands" of agriculture are often no longer suitable for many Christmas tree farms for exactly the same reasons that they are unsuitable for many other types of crop production.

From a strictly operational standpoint, lands having level to gently rolling terrain are most desirable for Christmas tree production (Fig. 2). All operations, from site preparation to harvesting, are accomplished faster, more easily and with less wear and tear on equipment and manpower than on more rugged terrain. As slopes become progressively steeper, they become more vul-

Fig. 1: Christmas tree plantings on steeply sloping land, where equipment operations are more difficult, need for manual labor is greater and length of time needed to raise a crop of trees may increase.

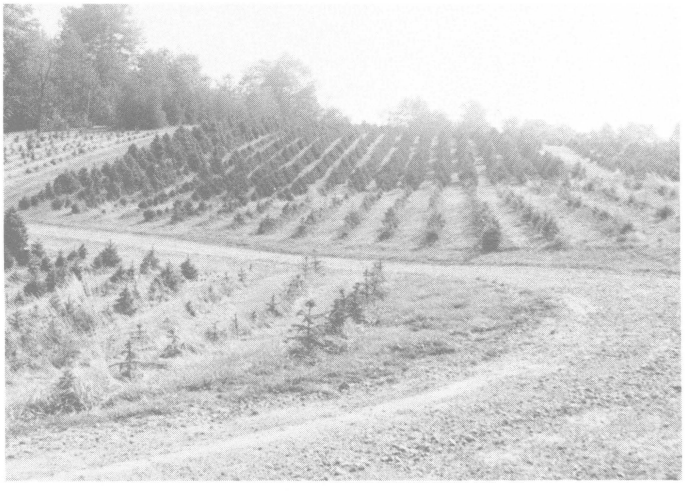


Fig. 2: Christmas tree plantings on level to gently sloping land, where all operations, from site preparation to harvesting, are accomplished easier, faster and with less wear and tear on equipment and manpower than on steeper lands.

nerable to erosion and may be drier and less fertile. On such areas, equipment operation becomes increasingly more difficult, need for manual labor increases and time needed to produce a tree crop often increases.

Land that is relatively free from obstacles, particularly rocks, large trees, fencerows and to some extent even smaller brush, is preferred for Christmas tree production. These must be removed or operations will be severely hampered. Removal can be quite costly, particularly if it involves use of heavy equipment.

Thus, other factors being equal, relatively level land free from obstructions is much preferred for Christmas tree plantings. This objective is often compromised to a greater or lesser degree. Land to be planted is often already owned by the established or beginning grower. In addition, land availability, consideration for other uses and land costs often dictate, or seem to dictate, where Christmas tree farms are established. However, careful cost analyses, including purchase price, preliminary site preparation, long-term operational costs and the relatively favorable competitive value of Christmas trees as compared to other agricultural crops, may show that considerably more can be invested in better land than is often believed. This is particularly true where land is purchased specifically for Christmas tree production, but it may also apply when land is already owned and decisions must be made concerning its use.

Plantation access and security are also factors that should be considered in selecting an area for Christmas tree production. Many Christmas tree operations, particularly harvesting, may have to be done during inclement weather. Good roads to plantation areas are needed, especially if trees are to be moved by truck. Good access is also important if the grower plans to develop a retail operation where consumers choose and/or cut their own trees. Conversely, safety from theft must be considered. Precautions must be taken against theft. Plantings located near houses or other activity are less vulnerable to theft than those in more isolated areas.

MAIN ROAD SYSTEM

Because many operations involved in Christmas tree production may have to be done during bad weather, subdivision of plantation areas by a good road system is very important (Fig. 3). Although the main purpose of these roads is to provide all-weather access, they can also serve as effective firebreaks if vegetation is kept to a minimum or eliminated.

Fig. 3: Subdivision of the Christmas tree farm with a good, all-weather road system. Roads not only provide access, but may also serve to subdivide the area into units having similar site characteristics and management problems.

Careful location of roads can serve another important function — subdivision into efficient management units. Where roads can be located to coincide with major changes in site quality (see section "Determination of Site Productivity"), planting units will have similar characteristics of soil, slope, etc. This can be beneficial in a number of ways. If a variety of species is to be grown, units having the best growth potential can be planted to the more demanding spruces, true firs or Douglas-fir, while those sites that are drier, wetter and/or less fertile can be planted to pines. This should help reduce variation in survival and growth, which often prolong harvest over several years. In addition, units subdivided by the main road system can be used to concentrate trees having similar management procedures. For example, insects and diseases are usually rather specific to certain species, and control can be accomplished more efficiently and cheaply when trees are concentrated in certain areas instead of scattered over many locations. The same principle of grouping trees needing similar treatments might also be applied to other management practices, including shearing, fertilization, weed control and harvesting, where movement of labor and equipment is required.

Choice of Species

The proper choice of a species or group of species to plant is of utmost importance. Unless a fitting choice is made, a substantial loss of time and money can result. A number of considerations may influence this choice: 1) consumer preference, 2) characteristics of different species, 3) characteristics of lands to be planted and growing requirements of the different species, 4) presence or absence of possible damaging agents or influences and 5) proximity to markets, etc.

Consumer preferences can vary considerably from one area to another and may be influenced by the type of tree used previously. Before plantation grown trees became generally available in Ohio, native species such as white pine were often used for Christmas trees in central and northern parts of the state, while eastern red cedar and Virginia pine were common in warmer areas. In addition, large numbers of balsam fir and white and black spruce were imported from Canada for sale in Ohio. As large quantities of plantation grown trees became more available, many of these "traditional" preferences were replaced. More emphasis has recently been placed on characteristics of different introduced and native species available from plantations. Foliage color, needle length, needle retention, stem straightness, shape and density are among the important factors influencing one's final choice of a Christmas tree.

Choosing a species that will survive and grow well on a particular area is extremely important and is often a very difficult decision for the Christmas tree grower to

make. The combination of soil conditions, topographic factors, climatic factors and biotic agencies prevailing in an area constitute the site factors of that area. The combination of these factors, along with a species' ecological requirements, must be carefully considered in order to ensure successful establishment, survival and growth. In Ohio, evaluation of site factors in relation to ecological requirements of a species can be particularly difficult because of variations in soil, topographic and climatic conditions associated with changes in latitude, as well as large variations in soil conditions in different parts of the state. The guides in the section "Determination of Site Productivity" are provided to assist in this determination. Christmas tree growers are also urged to seek professional advice from service and consulting foresters, Soil Conservation Service personnel or country agricultural extension agents. Excellent help can also sometimes be obtained by visiting Christmas tree farms and talking with growers about their experiences with different species on different sites.

The presence or absence of possible damaging agents should also be considered in choosing a species to plant in an area. These considerations should include not only effects of insects and diseases, but also such factors as winter hardiness, susceptibility to spring frost damage and ice and snow breakage and sensitivity to air pollutants.

In the following text, characteristics, site requirements and possible damaging agents are discussed in relation to the major species recommended for Christmas tree planting in Ohio.

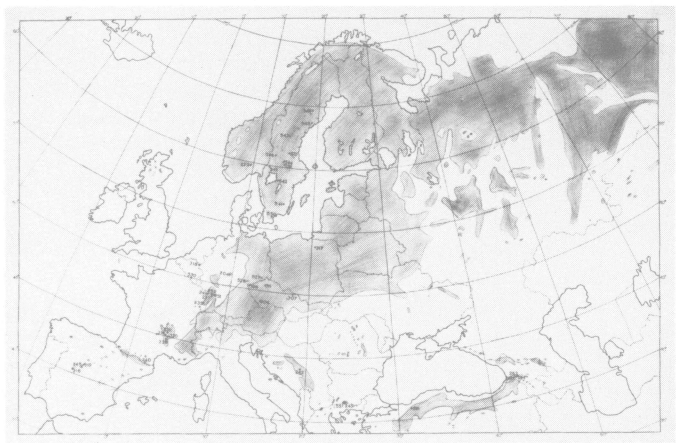


Fig. 4: Native range (shaded area) of Scotch pine. Numbers show locations of areas from which seed was collected for use in research studies.

The Pines (*Pinus* spp.)

Needles of the pines are borne in bundles of two or more along the twigs and are relatively long in comparison to those of spruces, true firs and Douglas-fir. Nutrient and water requirements are generally somewhat less exacting than those of most spruces, true firs and Douglas-fir. Because of this, pines are usually adapted to a wider variety of sites. Needle retention on cut trees is excellent.

Scotch Pine *(Pinus sylvestris):* Scotch pine, a two-needled pine native to Europe and Asia (Fig. 4) is the most widely planted and most extensively used Christmas tree species in Ohio (Fig. 5). There is considerable genetic variability in the species, and foliage color, needle length, stem straightness and growth rate vary greatly depending on the area from which seed was collected. Seedlings raised from seed sources originat-

Fig. 5: Well-shaped tree and foliage of Scotch pine.

ing in southern France and Spain appear to be best for planting in Ohio, although foliage of those from Spain may be injured by winter drying ("winter burn") during very cold winters. Trees from other southern and western portions of the range, particularly from Scotland, Greece and Turkey, also show promise. Trees from these areas have relatively short needles, adequate growth rate and green or blue-green winter foliage.

Scotch pine prefers moist, well drained soils but grows reasonably well on sites ranging from relatively dry to moderately wet. Although Scotch pine requires considerable shaping to produce high quality trees, it responds well to shearing. Depending on site characteristics and cultural practices, 6- to 7-foot Christmas trees can be produced in six to nine years.

Particularly troublesome pests of Scotch pine include sawflies, European pine shoot moth, white pine weevil, spotted pine needle aphid, pales weevil, northern pine weevil, Nantucket pine tip moth, eriophyid mites, *Diplodia* tip blight and needle casts, particularly those caused by the fungi *Lophodermium pinastri* and *Naemacyclus minor*. (More detailed information on insect, disease and animal pests of Christmas trees and their control is available from the Ohio Cooperative Extension Service).

White Pine *(Pinus strobus):* Eastern white pine is a five-needled pine native to southern Canada, the Lake States and the eastern United States (including scattered locations in Ohio) southward through the Appalachian Mountains and Plateau to northern Georgia (Fig. 6). Seedlings raised from seed sources from the southern portion of the species range tend to have longer, bluer-green needles and better second-year needle retention. They should be preferred for Christmas trees when available. Branches are slender and flexible, and trees usually require fairly heavy shearing to produce high quality trees. More growers in Ohio are planting eastern white pine due to increased demand for the species.

White pine prefers moist, well-drained soils but will grow on sites ranging from relatively dry to wet. It appears to be somewhat more tolerant of wet soils than Scotch pine, although trees on wet sites may suffer from white pine root decline. Fertility requirements of the species are somewhat higher than those of Scotch pine but are not as high as those of most spruces, true firs or Douglas-fir. White pine does well at all latitudes in Ohio, and 6- to 7-foot Christmas trees can be produced in six to nine years.

Important pests of eastern white pine include white pine weevil, various sawflies, bark and needle aphids, pine tube moth, white pine blister rust and white pine root decline, particularly on wet sites. White pine is also very susceptible to injury by atmospheric impurities, particularly sulfur dioxide, ozone and gaseous fluorides. Damage from air pollution may range from extreme stunting of growth and death of all or parts of the needles ("chlorotic dwarf") to mild yellowing of foliage. In areas where sulfur dioxide and ozone concentrations are high, 25 percent or more of trees in plantations may have visual symptoms. If white pine foliage gets wet on the sales lot, needles tend to clump together, decreasing the feathery natural beauty of trees. However, needles regain their natural appearance after drying.

Fig. 6: Well-shaped tree and foliage of white pine.

Fig. 7: Well-shaped tree (L.) and foliage (above) of Colorado (blue) spruce.

Other Pines: In the past, two other pines, Austrian or black pine *(Pinus nigra)* and red pine *(Pinus resinosa)*, were grown extensively for Christmas trees in Ohio. However, these species are difficult to shape into high quality Christmas trees, and growers now generally prefer Scotch and white pine. Austrian pine is still produced in limited quantities for live ornamental sales. Moisture requirements of Austrian pine are similar to those of Scotch pine. However, its nutrient requirements are considerably higher. It is a species that grows well on soils having a high pH. Austrian pine is also resistant to salt and air pollution injury.

Southwestern white or border pine *(Pinus strobiformis)* is another pine being planted in limited quantities by Christmas tree growers in Ohio. It appears promising for expanded planting. It is a five-needled pine, similar to eastern white pine, but has shorter needles that are usually retained for two or more years. Limbs are stiffer than those of eastern white pine. Site requirements and cultural practices needed to produce quality trees have not been well established in the state, and until more is learned about the species, growers should be cautious when planting it.

The Spruces (*Picea* spp.)

Spruce needles are borne singly along the twigs and are usually relatively short and sharp-pointed. Needle retention on cut trees varies somewhat, but in general is not as good as on pines. Although most species of spruce prefer moist, well drained soils with moderate to good fertility, they will grow on rather sandy soils if there is a favorable water table throughout the growing season. Growth of most species is not as good on poorly drained, fine textured clay soils. However, survival and growth are often acceptable on soils that are poorly or somewhat poorly drained because of a seasonally high water table. Spruces often undergo a slow-growing establishment period following planting, after which growth is usually relatively rapid. Therefore, although the basic form of most trees is good, some shearing is needed to produce high quality Christmas trees. As a group, the spruces are subject to spring frost injury if they leaf out early. Low lying sites or "frost pockets" should be avoided when possible.

Colorado Spruce *(Picea pungens):* Colorado or blue spruce is a native of western United States but is extensively planted as an ornamental and Christmas tree in Ohio (Fig. 7). Needles are generally longer than those of Norway and white spruces and are very sharp-pointed. Although foliage on some trees is a bright bluish color, most nursery run seedlings are green to blue-green. This characteristic is somewhat related to seed source. Generally, trees produced from seed originating in the southern Rocky Mountains of southern Colorado, Arizona and New Mexico are preferred for Christmas trees. Needle retention on cut trees is generally better than that for white and Norway spruces and is almost as good as that of pines. Site requirements are similar to those outlined earlier. However, growth is usually slower than that of Norway and white spruces. Eight to 12 years are needed to produce 6- to 7-foot trees on most sites.

Sawflies, gall aphids, spider mites, white pine weevil, *Cytospora* canker and *Rhizosphaera* needlecast are the major pests affecting Colorado spruce.

Fig. 8: Well-shaped tree (L.) and foliage (above) of Norway spruce.

Norway Spruce *(Picea abies):* In the past, Norway spruce, a native of Europe, was one of the most widely planted Christmas tree species in Ohio (Fig. 8). Temperatures in most of the state are suitable for its growth, and it is generally easier to establish than any of the other spruces. A rotation of 7 to 11 years is needed to produce 6- to 7-foot trees on relatively good sites. Needle retention on cut Norway spruce is very poor and because of this, sales, and consequently planting, of the species have declined in recent years. To minimize needle drop on cut trees, harvesting should be delayed as long as possible.

Pests particularly destructive to Norway spruce include gall aphids, white pine weevil, spider mites, *Cytospora* canker and *Rhizosphaera* needlecast.

White Spruce *(Picea glauca):* White spruce is native to the northern United States and Canada, although it grows well in Ohio at most latitudes (Fig. 9). Needles are whitish or bluish. Although not as good as for pines, needle retention on cut trees is generally better than for Norway spruce. However, like Norway spruce, harvesting of trees should be delayed as long as possible. Eight to 11 years are required to produce 6- to 7-foot trees on relatively good sites. Gall aphids, spider mites and *Rhizospaera* needlecast are major pests affecting white spruce.

Other Spruces: There are a number of other spruces that have been or could be planted for Christmas trees. Red spruce *(Picea rubens)* and black spruce *(Picea mariana)* were used extensively in the past. However, their site requirements are more demanding than those of Norway, white and blue spruce, and red and black spruce are not recommended for general Christmas tree planting in Ohio. Several European and Asiatic spruces have promise for use as Christmas trees in Ohio. Most have not been adequately tested and cannot be recommended for general planting at this time. One species for which information is available is Serbian spruce *(Picea omorika)*. It is a native of southern Europe and has relatively soft needles that are dark green above and bluish below. Branches are limber, often giving trees a drooping appearance. Site requirements are similar to those of Norway spruce. Growth begins later in spring than Norway spruce; thus, Serbian spruce is not as likely to be damaged by late spring frost. Needle retention on cut trees is poor, and rotation length should be similar to those for Norway and white spruces.

The True Firs (*Abies* spp.)

Needles of the true firs are borne singly along the twigs and are usually fairly short and rounded at the tips. Needle retention on cut trees is excellent. Most firs prefer moist, cool climates and moist, well drained soils with moderate to high fertility. The basic conical form of trees is good, but irregular growth rates and limbs of uneven length usually require some shearing in order to produce high quality trees. Firs are subject to late spring frost injury. Low lying sites or "frost pockets" should be avoided when possible.

Fraser Fir *(Abies fraseri):* Fraser fir, or southern balsam fir, is native to the Appalachian Mountains in parts of Virginia, North Carolina and eastern Tennessee (Fig. 10). Limbs are sturdy, and the tree has a pleasant "balsam" odor. It is quite similar to balsam fir except that needles are darker green above and it has prominent white bands on the undersides of needles. Growth begins later in spring, making it less susceptible to late frost injury than balsam fir. Fraser fir can be planted on moist, well drained sites at most locations in central

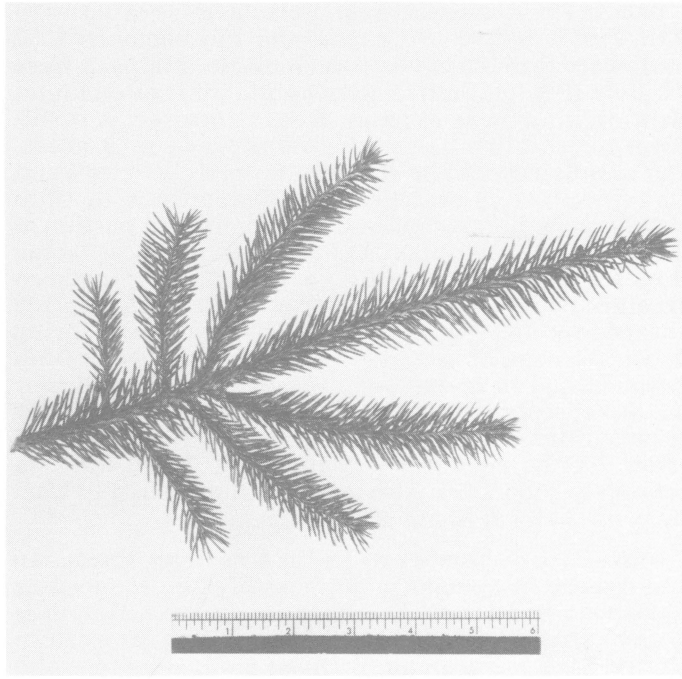


Fig. 9: Well-shaped tree and foliage of white spruce.

and northern Ohio. It should be adaptable to southern areas in the state, particularly on cooler north and east facing slopes. Fraser fir does not survive or grow well on wet sites; in addition, there are indications that the species may have problems on drier sites during periods of prolonged drought. Growth of Fraser fir is generally more regular and rapid than that of balsam fir, and 6- to 7-foot trees can probably be produced in 7 to 11 years on good sites. The balsam wooly aphid is the major pest affecting Fraser fir.

Fig. 10: Well-shaped tree and foliage of Fraser fir.

Balsam Fir *(Abies balsamea):* Balsam fir is not native to Ohio but is native to Canada and the northern U.S. southward through the Appalachian Mountains to West Virginia (Fig. 11). In its native habitat, it is often found growing in or near swampy areas. However, it is difficult to establish balsam fir plantings in such areas, and planting should be confined if possible to well and moderately well drained sites. Plantations in Ohio should probably be confined to the northern portion of the state, although plantings on north and east facing slopes might be successful in central and southern areas. Balsam fir often begins growth early in the spring and is therefore vulnerable to injury by late spring frosts. Because of this, planting of the species in Ohio has declined in recent years. Growers seem to prefer the more frost resistant Fraser fir. Because of irregular growth rates (partly related to frost injury), 10 to 15 years may be needed to produce 6- to 7-foot trees on relatively good sites. The major pest affecting balsam fir is the balsam wooly aphid.

Other Firs: A number of North American, European and Asiatic fir species might possibly be produced as Christmas trees in Ohio. These include red fir *(Abies magnifica)* and noble fir *(Abies procera)* from the western United States, Nordman fir *(Abies nordmanniana)* and Cilician fir *(Abies cilicia)* from Europe and Veitch fir *(Abies veitchii)* and Nikko fir *(Abies homolepis)* from Asia. However, these species have not been adequately tested under conditions in Ohio and cannot be generally recommended at this time. One species that has been planted in limited quantities in a number of areas is white or concolor fir *(Abies concolor)*. It is native to the West and has relatively long (2 to 3 inches), silvery-blue to silvery-green needles. Like balsam fir, white fir is relatively difficult to establish in plantations, and growth after planting is often very irregular. Temperature requirements for the species are not well established in Ohio, but sites in central and northern portions of the state are probably preferable. Rotation lengths to produce 6- to 7-foot trees are probably 10 to 15 years. Little damage from insects or diseases has been encountered on white fir.

Douglas-fir *(Pseudotsuga Menziesii)*

Douglas-fir is not a true fir. It is native to a wide geographic area in the West and Canada, and considerable genetic variation exists in the species (Fig. 12). Seedlings grown from seed collected on the West Coast are generally not winter-hardy in Ohio. Those from high elevations in the northern Rocky Mountains usually grow very slowly and are often damaged by late spring frosts after growth begins in early spring.

Seedlings raised from seed collected in southern Colorado, Arizona and New Mexico seem best for planting in Ohio. These include seed sources from the Coconino, Lincoln, Santa Fe, San Juan, San Isabel and Kaibab National Forests. These sources produce trees having good growth rates and relatively long needles borne singly along the twigs and usually have bluish or blue-green foliage. They also break bud somewhat later in the spring; thus, they are less subject to late spring frost damage.

Of those species commonly recommended for planting in Ohio, Douglas-fir is probably the most difficult species to grow successfully for Christmas trees. It prefers cool, moist, well drained sites with moderate to high fertility. It does not tolerate either excessive moisture or drought. Tight, fine textured soils, dry soils and dry ridges and slopes should be avoided as planting

Fig. 11: Well-shaped tree and foliage of balsam fir.

Fig. 12: Well-shaped tree (L.) and foliage (above) of Douglas-fir.

sites. Late spring frost injury is a major problem. The species should preferably be planted on cool, north and east facing slopes where there is good air drainage. The basic conical form of the species is good, but shearing is usually necessary to produce high quality Christmas trees. Needle retention on cut trees is excellent. About 7 to 11 years are needed to produce 6- to 7-foot trees on good sites. Gall aphids and *Rhabdocline* needle cast are the major pests affecting Douglas-fir.

In summary, of the several species that could be planted for Christmas trees in Ohio, five are recommended for general planting in the state: Scotch pine, white pine, Colorado spruce, Fraser fir and Douglas-fir. Scotch pine, adapted to a wide range of sites, has been by far the most widely planted species. However, because of continuing insect and disease problems and lower wholesale and retail prices, planting of Scotch pine has declined in recent years. Conversely, planting of white pine, also adaptable to a fairly wide range of sites, has been increasing steadily. Similarly, plantings of the more site-demanding Colorado spruce, Fraser fir and Douglas-fir have increased, although acreage in these species is still relatively low. The other three species discussed in detail in previous sections are not recommended for general planting. Needle shed on cut trees is the major problem with Norway and white spruces, while frost damage and irregular growth are the major problems with balsam fir.

Determination of Site Productivity

Of the species that might be grown for Christmas trees in a given area, some may be much more exacting in their moisture and fertility requirements than others. For example, Scotch pine has relatively low requirements for both moisture and nutrients and, consequently, can be grown successfully on a variety of sites having a wide range of conditions. In contrast, many true firs, spruces and Douglas-fir are more demanding and do well only on sites that are at least relatively moist and/or fertile.

Knowledge of characteristics and productive potential of individual planting sites, added to an understanding of species requirements, helps reduce some of the uncertainties of Christmas tree production. It is an area, however, that is badly neglected by many growers. All too often lands are planted without regard to site characteristics or species requirements. Consequently, survival and growth in some plantations can be unnecessarily poor, resulting in reduced tree quality, longer rotations and greatly increased costs.

Site quality determination can be done in a number of ways. Thorough evaluation of planting sites, either by the grower or by professional outside help, can provide the necessary information. Special emphasis should be placed on factors that affect moisture availability. These include soil texture, depth and drainage class, topographic slope position and aspect and slope steepness. Where topography is diverse, integration of all these factors into an accurate and meaningful estimate of available soil moisture can be difficult. Tables 1 and 2 on pages 12 and 13 have been prepared to aid in integration of these factors. Table 1 is designed to indicate the relative "moisture regime" or moisture supplying capacity of different topographic-soil combinations.

Table 1: Planting Site Classification for the Residual Soils Region of Southern and Eastern Ohio[1]

Area and Aspect	Soil Drainage Class	Soil Texture	Slope Position	Soil Depth and Slope Steepness: 6-12 Inches Slope Percent 0-20	20-40	40+	12-24 Inches Slope Percent 0-20	20-40	40+	24+ Inches Slope Percent 0-20	20-40	40+
Slopes and Bottoms — Northeast	Well and Moderately Well	Coarse	Upper	4	4	4	4	4	4	3	4	4
			Middle	4	4	4	3	3	4	3	3	3
			Lower	—	—	—	3	3	3	2	3	3
		Medium To Fine	Upper	4	4	4	3	3	4	2	2	3
			Middle	4	4	4	2	2	3	2	2	2
			Lower	—	—	—	2	2	2	2	2	2
	Somewhat Poorly	Coarse	Middle & Lower	—	—	—	—	—	—	2		
										2		
		Medium To Fine	All	—	—	—	—	—		2	—	—
	Poorly and Very Poorly	Medium to Fine	Middle & Lower	—	—	—	—	—	—	1	—	—
Slopes and Bottoms — Southwest	Well and Moderately Well	Coarse	Upper	4	4	4	4	4	4	3	4	4
			Middle	3	4	4	4	4	4	3	3	4
			Lower	—	—	—	3	3	3	3	3	3
		Medium To Fine	Upper	4	4	4	3	4	4	2	3	4
			Middle	4	4	4	3	3	3	2	3	3
			Lower	—	—	—	2	3	3	2	2	3
	Somewhat Poorly	Coarse	Middle & Lower	—	—	—	—	—	—	2	—	—
		Medium To Fine	All	—	—	—	—	—	—	2	—	—
	Poorly and Very Poorly	Medium to Fine	Middle & Lower	—	—	—	—	—	—	1	—	—
Ridges	Well	Coarse		4	—	—	4	—	—	3	—	—
		Medium to Fine		4	—	—	3	—	—	2	—	—
	Somewhat Poorly	Coarse		—	—	—	—	—	—	2	—	—
		Medium to Fine		—	—	—	3	—	—	2	—	—
	Poorly	Coarse		—	—	—	1	—	—	1	—	—
		Medium to Fine		—	—	—	1	—	—	1	—	—

[1]Numbers Indicate Moisture Regime
1 = Wet
2 = Moist
3 = Dry
4 = Very Dry

Key to Soil Textures
Coarse = loamy sand to fine sandy loam
Medium to fine = very fine sandy loam to clay

Key to Soil Drainage Classes
Well: generally free of mottling
Moderately well· mottling generally below 16"
Somewhat poorly: mottling usually occurring between 6" to 16"
Poorly: mottling or evidence of poor drainage ("gray" coloring, etc.) at or near surface

Special Note: If area is heavily eroded, increase moisture class by one number in classes 2 and 3.

Table 2 gives the general suitability of each Christmas tree species for planting under each moisture regime: S = suitable, L = limited suitability and N = not suitable.

An example of the use of Tables 1 and 2 follows: Examination of a field to be planted indicates that the site is located on the upper portion of a 20 percent slope that faces to the northeast. The soil is a well drained loam (medium texture), and depth of the soil to bedrock is 20 inches. Using this information in Table 1, one obtains a soil moisture rating of "3," indicating a dry soil moisture regime. Looking at Table 2, one can see that the dry soil moisture regime is most suitable (S) for Scotch, white and Austrian pines. Additionally, limited suitability (L) is indicated for the spruces, true firs and Douglas-fir.These species could probably be grown on the site, but growth and/or foliage quality would probably be reduced to some extent. Although Tables 1 and 2 are most applicable to areas where topography is varied such as southeastern Ohio, they should also be helpful for use in choosing species for planting on specific soil-topography combinations in other areas.

Soils maps prepared by the Soil Conservation Service offer another excellent means of determining site potential (Fig. 13). These are available as parts of county soil surveys or through mapping of individual farms by SCS soil scientists as a service available when growers participate as cooperators with local soil and water conservation districts. These maps not only delineate specific soils and their characteristics but also subdivide them into mapping units based on slope and degree of erosion. Accompanying soil descriptions provide an excellent basis for evaluating potential mois-

Table 2: Suitability of Christmas Tree Species According to Soil Moisture Regime for Planting Sites in the Residual Soils Region of Southern and Eastern Ohio[2]

Species	Soil Moisture Regime			
	1 Wet	2 Moist	3 Dry	4 Very Dry
Scots (Scotch) Pine	L	S	S	L
Eastern White Pine	L	S	S	L
Black (Austrian) Pine	L	S	S	L
Norway Spruce[1]	L	S	L	N
White Spruce[1]	L	S	L	N
Colorado (Blue) Spruce[1]	L	S	L	N
Douglas-Fir[1]	N	S	L	N
Fraser Fir[1]	N	S	L	N
Balsam Fir[1]	L	S	L	N

Key to Species Suitability

S = Suitable: Growth and/or foliage quality should be good to excellent with proper management.

L = Limited suitability: Species will probably grow on sites but there may be reductions in growth and/or foliage quality, even with good management.

N = Not suited: Survival, growth and/or foliage quality will probably be so impaired that species should not be planted.

[1]Avoid planting species in "frost pockets;" species commonly leafs out early in spring and may be damaged by frost (Fraser fir is least susceptible of the group).

[2]Adapted from "Planting Sites in the Northeast," NEFES Pap. 157, 1961. This table is most suitable for use in the unglaciated soils region of southern and eastern Ohio. However, because of general soil-topographic relationships, it might also serve as a tentative guide in other areas for which other suitable information is not available.

ture and nutrient supplying capacity. Additional interpretive data related specifically to Christmas trees are also available in some locations. These interpretations include specific species suitable for planting, constraints on equipment operation, probable seedling mortality and intensity of vegetative competition.

Because these maps and interpretations relate to specific soil mapping units occurring in Ohio, it would be impossible to provide a comprehensive list in this publication. However, Table 3 provides guidelines for selection of Christmas tree species for planting in the broad "Soil Conservation Service Woodland Suitability Groups" to which different soil mapping units are assigned. The woodland suitability classes, with ratings

Fig. 13: Soils maps can be used to evaluate characteristics of planting sites and to choose species for planting. They can also provide the basis for subdivision of the Christmas tree farm into similar units for more efficient management.

from 1 (best) to 5 (poorest) are designed primarily to designate potential growth and yield of timber crops growing on soil-topographic combinations (soil mapping units) assigned to each class. Subclasses indicate possible "limiting factors" within each major suitability class as follows: 0 = none, R = relief or slope steepness, F = fragmental or skeletal soil, S = sandy soil, C = high clay content soil, D = restricted rooting depth, W = excessive wetness and X = stoniness or rockiness. Guidelines in Table 3 are set up similar to Table 2 to indicate the relative suitability (S, L, N) of different Christmas tree species for planting on each woodland suitability class-subclass combination.

Interpretations in Tables 2 and 3 relate primarily to the moisture status of soils and planting sites. Additional laboratory analyses of soil samples to evaluate fertility status may also be needed, particularly if some of the spruces, true firs or Douglas-fir are to be planted. Soil sampling "kits," including instructions and sample bags, are available from county agricultural extension agents.

Table 3: Suitability of Christmas Tree Species for Planting in Ohio on Soils Grouped Under Different Soil Conservation Service "Woodland Suitability Classes" and "Subclasses"[1]

Woodland Suit. Class	Subclass (Limiting) Factor)	Scotch (Scots) Pine	Black (Aust.) Pine	White Pine	Colorado (Blue) Spruce	Norway Spruce	White Spruce	Fraser Fir	Balsam Fir	Douglas-Fir
1	O	S	S	S	S	S	S	S	S	S
	R	S	S	S	S	S	S	S	S	S
	F	S	S	S	S	S	S	S	S	S
	S	S	S	S	S	S	S	S	S	S
	C	S	S	S	S	S	S	L[4]	S	L[4]
	D	S	S	S	S	S	S	S	S	S
	W	L	L	L	L	L	L	N	L	N
	X	S	S	S	S	S	S	S	S	S
2	O	S	S	S	S	S	S	S	S	S
	R	S	S	S	S	S	S	S	S	S
	F	S	S	S	S	S	S	S	S	S
	S	S	S	S	S	S	S	S	S	S
	C	S	S	S	S	S	S	L[4]	S	L[4]
	D	S	S	S	S	S	S	S	S	S
	W	L	L	L	L	L	L	N	L	N
	X	S	S	S	S	S	S	S	S	S

(continued next page)

Table 3: Suitability of Christmas Tree Species for Planting in Ohio on Soils Grouped Under Different Soil Conservation Service 'Woodland Suitability Classes" and "Subclasses"[1]—Continued

Woodland Suit. Class	Subclass (Limiting) Factor)	Scotch (Scots) Pine	Black (Aust.) Pine	White Pine	Colorado (Blue) Spruce	Norway Spruce	White Spruce	Fraser Fir	Balsam Fir	Douglas-Fir
3	O	S	S	S	S	S	S	S	S	S
	R	S	S	S	S	S	S	S	S	S
	F	S	S	S	S	S	S	S	S	S
	S	S	S	S	S	L	L	L	L	L
	C	S	S	S	S	S	S	L[4]	S	L[4]
	D	S	S	S	L	L	L	L	L	L
	W	L	L	L	L	L	L	N	L	N
	X	S	S	S	L	L	L	L	L	L
4	O	S	S	S	L	L	L	L	L	L
	R	S	S	S	L	L	L	L	L	L
	F	S	S	S	L	L	L	L	L	L
	S	S	S	S	L	L	L	L	L	L
	C	S	S	S	L	L	L	L[4]	L	L[4]
	D	S	S	S	L	L	L	N	N	N
	W	L	L	L	L	L	L	N	L	N
	X	L	L	L	L	L	L	N	N	N
5	O	L	L	L	N	N	N	N	N	N
	R	L	L	L	N	N	N	N	N	N
	F	L	L	L	N	N	N	N	N	N
	S	L	L	L	N	N	N	N	N	N
	C	L	L	L	N	N	N	N	N	N
	D	L	L	L	N	N	N	N	N	N
	W	L	L	L	L	L	L	N	N	N
	X	L	L	L	N	N	N	N	N	N

[1]Key to Species Suitability:
S=Suitable: Growth and/or foliage quality should be good to excellent with proper management.
L=Limited suitability: Species will probably grow on sites, but there may be reductions in growth and/or foliage quality, even with good management.
N=Not suited: Survival, growth and/or foliage quality will probably be so impaired that species should not be planted.
[2]Soils are grouped under Woodland Suitability Classes with reference to potential growth ("site index") of trees, with: 1 = very good, 2 = good, 3 = fair, 4 = poor and 5 = very poor.
[3]Subclasses or limitations within Suitability Classes: O=None, R=Slope steepness, F=Fragmental soil, S=Sandy soil, C=Clayey soil, D=Restricted root depth, W=Wet soil and X=Stony soil.
[4]Clay content of soil may make it too wet or poorly aerated for good survival and growth during wet years.

Plantation Establishment and Management

Preplanting Land Preparation

A number of major problems that can impede efficiency of operations in Christmas tree plantations can be prevented if consideration is given to land and site preparation before planting.

Bulldozing: Special attention should be given to removal of major obstacles such as large trees, rocks and unneeded fences that interfere with efficient operations. Removal of these materials, as well as heavy concentrations of medium to smaller trees and brush, can best be accomplished using heavy equipment that would be difficult to use once seedlings were planted (Fig. 14). When sites are to be bulldozed, the blade should be maintained just at ground level. If the blade is only a few inches above the ground, much of the smaller material may be matted down, and roots will not be pulled from the soil. If the blade is positioned too low, valuable topsoil may be removed from the site during the bulldozing. Costs for bulldozing can be quite high and vary considerably depending on concentra-

Fig. 14: Planting site on which brush, trees and other obstacles have been removed by bulldozing.

Table 4: Examples of Labor and Equipment Requirements for Various Site Preparation and Planting Practices[1]

Type of Practice	Time Requirements, Hours Per Acre		Per 1,000 Trees	
	Equipment	Labor	Equipment	Labor
Clearing: 140 HP Crawler Tractor	6.03	6.03	—	—
Clearing: 65 HP Crawler Tractor	10.00	10.00	—	—
Cultivation: 30 HP Tractor and Plow	3.84	3.84	—	—
Cultivation: 30 HP Tractor and Disk	3.24	3.24	—	—
Cultivation: 30 HP Tractor and Subsoiler	4.50	4.50	—	—
Mowing: 30 HP Tractor and Mower	0.91	1.03	—	—
Mowing: 12 HP Tractor and Mower	5.50	7.10	—	—
Herbicide: Hand Application	0	5.50	—	—
Herbicide: 30 HP Tractor and 100 gal. Sprayer	0.92	0.92	—	—
Planting: Hand	—	—	0	21.49
Planting: 30 HP Tractor and Planter	—	—	3.0	7.14
Planting: Replanting, 1st year	—	—	0	19.90

[1]Information taken from: Leuschner, W. A. and W. A. Sellers. 1975. The economics of producing and marketing Christmas trees. Virginia Polytechnic Institute and State University, Division of Forestry, FWS-1-75. 47 pp.

Rates listed are for comparison only and can be expected to vary considerably from one Christmas tree operation to another.

tion and size of materials to be removed, equipment and labor costs, etc. Table 4 gives examples of time needed to clear land using two different sizes of crawler tractors. A grower buying lands for planting can save these costs or pay more per acre if clearing is not needed.

Pre-Planting Tillage: In some instances, some type of tillage (plowing, disking, rototilling, etc.) may be desirable before trees are planted, either before the first crop of trees are established on a site or after removal of a stand and before the new rotation is begun (Fig. 15). This can help to eliminate or reduce woody and herbaceous vegetation and roots of cut trees. It can also provide a loosened soil layer, which may permit easier planting and better root development of planted seedlings. This is particularly important on finer textured soils having high clay content. In such soils, roots of seedlings may be restricted by compacted soil around the planting slit made during hand or machine planting, which makes normal root orientation difficult and causes a number of root abnormalities (see section "Tree Planting Operations"). In addition, in fine textured soils it is often difficult to close the planting slit tightly around roots of seedlings after planting. Slits often open up when soils dry out. Tillage helps to break down the compact structure of the soil, providing granular soil particles more favorable to root development and planting slit closure. Tillage can also be used to incorporate fertilizers into the soil (see section "Pre-Planting Fertilization"). Following tillage, the grower also has the opportunity to establish a more desirable ground cover—possibly a legume—on the area.

The entire planting area can be tilled or 2- to 4-foot wide strips prepared (along the contour on sloping

Fig. 15: Planting area being fertilized and tilled before planting seedlings.

ground) in which trees are to be planted. To prevent formation of "clods," particularly in finer textured, high clay content soils, tillage should be done when soils are moist but not wet. Additionally, tilled areas should be allowed to settle before planting, and because of these two restrictions, late summer or fall preparation is usually preferred.

Cost of various tillage practices varies considerably depending on equipment, labor costs, terrain, type, complete vs. partial preparation, etc. Table 4 gives examples of time required to prepare land using some common combinations of tillage practice.

Chemical Control of Woody Plants: Species that root sprout (black locust, cottonwood, aspen, etc.) should probably be killed at least a year before they are to be removed from the planting site by cutting or bulldozing. Use of appropriate silvicides in conjunction with frilling (for larger trees), injectors (for medium-sized trees) or basal spraying (for smaller trees and brush) is very effective for this purpose (see Fig. 16 on page 16). Foliage sprays with silvicides should also be used to kill smaller brush (see Fig. 17 on page 16). If areas are mowed only and then planted, as is often done, much of the woody brush may sprout. Choice of methods and materials for control will be more limited, and total costs will increase.

A number of chemicals are effective for this purpose. However, use is closely controlled by the Environmental Protection Agency, and regulations are subject to periodic change. For these reasons, specific chemicals, rates and methods of application are not presented in this section. The grower is referred to recommendations that are updated periodically by personnel of the Cooperative Extension Service. In using all chemical herbicides, rates and methods of application listed on the product label **must** be followed closely in order to ensure safe, effective control. (For additional information on herbicides and their use, see section "Weed Control").

Control of Herbaceous Weeds at Planting Time:[d] Control of heavy grass and broadleaf weeds in Christmas tree plantations at planting time is extremely important. Initial weed control often determines whether or not trees survive and how well they grow (see Fig. 18 on page 16).

Fig. 16: Scattered individual small trees on planting sites can be killed by basal spraying with herbicides prior to planting seedlings.

Ideally, control of herbaceous weeds in Christmas tree plantations begins the fall prior to spring planting. Many growers accomplish this by spraying herbicide in 2- to 3-foot wide strips or spots in which trees will be planted the following spring. Some growers apply a foliar herbicide early in the fall when weeds are actively growing to eliminate the well established perennials. Many growers who till in the fall prior to spring planting spray areas to be tilled with a foliar herbicide a week or two before tilling. If a foliar applied herbicide is used in early fall, some additional form of weed control will be necessary to prevent re-invasion of weeds the following year. A soil applied herbicide may be applied in late fall before the soil freezes up (usually around the end of November in mid-Ohio). This will control weeds effectively during the following growing season or it may be applied in the spring about two weeks prior to planting or after one or two good rains following planting. This wait allows the soil to settle and the planting slit to close. If this is not done, the herbicide may be carried into the slit by rain and kill the tree. The heavier (finer) the soil, the greater the danger. Alternatively, other weed control techniques such as mulching or tilling may be started in the spring.

Other growers omit the foliar herbicide and use only a soil applied herbicide late in the fall. Soil applied herbicides should not be applied early in the fall because they lose much of their effectiveness in controlling weeds the following year. Mowing or tilling prior to applying these herbicides produces better and more uniform results.

[d]For a detailed discussion of weed control principles and techniques, an explanation of terms and examples, see section "Weed Control" in this manual.

Fig. 17: Where brush cover is extensive on planting sites, foliage sprays with herbicides can be used to kill trees before seedlings are planted.

Sometimes weed control in plantations cannot be started until the spring of the planting year. If it is begun early, before weeds have begun substantial growth, an application of a soil applied herbicide about two weeks before planting or after one or two rains following planting normally controls all but the most deep rooted perennials. Mulching and tilling can also be used effectively. If, however, weeds have already begun to grow vigorously, effective weed control probably will require tilling and/or application of a foliar herbicide followed by use of a soil applied herbicide, tilling or mulching.

Examples of time required for spraying using hand and mechanized equipment are presented in Table 4.

Fig. 18: Seedling in dense grass sod, where survival and growth may be very poor.

Pre-Planting Fertilization: Many fertilizers, particularly lime and phosphorus, should be plowed down and mixed into the soil before planting (Fig. 15). Such materials are somewhat insoluble, and it may take two or more years for them to become distributed throughout the rooting zone after surface application. Additionally, when large amounts of soluble fertilizers such as potassium are needed, they should be incorporated into the soil well in advance of planting, if possible. High concentrations of soluble fertilizer salts can kill or injure seedlings if they are in close proximity to roots of recently planted trees. Nitrogen fertilizers should probably not be used before planting because they are usually leached from the soil before they can provide benefits to seedlings. Pre-planting applications of fertilizers should be based on laboratory analyses of soil samples to evaluate fertility status. Soil sample "kits," including instructions and sample bags, are available from county agricultural extension agents.

Choice of Planting Stock: Seedling Quality and Age

Success or failure of Christmas tree plantings depends to a great extent on the quality of planting stock used. Economizing through use of lower priced seedlings may not be wise. Such trees are often smaller and less vigorous, and their use can result in poor survival and slower growth.

Seedlings are usually raised from seed in nursery seedbeds. They are sometimes transplanted to other beds to allow more room for both shoot and root development. Seedling age is designated by two numbers connected with a hyphen. The first number designates the number of years the tree was raised in the original seedbed; the second figure indicates the additional years in a transplant bed. Thus, a 2-0 Scotch pine seedling would be one grown for two years in the original seedbed and not transplanted. A 2-2 Fraser fir transplant would be one grown for two years in the original seedbed and an additional two years in a transplant bed.

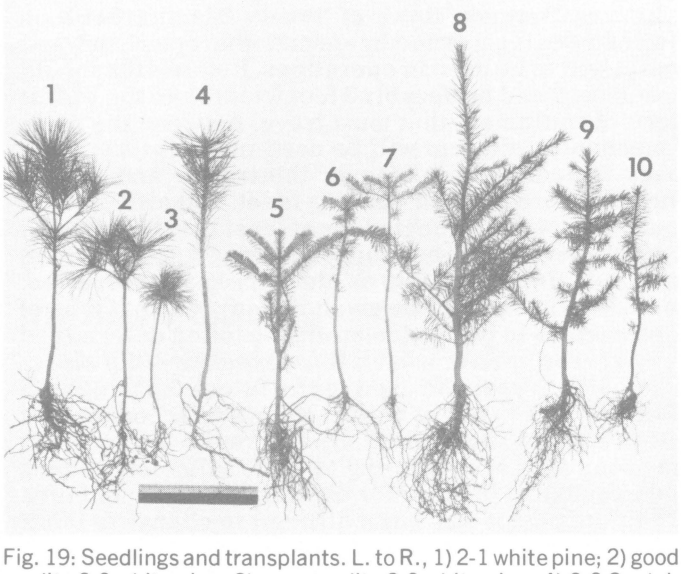


Fig. 19: Seedlings and transplants. L. to R., 1) 2-1 white pine; 2) good quality 2-0 white pine; 3) poor quality 2-0 white pine; 4) 2-0 Scotch pine; 5) 2-2 Fraser fir; 6) 3-0 Fraser fir; 7) 4-0 Fraser fir, grown in dense seedbed; 8) 3-3 Douglas fir; 9) 3-2 Douglas-fir and 10) 3-0 Douglas-fir.

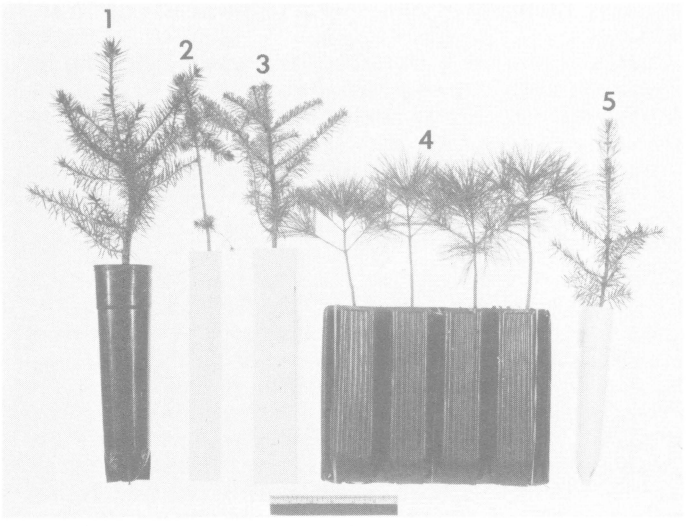


Fig. 20: Seedlings grown in a few of many different types of containers. L. to R., 1) Douglas-fir; 2) Colorado spruce; 3) Fraser fir; 4) white pine and 5) Douglas-fir.

Because the development of planting stock varies greatly among species, among nurseries and from one season to another in the same nursery, age alone may not be a reliable indicator of planting stock quality. Quality should be judged mainly on the basis of size and balance. Stem caliper and length and weight of shoots compared to length and weight of roots are probably the best criteria for judging seedling quality (Fig. 19). Seedlings should be a minimum of 6 inches and preferably 9 inches in height. Maximum height varies but should not exceed that which provides a well balanced seedling still convenient for machine or hand planting. In most instances this is no more than 12 inches.

For pines commonly planted in Ohio, the above criteria can usually be met with 2-0 or sometimes 3-0 seedlings. Transplants are usually not needed. For spruces, firs and Douglas-fir, three or more years are usually needed to produce high quality planting stock. In many, if not most, instances (depending on species, nursery, season, etc.), transplanted stock (2-1, 2-2, 3-1, 3-2, etc.) is preferred.

In recent years, there has been increasing interest in use of "containerized" seedlings in Christmas tree plantings. Seedlings are grown from seed in small containers. These seedlings, with root systems intact and never out of contact with the rooting medium, are outplanted. Such seedlings have a number of potential advantages. Because these trees do not have to regenerate new root systems, survival and early growth may be better than that of bare-rooted seedlings or transplants. Additionally, soil moisture conditions following planting may not be as critical, and it may be possible to plant successfully later in the spring. Because of faster, more uniform growth, it may also be possible to grow trees to a merchantable size sooner and to harvest all trees in a plantation in fewer years.

As with conventional seedlings or transplants, quality of container-grown seedlings varies. Age criteria discussed previously do not apply because hardy containerized seedlings can often be grown in a year or less. However, guidelines based on size and/or balance between tops and roots are probably still appropriate. Seedlings can be grown in containers having a variety of sizes and shapes (Fig. 20). Tops and roots must be large enough and in balance to provide seedlings that can

establish themselves and compete successfully in the field.

Cost of container grown trees is greater than that for seedlings, and it may be higher than that for transplants This additional cost should be justified for establishment of most spruces, true firs and Douglas-fir. It may not be justified for the pines on most planting sites.

Care of Trees Before Planting

Improper care of seedlings before planting can result in poor initial survival. Drying and heating are the major causes of injury during transport. Seedling bundles or cartons should be delivered as quickly as possible, and when received, they should be opened immediately. Roots and packing material should be moistened but they should not be allowed to stand in water.

If seedlings cannot be planted immediately after arrival, they must be stored carefully until planted. If they are to be planted within a week, seedlings may be kept in the bundles, bales or crates in a cool, moist location. Stock should be moistened, but not soaked, daily. If they must be stored for longer periods, it is best done in cold storage, if such facilities are available. Temperatures must be maintained above freezing, preferably about 35° F and never above 40°. Stock should be watered weekly; this can be facilitated by attaching a perforated tube to the end of a hose and inserting the tube into the bundles. If these recommendations are followed, seedlings can probably be stored safely for at least four to five weeks.

If cold storage facilities are not available, seedlings should be placed in heel-in beds to keep roots in contact with moist soil (Fig. 21). A trench is dug, seedling bundles are placed side by side, the trench is refilled and soil is packed tightly around the roots up to the root collar. If seedlings are to be left in the heel-in bed for an extended period, bundles should be opened and seedlings spread out to promote better contact between roots and soil. Heel-in beds should be located in moist, well drained soils in shaded areas. Heavy clay soils should be avoided because aeration is poor and roots can smother.

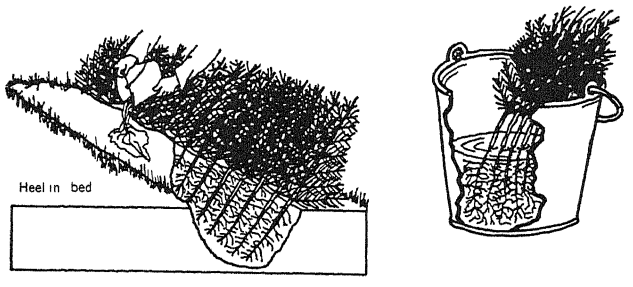


Fig. 21: Care of seedlings before planting. 1) Unpack immediately. Inspect and water. 2) Place in ground—"heeling-in." Dig trench in loose, moist soil. Break bundles and spread out evenly. Pack soil firmly and water. 3) When ready to plant seedlings: remove seedlings from "heel-in" bed; place seedlings in pail, keeping roots covered with thin mud or water at all times; carry pail of seedlings to planting site; remove and plant one at a time. 4) Plant as soon as possible. Delay reduces chances of survival.

Season of Planting

Christmas trees, like other plants, cannot be planted successfully in the field at all times of the year. In general, trees should be planted during the dormant season after the shoots cease growth in the fall and until growth begins in the spring. Soil moisture conditions should be favorable. Planting should not be attempted in frozen or snow-covered ground or when soils are wet and sticky.

In Ohio, spring planting is preferred. Fall planting should be avoided in most instances. Seedlings planted in autumn are subject to frost heaving before roots can become established, a problem most serious on bare soils and in finer textured soils. In addition, tops are more vulnerable to winter drying as needles continue to lose moisture faster than the newly planted root system can take in water.

Preferred dates for spring planting vary in different parts of Ohio and from season to season. In general, planting should be done as early as possible in the spring. In most years, this will be from about March 1 to April 15 in the southern portion of the state and about mid March to late April in the northern part.

Spacing Within and Between Rows

One of the most frequent questions asked by a person just getting into the Christmas tree business is, "What spacing should I use in my plantings?" It is also a question for which there is no simple answer. Obviously, spacing should be kept to the minimum possible so that the greatest number of trees can be grown per acre. The total number of trees planted on a farm dictates equipment needed for mowing, spraying, etc.

Spacing Within Rows of Trees: Spacing within rows is usually determined by species characteristics and the size to which they will be grown. Pines generally have relatively broad crowns (Figs. 5 and 6). A spacing of 5 to 6 feet between trees within rows is needed if trees are to be grown to a height of 6 to 8 feet. Spruces, true firs and Douglas-fir usually have narrower crowns (Figs. 10 and 12); thus, a spacing of 4 to 5 feet within rows should be adequate for growing 6- to 8-foot trees.

Spacing Between Rows of Trees: Spacing between rows of trees is governed by species characteristics and equipment to be used in operations. Row widths should be at least 2 and preferably 3 feet wider than the widest piece of equipment that must travel between the rows. If mechanical diggers will be used in the future, extra space is needed to maneuver the tractor and digger. Once trees are planted, spacing is set, and efficiency of operations will be affected for at least the time needed to grow one crop of trees and longer if new seedlings are replanted (interplanting) as older trees are harvested. Consideration should be given not only to what type of equipment is to be used *immediately* (often determined by what is on hand or what is least expensive) but also to what will probably be used in the future. Spacings are often set at 5 to 6 feet between rows to accommodate self-propelled, non-riding type mowers. The grower may soon find such mowing to be too time consuming and exhausting to allow for efficient management (Fig. 22). In the past it was often difficult to change to other types of mowers because of limited alternatives (such as brush-hogs), and those available were often too wide to fit between the rows without injuring the trees. If large tractors and trail-behind mowers are used, spacings of 7 to 9 feet between rows are required, with a

Fig. 22: Mowing for weed control with one of the many types of "walking" mowers. With such equipment, spacing between rows of trees can be closer, but labor requirements are higher.

Fig. 23: Mowing with narrow width farm tractor. Such tractors speed up the operation and reduce the amount of space required between rows of trees.

corresponding decrease in the number of trees grown per acre. This problem has been greatly alleviated by the introduction of tractors having not only narrow axle widths (for which 5 to 7 foot spacing may be suitable) but also sufficient power to operate mowers, sprayers, diggers, etc. (Fig. 23).

Trees Per Acre for Different Spacings: As noted previously, spacing should be minimized to that needed to accommodate species-equipment combinations being used. Wider spacings reduce the number of trees that can be grown on each acre and increase operational costs per tree for many cultural practices such as mowing, chemical weed control, etc. The number of trees that can be planted per acre using different combinations of spacing, independent of access roads, harvest lanes, buffer strips, etc. is presented in Table 5.

Table 5: Number of Trees Per Acre for Different Spacings in Christmas Tree Plantings

Spacing (feet)	Number of Seedlings	Spacing (feet)	Number of Seedlings
4 x 4	2722	5 x 8	1089
4 x 5	2178	6 x 6	1210
4 x 6	1815	6 x 7	1037
4 x 7	1556	6 x 8	908
4 x 8	1361	7 x 7	889
5 x 5	1742	7 x 8	778
5 x 6	1452	8 x 8	681
5 x 7	1245	8 x 9	605

Tree Planting Operations

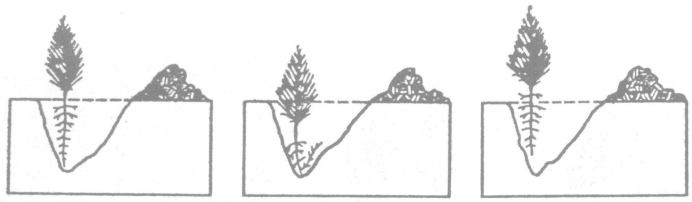
Planting of trees can be done by hand or machine. The choice between the two depends on a number of factors, including the number of trees to be planted, roughness and/or steepness of the terrain and, in some cases, the availability of a planting machine.

In all methods of planting, these guidelines should be observed: (1) seedlings should be planted slightly deeper (never shallower) than the depth in the nursery bed; (2) long roots should be pruned to about 8 inches in length (or not longer than the depth of the planting hole) using a sharp knife or clippers (never torn); (3) the tree should be planted with the main root straight down — never twisted, doubled up or sharply bent in the planting hole; (4) soil should be pressed firmly around roots to hold the tree firmly in place and (5) seedlings should be planted in a vertical position (see Fig. 24 on page 20).

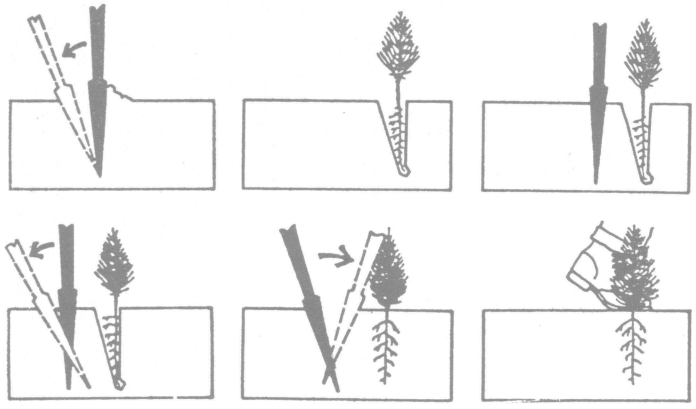
Efforts should be made during planting to ensure that trees within rows are lined up and spacing between rows is fairly uniform. This facilitates movement of equipment between rows without damaging trees and promotes uniform applications of herbicides, fertilizers, insecticides, fungicides, etc. It can be done in a number of ways. Stakes placed at intervals in rows can be used, particularly when trees are to be hand planted. Marking rows with lime or a slit in the soil made with a disk or planting machine is also helpful. Bars mounted on the tractor can be used when machine planting. The tip of the bar or a rope dangling from it is kept even with the previously planted row, regulating distance between rows. When laying out areas for planting, rows of trees should be as long as possible (depending on size and configuration of area, terrain, etc.) to reduce delays associated with turning equipment, etc.

Hand planting methods fall into two general groups — hole and slit methods. Techniques used with these methods are illustrated in Fig. 24. Hole planting can be done with a mattock, hoe or shovel. It is particularly adapted to rough, rocky land, trees with large, spreading root systems, finer textured (clay) soils and for interplanting in previously planted areas. Slit planting is much faster than hole planting and is especially adapted for tap-rooted species and use on coarse (sandy) and medium textured loam and silt loam soils. Hand planting rates generally vary from 200 to 500 trees per man day, although faster rates may be possible under optimum conditions. Average time requirements for hand planting are listed in Table 4.

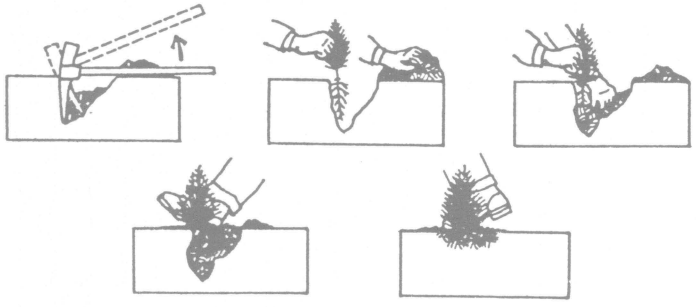
If a tree planting machine is available, planting can be done more quickly and efficiently than hand planting (see Fig. 25 on page 20). The planting machine is either attached to a tractor by a standard three-point hitch or is pulled behind a tractor on wheels attached to the planting machine. Although designs vary considerably, several components are common to all mechanical planters—a rolling coulter or cutting blade that cuts through the ground surface, a trenching plate or plow that opens a furrow, a pair of packing wheels that firm



Correct and incorrect depths. L. to R., correct: at same depth or ½" deeper than seedling grew in nursery; incorrect: too deep and roots bent; incorrect: too shallow and roots exposed.



Dibble planting. Clockwise from upper left, 1) insert the dibble as shown and pull toward planter; 2) remove dibble and place seedling at correct depth; 3) insert dibble 2 inches toward planter from seedling; 4) pull handle of dibble toward planter, firming soil at bottom of roots; 5) push handle of dibble forward from planter, firming soil at top of roots and 6) firm soil around seedling with feet.



Mattock planting. Clockwise from upper left, 1) insert mattock—lift handle and pull; 2) place seedling along straight side at correct depth; 3) fill in and pack soil to bottom of roots; 4) finish filling in soil and firm with heel and 5) firm around seedling with feet.

Fig. 24: Planting methods.

the soil after planting, some type of carrier (usually a tray) for planting stock and a seat for the person doing the planting. Some planters accommodate two people. With most machines, the roots of the seedlings are placed by hand in the hollow created by the trencher and are held until the packing wheels compress the soil around the roots. Some machines have clips arranged on a rotating arm or chain. Seedlings are placed in the clips, and the trees are moved into position in the furrow and held by the clips until the packing wheels close the trench. Such machines do not require the planter to bend down each time a tree is planted. Planting depth and spacing between trees can be controlled closely with this type of machine. Those without clips can be equipped with a spacing wheel that makes a sound when a tree is to be planted.

Topography is one of the major factors limiting use of planting machines. On sloping ground, trees are usually planted along the contour. Slopes up to 20 to 25 percent can be planted safely, depending on tractor type and the particular planting machine. Machine planting may also be difficult on stony and fine textured soils because it is difficult for the machine to open a suitable trench and pack the soil firmly around the roots (see section "Chemical Control of Woody Plants"). A crew of two (one on the tractor and one on the planter) can plant 2,000 to 5,000 or more seedlings per day, depending on soils, terrain, planting stock, etc. Table 4 gives typical time requirements for equipment and labor for machine planting.

Regardless of the planting method, care must be taken to keep seedlings moist while planting. When trees are taken from bundles, cold storage or heel-in beds, they should be placed in containers filled with wet sphagnum moss, water or moist soil. The former is preferred. When hand planting, seedlings should not be removed from the container until after the planting hole is prepared. While using a machine, it may be necessary to take several seedlings from the planting

Fig. 25: Two types of tree planting machines. Upper photo, planter where seedlings and placed by hand in the planting slit. Lower photo, planter mechanically places seedlings in the planting slit by use of mechanical "fingers" attached to a rotating chain. Parts of the machines include seedling carrier, seat, packing wheels, coulter, trencher or plow, spacing wheel and contour adjustment.

box at one time because of the speed of the operation. However, every effort must be made to keep roots moist.

Fertilization at Planting Time

Fertilization of seedlings at planting time must be done with care. Seedlings can be injured or killed if soluble fertilizers such as nitrogen and potassium come too close to roots. Banding fertilizers without adequate prior weed control also stimulates excessive competition from herbaceous vegetation, thereby reducing tree survival and growth. In addition, some species, particularly the pines, have relatively low fertility requirements and may not require fertilization on many sites. Research results in Ohio show that only small increases in shoot growth resulted during the first three years after planting as a result of fertilization of six Christmas tree species grown on sites having varying moisture and native fertility conditions.

On sites where moisture conditions are favorable but fertility is low, the more demanding species such as spruces, true firs and Douglas-fir can sometimes benefit from fertilization at planting time. On such sites, use of slow release fertilizers in either pelleted or granular forms usually gives best results. Suitable fertilizers include several formulations of different metal ammonium phosphates (8-40-0[1], 7-40-6, etc.). These can be placed in holes adjacent to but separated from the roots or placed in special packets or tablets that can be placed in the planting holes themselves (Fig. 26). About one ounce of fertilizer is needed for each tree.

Plantation Subdivision into Planting Blocks

On most Christmas tree farms, some subdivision of the major planting units into smaller blocks contained within the main road system is needed. These blocks are used to provide additional access and, in some cases, to further subdivide areas into sites having similar characteristics and/or management requirements.

[1]The designation 10-10-10, 15-15-15, 12-6-6, etc. on a fertilizer bag refers to the guaranteed minimum percent by weight of nitrogen, phosphorus and potassium (in that order) contained in the fertilizer material. Thus, a 12-6-6 fertilizer would contain 12 percent total nitrogen, 6 percent phosphorus expressed as P_2O_5 and 6 percent potassium expressed as K_2O.

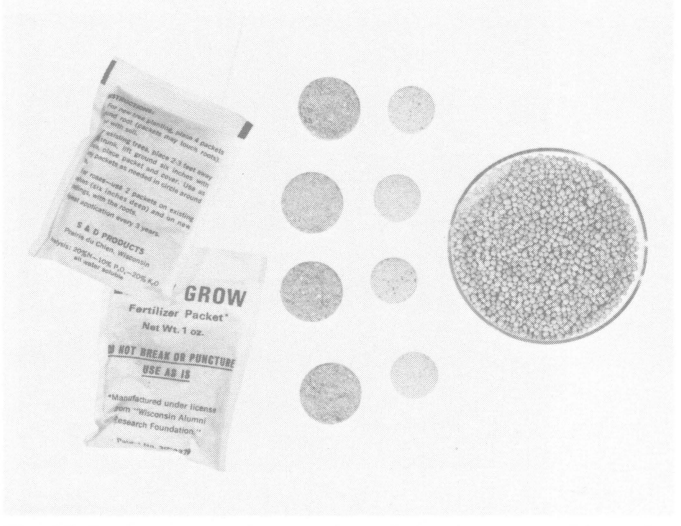


Fig. 26: Packets, tablets and pellets of slow-release fertilizers that can be used safely at time seedlings are planted.

Fig. 27: Christmas tree farm subdivided into planting blocks containing 15 to 20 rows to accommodate the cultural operations and harvesting techniques, including cut-your-own, used by the grower.

In general, the length of planting blocks should be as long as possible (considering limitations mentioned previously) in order to minimize lost space and turnaround time needed at ends of rows.

The width of individual planting blocks, or the number of rows of trees within each, often depends on factors peculiar to the individual farm. The distance from the center of any block to the alley between blocks represents the maximum distance any tree should have to be moved by hand during harvesting. If only cut trees are to be sold, block width may be relatively large—15 to 20 rows or more (Fig. 27). However, if trees are to be balled-and-burlapped, it may be more efficient to reduce block width, and subsequently, the distance heavy balled trees must be moved (Fig. 28). Also, the number of rows included in each block should be based partly on necessary cultural treatments and methods of application. Thought should be given to width of coverage provided by spray equipment used in insect and disease control, chemical weed control application and fertilization so that materials can be applied evenly throughout the blocks.

Fig. 28: The system of four-row blocks on this Christmas tree farm has been developed to accommodate the cultural operations and harvesting techniques, including cut-your-own, used by the grower.

Initial Survival and Replanting

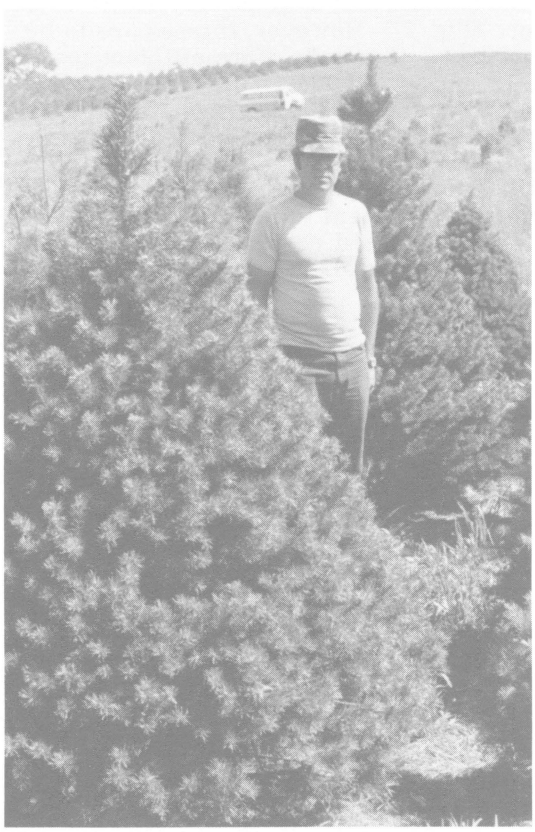
First year survival in plantings depends on a number of factors: vigor of planting stock; proper matching of species requirements and site characteristics; care of seedlings before and during planting; time of planting; vegetative competition and weather conditions before and after planting, particularly as they affect available soil moisture. Seedlings that die during the first year should probably be replaced the following spring to maintain a high level of stocking and potential income. Replanting should be done carefully with large, healthy seedlings. Special care helps maintain uniformity in tree size and minimize the number of years trees are harvested on a given planting site. Some growers provide extra stock for replanting by planting the entire area and then forming planting blocks (see section "Plantation Subdivision into Planting Blocks") by removing full rows of trees used for replanting.

Weed Control

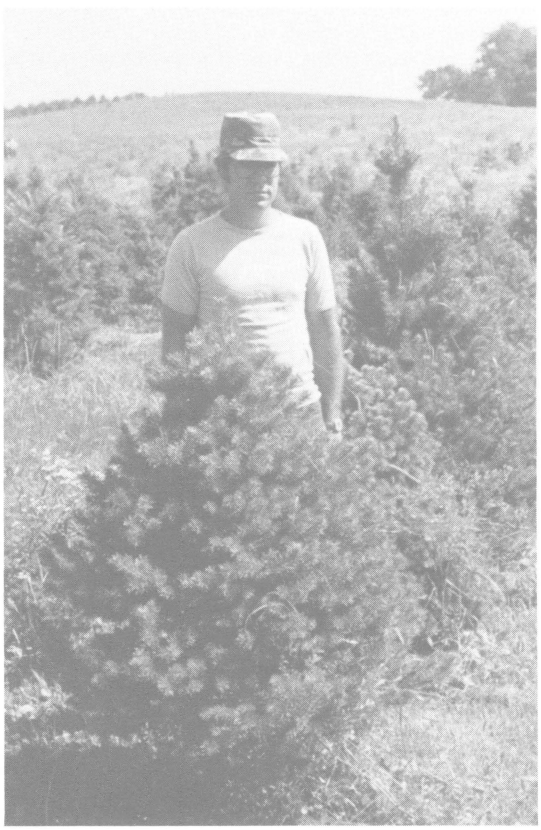
Why Control Weeds? Good weed control is one of the most important operations if high quality Christmas trees are to be grown at minimum cost. The control of weeds in a Christmas tree plantation produces several important benefits:

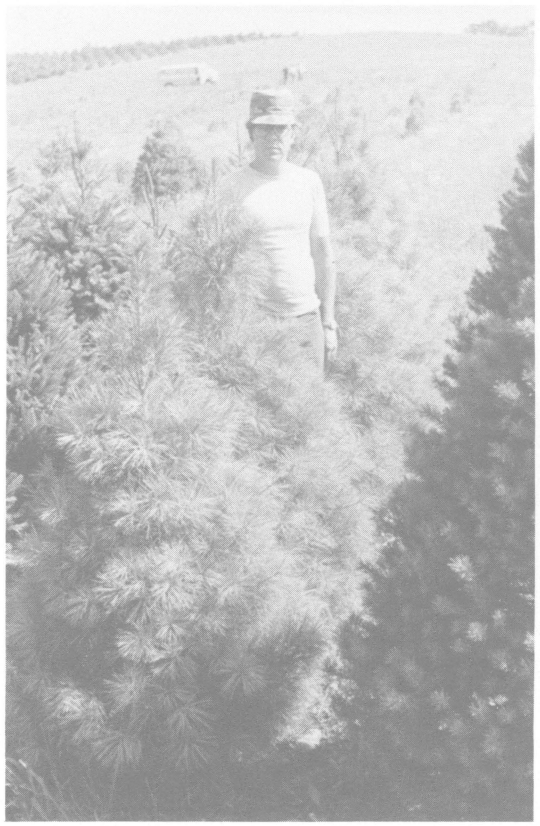
It improves the survival and growth of the trees. Weeds compete with Christmas trees for the limited amounts of sunlight, water and nutrients available on the site (Fig. 18). Excessive weed competition significantly reduces the survival and growth of the trees (Fig. 29). Such competition is particularly detrimental when trees are young and during years when the spring and summer

Fig. 29: Effects of weed control on growth of 7 to 8 year old Christmas trees. Trees on left have had annual mowing and chemical weed control, while those on right have had annual mowing only.

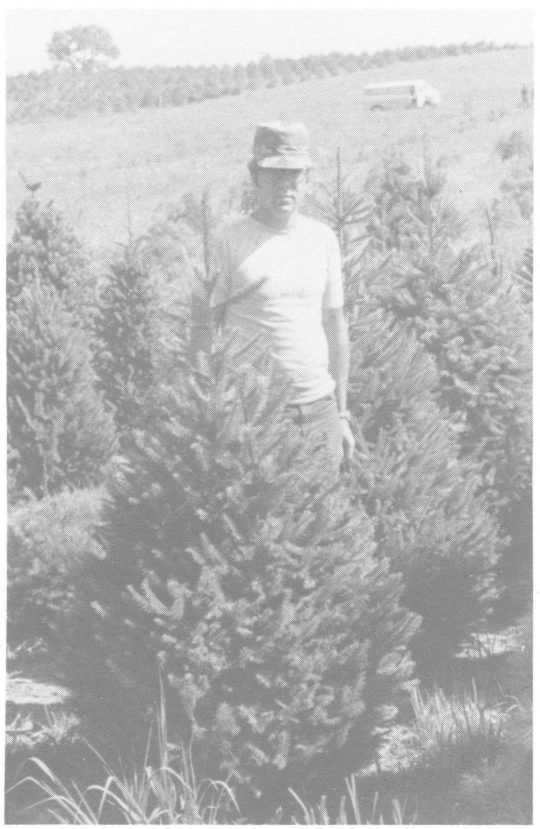


Scotch Pine

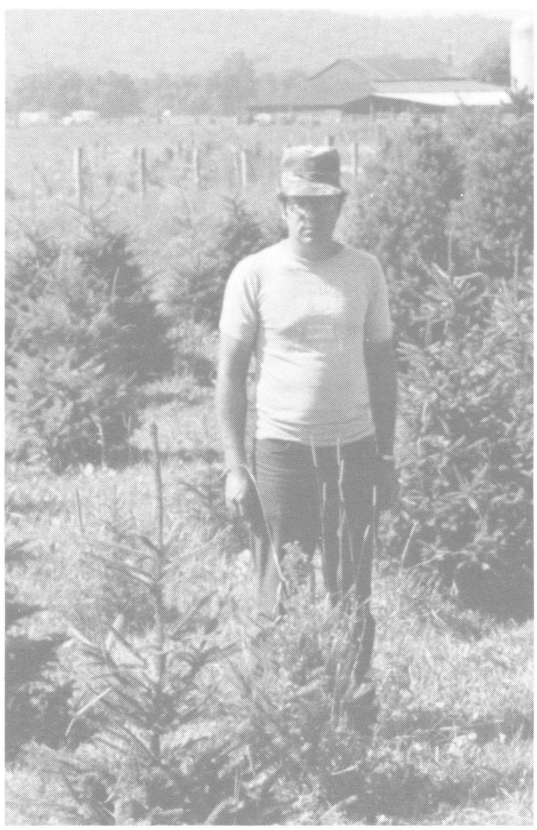


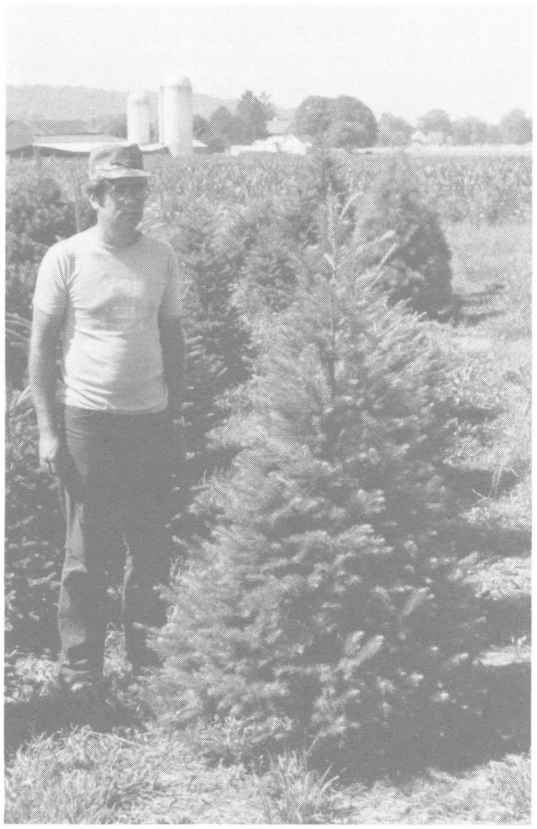


White Pine

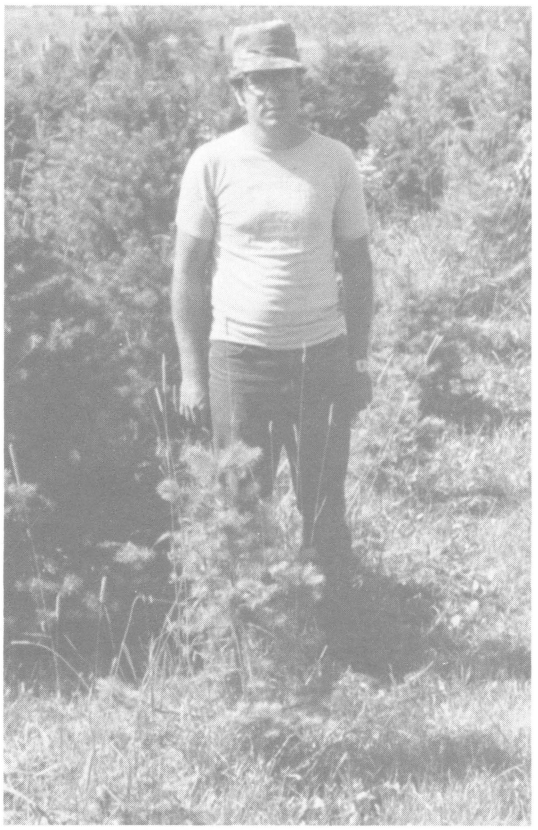


Norway Spruce





Douglas-Fir



Fraser Fir

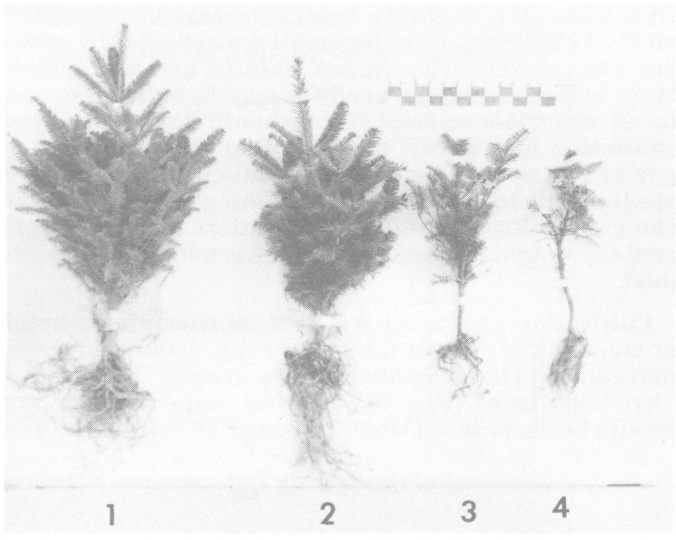


Fig. 30: Fraser fir seedlings grown for three years on areas having different methods of weed control or types of herbaceous weed competition. L. to R., 1) site scalped and kept bare with mechanical cultivation; 2) vegetation controlled with herbicide; 3) site having broadleaf weed competition and 4) site having grass sod competition.

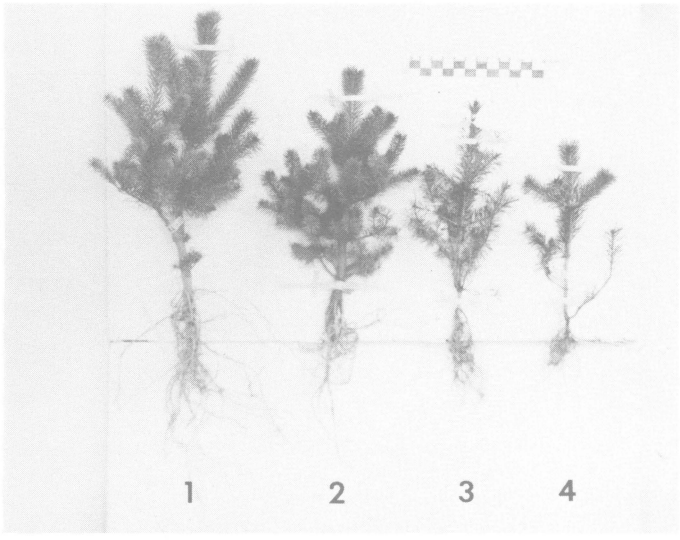


Fig. 31: Scotch pine seedlings grown for three years on areas having different methods of weed control or types of herbaceous weed competition. L. to R., 1) site scalped and kept bare with mechanical cultivation; 2) vegetation controlled with herbicide; 3) site having broadleaf weed competition and 4) site having grass sod competition.

are dry. Benefits are most pronounced on sites having heavy weed cover and with the more demanding spruces, firs and Douglas-fir, but any species of Christmas tree planted on any site benefits from good weed control (Figs. 30, 31).

It results in better formed trees. Physical abrasion and shading by tall weeds growing near Christmas trees destroy needles and branches on the lower portion of trees (Fig. 32). Unless these limbs are removed, trees will be of lower value, and removal of limbs can add one to three years to the time needed to produce quality trees of the desired size.

Fig. 32: Effect of tall weed competition on Christmas tree form.

It makes it easier to work in plantations. It is much easier and quicker to walk and move equipment through weed free plantations. Activities such as spraying, shearing, inspecting for insect and/or disease problems, evaluating and grading trees and harvesting can be carried out quicker and at less expense. Ease of movement is essential in choose-and-cut operations.

It reduces the insect and disease potential. Tall weeds in Christmas tree plantations increase the risk of serious insect and/or disease problems. Weeds may act as an alternate host for diseases. They may provide an alternate source of food for insects, and they create a dark, damp environment ideal for many insects and diseases. For example, dew remains on weeds and lower branches of trees much later in the day, providing a good environment for fungus diseases and resulting in greater damage from needlecasts such as *Lophodermium*.

It reduces animal damage potential. Weeds around young Christmas trees provide cover and nesting material for mice and other animals that may kill or deform trees.

It reduces fire hazard. Standing or fallen dry weeds can be highly flammable fire hazards in late fall, winter and early spring.

It produces more attractive plantations. Plantations without adequate weed control may look ragged and ill kept. They can give the impression that the grower is less competent than others with better kept plantations. This can be especially important in choose-and-cut operations.

Because of these benefits, most Christmas tree growers perform some type of weed control throughout the entire life of a plantation with three important objectives in mind:

1. Preparation of the site for planting.
2. Intensive control of weeds around the base of Christmas trees during the critical early years of es-

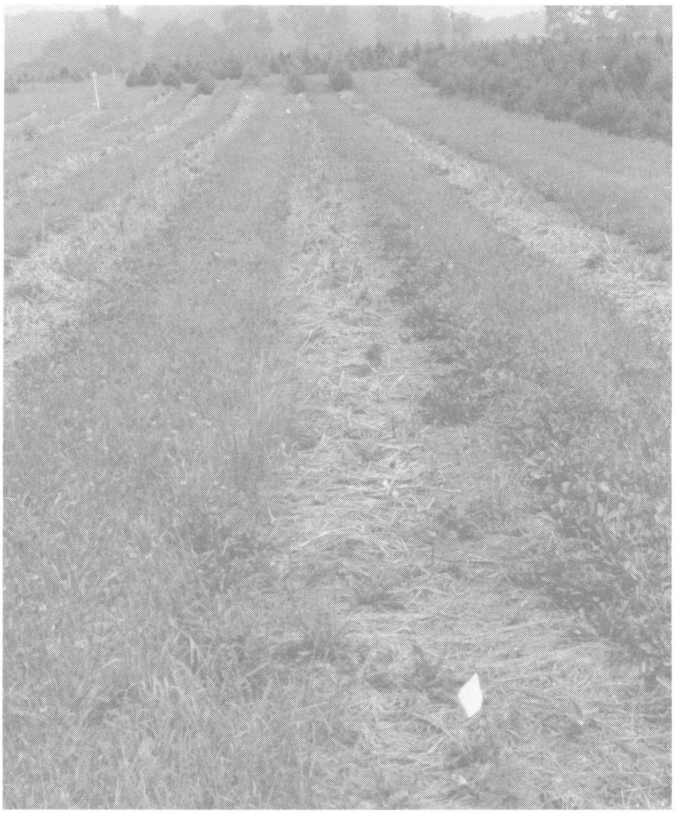


Fig. 33: Strip application of herbicides to control vegetation around base of trees.

tablishment and growth (Fig. 33). Elimination of weed competition in bands 2 to 3 feet wide along planting rows or in spots 2 to 3 feet in diameter around individual trees usually provides sufficient protection to allow good establishment and growth.

3. Reduction of weed competition throughout the entire plantation (e.g. mowing) (Fig. 23).

Weed Control Methods: Six general methods exist for controlling weeds. Although all have at least limited application in Christmas tree plantation management, some have more utility than others for most commercial growers.

Fire—Of the six methods, use of fire to control weeds in established Christmas tree plantations is of least value. However, it can be useful to eliminate dense weed growth and low brush cover prior to planting. Use of fire depends on the type of cover and characteristics of the planting site, especially the soil. Although fire can be a useful tool, it can also be extremely dangerous. It requires special techniques to achieve the desired results, and in most instances it should be done only with consultation of a professional forester.

Biological Control—Use of livestock is the only type of biological weed control currently of potential use in Christmas tree plantations. The decision to use livestock depends on a number of factors, including species of trees being raised, type of livestock available and skills of the grower.

Mulch—Mulches can effectively control weeds around the bases of trees and reduce evaporation of moisture from the soil. However, obtaining and spreading mulches on a large scale can be difficult and expensive. They are probably best used as an alternative method of weed control for small growers, hobby growers and growers who do not want to use herbicides. Many materials can be used for mulch, but coarse textured materials such as straw should not be used because they may attract mice or other pests. Sawdust is one of the most commonly used mulches. It should be applied only to the soil surface. If mixed into the soil , it can cause nitrogen deficiencies unless about two percent (by weight) nitrogen fertilizer is added to the sawdust.

Cultivation—Although it is not extensively used, hand or mechanical cultivation (rototilling, disking, harrowing) can effectively control weeds around the bases of Christmas trees (Fig. 34). Several important factors should be considered when considering cultivation as a weed control technique. First, it takes two to four or more cultivations per year to effectively control weeds. The exact number depends on weather, soil fertility and type of weeds. On sites with severe weed problems, cost of effective weed control by cultivation may be quite high. Second, cultivation should be relatively shallow to prevent root damage (probably not more than two or three inches). Third, cultivation should not be done on steep topography where it might substantially increase erosion.

Fig. 34: Rototilling to control weeds in Christmas tree plantings. Tillage should be shallow to prevent damage to roots of trees.

Mowing—Mowing is the most commonly used method for controlling weeds in Christmas tree plantations, except around the bases of young trees where almost complete control is generally desired for at least the first few years after planting. Mowing does not eliminate weeds, but it does reduce their size, and it may also change species composition.

Although it is desirable to keep weeds closely mowed to minimize their impact on tree growth, mowing too frequently is unduly expensive. The number of mowings needed in a plantation in any year depends on weather, soil fertility and the type of weeds. Three are usually sufficient—one in mid to late May, about a month later and about the third week in August.

The kind of mowing equipment used depends on the type and size of the Christmas tree operation and the capital resources of the grower. While walk-behind

Table 6: Examples of Labor and Equipment Requirements for Various Cultural Practices[1]

Practice	Time Requirements, Hours per 1,000 Trees	
	Equipment	Labor
Mowing:		
30 HP Tractor	1.25	1.25
12 HP Tractor	1.84	1 84
6 HP Tractor	2.33	2 33
Herbicide Application·		
Hand	0	2.31
12 HP Tractor and 50 Gal Sprayer	0.81	0 81
30 HP Tractor and 100 Gal Sprayer	0.74	0.74
Insect Control:		
Hand Sprayer	0	3.11
12 HP Tractor and 50 Gal Sprayer	2.02	2.02
Fertilization:		
Hand	0	2.73
12 HP Tractor and Spreader	0	0.58

[1]Information taken from Leuschner W A and W A Sellers 1975 The economics of producing and marketing Christmas trees Virginia Polytechnic Institute and State University Division of Forestry FWS-1-75 47 pp
Rates listed are for comparison only and can be expected to vary considerably from one Christmas tree operation to another

mowers may be perfect for some growers (Fig. 22), others may need a small riding tractor with an attached mower or a large orchard or agricultural tractor with an attached mower (Fig. 23). Relative times required for mowing using three types of tractors are listed in Table 6. In choosing equipment, factors other than initial equipment cost must be taken into consideration, including cost of labor to do the mowing, expected short-term and long-term future changes in labor costs and expected maintenance costs. Considerations should also include reliability of equipment and the availability of service.

Chemical Weed Control—In most Christmas tree plantings, use of chemical herbicides provides the most effective and economical way of reducing or eliminating weeds around the base of Christmas trees during the critical early years of establishment and growth (Figs. 29, 33).

Types of Herbicides: Herbicides can best be classified based on whether the chemical is soil- or foliar-applied.

Soil-Applied Herbicides—As the name implies, soil-applied herbicides are applied to the soil, although some require incorporation into the soil. They are carried into the soil by water and absorbed by the roots of weeds. These herbicides effectively control weeds for a few weeks to several months, with the exact time depending on the particular herbicide, rate and time of application, weather and type of soil. Because of this long-term residual effectiveness, soil-applied herbicides are sometimes referred to as residual herbicides. Examples of soil-applied herbicides currently used by Christmas tree growers include simazine (Princep), atrazine (Aatrex), pronamide (Kerb) and hexazinone (Velpar).[a]

[a]Reference to a herbicide in this article, either by trade or common name, in no way represents a recommendation or endorsement of that chemical.

Soil-applied herbicides are the "backbone" of chemical weed control in Christmas tree plantation management and are the chemicals used year-in and year-out for maintenance of relatively weed-free areas around the base of young trees Depending on the particular herbicide and management system, these herbicides are applied either in late fall or early spring.

Many of the residual herbicides such as simazine can normally be applied directly over trees at any time with no expected damage to the foliage. With some, such as atrazine, care must be taken to be sure the trees are not actively growing or some damage will occur Check the herbicide label for recommended time of application

Foliar-Applied Herbicides—Foliar-applied herbicides are applied directly to the weeds and kill them primarily by being absorbed into the foliage For this reason, they are often referred to as contact herbicides. In addition, some of the contact herbicides have a relatively short-lived soil activity. Historically, the contact herbicide most commonly used by Christmas tree growers was Amitrol-T. Glyphosate (Roundup) is a relatively new contact herbicide gaining wide acceptance among growers.

In Christmas tree plantations, contact herbicides are of more limited and special use than residual herbicides. Some growers use them in site preparation before planting, as described earlier. They may also be useful in salvaging plantations in which weeds have gotten out of control or in eliminating difficult to control deep rooted perennials. Soil-applied herbicides, at recommended rates, usually do not "knock down" tall, well-established weeds. A foliar herbicide is needed to weaken or kill such weeds and allow the soil-applied herbicide to gain control. Generally, a soil-applied herbicide is applied with or after the contact herbicide.

When foliar-applied herbicides are sprayed in established plantations, trees should usually be protected (read the label). This can be done by rigging shields on the sprayer, placing stovepipe or a similar shield around each tree as it is hand sprayed or carefully keeping the spray off trees on a very calm day.

Hand or tractor drawn rope-wick applicators are an alternative method of applying contact herbicides. With these applicators, the herbicide is applied by rubbing the weeds with a rope wetted with the chemical. A reservoir continually supplies the rope with herbicide. The rope applicator can be drawn down either side of a row of trees, or if the weeds are taller than the trees, the rope applicator can be passed over the row of trees, applying the herbicide to the taller weeds but not the trees.

Some foliar herbicides can be applied over Christmas trees in the fall while the weeds are active but after trees have hardened off sufficiently. Such applications are useful for controlling deep-rooted perennial weeds not easily controlled with residual herbicides. In central Ohio, such an application is usually made between the end of the first and third weeks of September, depending on weather conditions in that particular year. **Extreme care** should be taken when using this technique because the condition of the trees is critical, and dates for safe application vary from year to year. Growers considering using this technique should test the technique on a few trees to **absolutely** identify when it is safe to apply herbicide to each species of tree. If the chemical is applied too early, trees may be injured or die, and nothing can be done to save them.

The label of a foliar-applied herbicide may recommend the use of a wetting agent or sticker-spreader. This is a compound that reduces the surface tension of the herbicide-water mix and allows the drops to spread out, resulting in better coverage. Sticker-spreaders are very effective for some foliar-applied herbicides but are not recommended for others because they reduce the effectiveness of the herbicide. Check the label.

General Considerations When Using Herbicides: Regardless of what type of herbicide is being used, several important considerations should always be kept in mind:

Legal Responsibilities in the Use of Herbicides—The use of pesticides, including herbicides, is regulated by both federal (Federal Insecticide, Fungicide and Rodenticide Act) and state law. While a discussion of these regulations is beyond the scope of this publication, growers are encouraged to familiarize themselves with their responsibilities under these laws.

Label Specifications—The label on a pesticide is a legal document. Use of any pesticide, including herbicides, contrary to label specifications is illegal. Growers should read and understand the labels on herbicides and other pesticides they use.

Rate of Application—Stay within the label specifications. For some herbicides such as foliar-applied, a single rate such as one gallon per acre may be specified. Conversely, the label usually provides a range of application rates for many of the soil-applied herbicides. For example, the Princep 80W label indicates that it may be applied at rates from 2½ to 5 pounds of the material in the bag (referred to as the bag formulation) per acre. This range allows the rate of application to be adjusted for differences in soil texture and organic matter content. Clay and organic matter reduce the effectiveness of many herbicides. As a result, on soils with sandy texture and relatively low organic matter content, lower rates of the herbicide are needed. As the amount of clay and/or organic matter increase, higher rates of the herbicide are required. Growers need to experiment to determine exactly what rate, within label limits, will most economically give the desired weed control.

Sprayer Calibration—Herbicides must be applied at the prescribed rate. If too little or too much herbicide is applied, it may result in unsatisfactory weed control, damage or death of trees.

Herbicides are generally prescribed in pounds or quarts per acre. Sprayer calibration involves determining how much herbicide and water (or other carrier) should be mixed in a sprayer to deliver the herbicide at the desired rate, whether the area to be sprayed is one acre or 1/1000 acre.

The first step in calibrating a sprayer is to determine the volume of spray delivered to a known area. This may be done in one of two ways: (1) Fill the sprayer with a known volume of water, spray a known area of ground as if you were applying herbicide and measure the amount of water needed to refill the sprayer. For example, a small compression tank sprayer might use 1 gallon (128 fluid ounces) to spray an area 4 ft. wide and 85 ft. long (340 sq. ft. or .0078/A).[b] Similar determinations can be made using larger sprayers. (2) Fill the sprayer with a known amount of water, spray as if you were applying herbicide until the tank is empty and then measure the area sprayed.

Make these determinations several times and use the average value. The amount of herbicide to add to a particular volume of water can now be calculated as follows:

Weight of Herbicide Needed = Recommended Herbicide Rate in Pounds/Acre x Acreage Covered with Known Volume of Water

Using our example sprayer that sprays .0078/A with 1 gallon and a recommended herbicide application rate of 2 lbs./A (32 ounces/A), the calculation should be as follows:

Weight of Herbicide Needed = (32 ounces/A) x (.0078/A) = 0.25 ounces

To apply herbicide with our sprayer at a rate of 2 pounds acre, ¼ ounce of herbicide should be added to each gallon of water. The amount of herbicide to mix with a full sprayer of water is then calculated as follows:

$$\text{Weight of Herbicide to Add to Full Sprayer} = \text{Weight of Herbicide to Add to Known Volume of Water} \times \frac{\text{Volume of Sprayer}}{\text{Known Volume of Water}}$$

In our example, if the sprayer's total capacity was 2½ gallons:

$$\text{Weight of Herbicide to Add to Full Sprayer} = (\tfrac{1}{4}\text{ ounce}) \times \frac{2\tfrac{1}{2}\text{ gallon}}{1\text{ gallon}} = .625\text{ ounces}$$

Herbicide recommendations are sometimes made in pounds of active ingredients per acre (lbs.a.i./A) instead of the usual pounds of total material per acre (lbs./A). When this is the case, the amount of herbicide needed is determined by dividing the "Weight of Herbicide Needed," as calculated above by the percent active ingredients in the herbicide.[c] Using our example above, if the recommendation had been for 2 lbs. a.i./A instead of 2 lbs./A, and the herbicide had 80 percent active ingredient, we would have needed to add 0.31 ounces to each gallon of water or 0.78 ounces to our full sprayer to obtain the recommended rate of 2 lbs. a.i./A.

$$\frac{.25\text{ ounces}}{.8} = .31\text{ ounces} \qquad \frac{.625\text{ ounces}}{.8} = .78\text{ ounces}$$

When adding herbicide to a sprayer, it is convenient to find a container that holds exactly the desired amount of herbicide, determine how many teaspoons or tablespoons of herbicide equals that amount or mark on a large container exactly how full it should be to contain the desired amount of herbicide.

Several factors significantly affect the spray rate of a sprayer.

Spraying Pressure—Spraying should be done at the same tank pressure as when the sprayer was calibrated. If a small compression tank sprayer is calibrated at 25-30 p.s.i. pressure, spraying should be done at that pressure. Spraying at higher or lower pressures delivers higher or lower than desirable rates of herbicide as the sprayer passes over the ground.

[b] There are 43,560 sq. ft./A. Therefore, $\frac{340\text{ sq. ft.}}{43{,}560\text{ sq. ft.}} = .0078/A.$

[c] Percent active ingredients is stated on the label.

Nozzle Size—Sprayers must be calibrated for each nozzle size. The larger the nozzle, the more spray applied (at a given pressure) as the sprayer passes over the ground. To maintain a particular rate of application, a smaller amount of herbicide is needed when larger nozzles are used. Also, some herbicides, particularly the wettable powders, are abrasive and enlarge nozzle openings with use. This changes the calibration. Nozzles should be recalibrated or replaced often.

Speed of Travel—Spraying should be done at a uniform speed and at the same speed at which the sprayer was calibrated. Slower or faster speeds result in higher or lower rates of herbicide application. For this reason, hand sprayers such as small compression tank sprayers should be calibrated for use by each individual who uses them. Each person has a different speed of walking, and rates of application may vary. Self propelled sprayers should be operated at the speed they were calibrated. Examples of time required for herbicide applications using hand and tractor drawn equipment are presented in Table 6.

Method of Application—Most herbicides used to control herbaceous weeds in Christmas tree plantations are formulated to be mixed with water and applied by spraying. Most liquid and water soluble powder formulations mix easily with water at the recommended rates. However, some of the commonly used soil-applied herbicides are wettable powders (often indicated by the letter W after the name, as in Kerb 50W or Princep 80W). These disperse but do not dissolve in water, and at high application rates it may be difficult to keep them evenly dispersed. With uneven dispersal, the herbicide-water mix will not have a uniform concentration, and some areas may be sprayed at rates well above and others well below the desired rate. Care should be taken to be sure wettable powders are shaken periodically; large sprayers and tanks should have some type of agitator or mixing action.

Comments made earlier regarding selection of mowing equipment apply equally to selection of spraying equipment. Similar factors must be considered in determining what spray equipment is best and most economical for a particular operation (Figs. 35 and 36).

A few herbicides such as Princep also come in granular form (Princep 4G) for dry spreading. Such formulations are often attractive to small growers because of the ease of application and the fact that they may be used with considerably less equipment investment. They can be spread by hand, hand spreader or machine drawn spreader. However, cost of herbicide for each area treated is usually higher.

Selecting Herbicides: Five important factors should be considered in selecting the herbicide or combination of herbicides to be used in a particular Christmas tree plantation:

Use—Does the condition of a particular plantation require a maintenance herbicide, in which case a soil-applied herbicide is generally used, or is a "knockdown" required, in which case a contact and soil-applied herbicide is required.

Tree Species Being Grown (Crop Species)—Herbicides are labeled for use on specific crop species. To legally use a particular chemical to control weeds around a

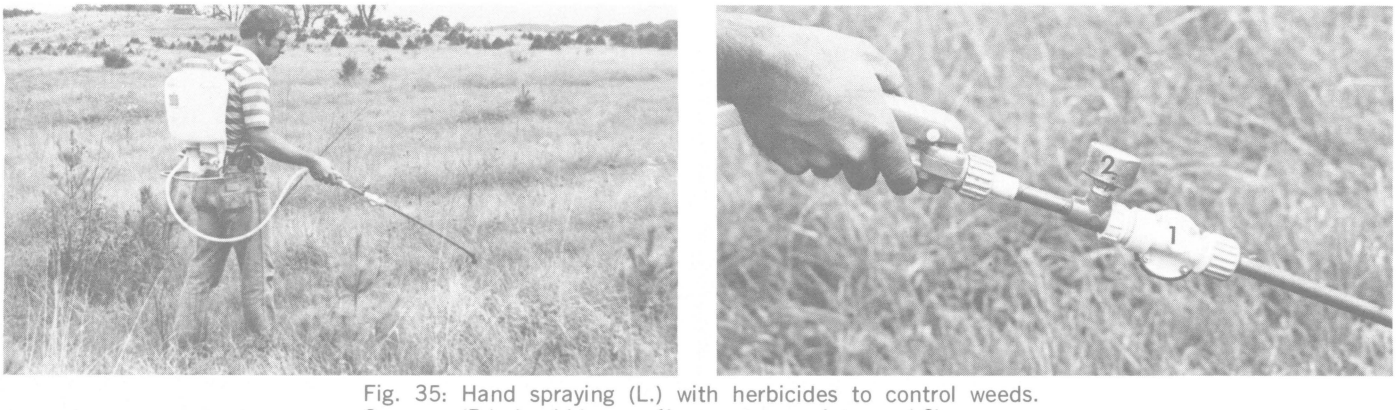


Fig. 35: Hand spraying (L.) with herbicides to control weeds. Sprayers (R.) should have a 1) pressure regulator and 2) gauge so herbicides can be applied uniformly.

Fig. 36: Weeds can be controlled with tractor-mounted sprayers if the proper herbicides and time of application are used.

certain tree species, that species must be listed on the label. There may be a high risk that a particular herbicide will cause damage to species not listed on the label. Different tree species may show dramatically different sensitivities to herbicides, particularly when trees are young.

Weed Species To Be Controlled—Different weed species are susceptible to different herbicides. Some knowledge of the predominant weed species or groups to be controlled is desirable. Kerb and Dowpon, for example, are very effective on grasses but much less effective on broadleaf weeds.

Site Conditions—Some knowledge of site factors such as soil texture, relative amount of soil organic matter and degree of wetness in a plantation often aid in selecting herbicides. Some site conditions such as high amounts of clay or organic matter in the soil make some soil-applied herbicides much less effective.

Cost-Results—Other factors being equal or near equal, the deciding factor is cost. Compare the cost of achieving the desired weed control by the alternative herbicide treatments.

Controlling Weeds: Weed control, then, is an operation that should be performed in some form throughout the entire life of a Christmas tree planting. A typical weed control program using herbicides and mowing as the primary weed control techniques might be as follows:

Fall Prior To Planting
Planting site mowed while the weeds are still active in late August to early September. About a week later, three foot wide strips are sprayed using a contact herbicide where the tree rows will be planted.

First Year
In spring, after the frost is out of the ground and before planting seedlings, a residual herbicide is applied to the three foot wide strips. With many residual herbicides, this application could also have been made the previous late October to mid November before the ground freezes.
During the growing season, areas between rows and between trees are mowed several times.

Second and Third Year
Intensive weed control around young trees using residual-herbicide.
Weed control between rows and trees by mowing.

Remainder of Rotation
Weed control between rows and trees by mowing.

Other control techniques could obviously be substituted in this program (e.g. the intensive weed control could have been accomplished by rototilling or mulching). Also, the exact weed control program varies with the particular grower, site and species of tree. For example, on some sites, intensive weed control may be needed only the first two years for Scotch pine, while on other sites it might be needed the first four years. On similar sites, Douglas-fir or Fraser fir may need intensive weed control longer than Scotch pine. Many growers use intensive weed control annually throughout the entire rotation; others practice intensive weed control until the seedlings are established and every other year thereafter. Still others intensively control weeds during the seedling establishment period, then once at about mid-rotation and again the year of harvest. The grower must become the expert for his plantations to develop the weed control program that best achieves his objectives. This cannot be over-emphasized if highest quality Christmas trees are to be produced at the lowest cost.

Throughout this discussion specific herbicides have been presented as examples, but no recommendations have been made. Nor has a complete list of herbicides labeled for use by Christmas tree growers been presented. Labeling of a herbicide is subject to change on relatively short notice, making such a list obsolete. State extension foresters are probably the best source of information on herbicides currently labeled for Christmas trees. In some states, service foresters and growers' associations can also assist.

Shearing for High Quality Christmas Trees

Pre-Shearing Care: The grower's main concern during the first, second or third year after planting seedlings or transplants is to keep the trees alive, healthy and growing well. The benefits of grass and weed control have already been described. Additional attention should be given to:

1. Replacing dead, dying or unhealthy looking plants with healthy stock within one or two years after the initial planting.
2. Removing all multiple leaders except one by cutting off extra leaders at their base and flush with the main stem. The single leader retained should be selected on the basis of size, vigor and straightness. The number of internodal buds is important on spruces and firs.
3. Shearing off the ends of any lateral branches growing to an abnormal length and extending outside the desired cone shape of the tree.
4. If a terminal bud dies or a leader is broken off at its base, a new leader will likely develop from a turned up lateral branch of the top whorl. However, multiple leaders often develop in this case. To replace lost or seriously damaged leaders throughout the production period, a lateral branch can be trained to replace a lost leader. In July or early August, select a strong, closely spaced lateral branch in the top whorl for the new leader. If possible, the branch selected should be backed up by a strong branch growing directly below it, especially on Fraser fir. If there is enough of the stub of the damaged leader remaining on the tree, the new leader can be tied to the older leader stub with a soft material such as plastic flagging. If the old leader broke off at its base, it may be necessary to tie the new leader to a wooden splint that has been tied to the stem at the upper portion of the previous year's growth. Some growers tie the lateral branch that is to become the new leader to a lateral branch on the opposite side of the broken base. On a true fir such as Fraser fir this may leave an open space in the whorl of limbs at the points where the two lateral branches were pulled together.

Shearing: Shearing is the most important cultural practice involved in growing quality Christmas trees. Of all the practices that can be employed by a grower, shearing probably gives the greatest return for labor invested. Consumers demand a dense, well-shaped tree with relatively uniform taper.

The practice of shearing involves controlling growth in height and width by cutting off the tip of the leading shoot (leader or terminal) and the ends of the lateral branches to develop the desired conical shape. The purposes of shearing are: 1) to control tree height and width and develop desired taper and shape; 2) to stimulate increased numbers of buds and bud development, thus increasing the number of branches and foliage density (pines) and 3) to correct branch deformities and insect and disease damage and to remove competing multiple leaders.

Trees are sheared to the shape of an inverted ice cream cone with a wide base and a uniform taper to the tip of the tree. "Taper" means the relationship of the width of the tree to its height and is determined by dividing the width of the tree at its base by tree height and multiplying the result by 100. The ideal tree shape is about two-thirds as wide as it is high, or a 66-2/3 percent taper. A tree 6 feet tall and 4 feet wide at the base has this percentage taper. United States standards for grades of Christmas trees (Table 7) define taper standards as follows (Fig. 37):

Flaring: more than 90 percent taper
Normal: 40 to 90 percent taper
Candlestick: less than 40 percent taper

Pines are usually grown with a taper in the range of 60 to 90 percent, while for the spruces and firs, it is usually from 40 to 70 percent. As a grower gains experience, the market determines the amount of taper. Some buyers prefer "fat" trees while others prefer a more normal taper. Shearing controls the taper.

After planting, seedlings or transplants usually undergo a slow-growing initial establishment period of one to three or more years. During this time, root systems are developing and adjusting to their new environment, and terminal elongation is usually less than 12 inches. During the second or third year in the field, pine leaders normally start to grow more rapidly. Shearing should be initiated at this time. If it is not, excessively long internodes ("goosenecks") will develop. The combination of "goosenecks" and varying length laterals give trees an open, irregular appearance not representative of a quality Christmas tree (see Figs. 38 and 39 on page 32). Spruces and firs go through a process called "planting check." Terminal growth elongation usually resumes more slowly after planting. Shearing on spruces and firs may have to be delayed until the fourth or fifth year in the field unless good grass and weed control practices are initiated and maintained. These time periods are guidelines only! Once terminal elongation exceeds 10 to 12 inches, shearing must be started and continued every year, if necessary, until the trees are harvested as quality trees (Figs. 5 to 12).

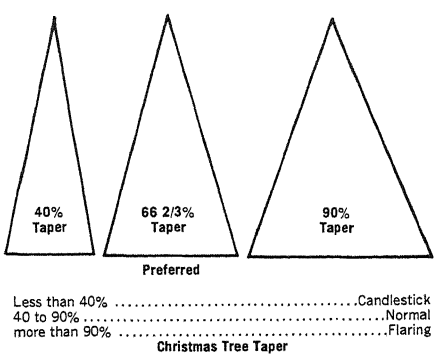


Fig. 37: Diagram showing relative taper of Christmas trees. L. to R., candlestick, preferred and flaring.

Table 7: Summary of United States Standards for Grades for Christmas Trees

Factor	U.S. Premium	U.S. Choice or U.S. No. 1	U.S. Standard or U.S. No. 2
Foliage	Fresh, clean healthy, well trimmed	Fresh, clean, healthy, well trimmed	Fresh, fairly clean, well trimmed
Density	Medium	Medium	Light
Taper	Normal	Normal	Candlestick, normal or flaring.
Faces	4 free from damage	3 free from damage	2 adjacent free from damage

Definitions of terms:

1. Fresh: needles pliable and generally firmly attached.
2. Clean: practically free of moss, lichens, vines, etc.
3. Fairly clean: tree moderately free from moss, lichens, vines, etc.
4. Well trimmed: all barren branches below first whorl removed and butt of trunk cut smoothly at approximately right angle to trunk.
5. Healthy: foliage has thrifty, fresh, natural appearance.
6. Density: amount of foliage present; determined by number and size of branches, distance between whorls, number and arrangement of branchlets, extent of internodal branching, needle arrangement, needle length, etc. Species differ in these characteristics, and density is judged on the basis of "species characteristics."
7. Taper: relationship of tree width to height, expressed as %:

	Pines	Spruces, firs, Douglas-fir
Normal	40 to 90%	40 to 70%
Flaring	more than 90%	more than 70%
Candlestick	less than 40%	less than 40%

8. Faces: refers to visible surface area of tree, with four faces, each consisting of one-fourth of the surface area of the tree.
9. Cull: any tree that does not meet the above standards.

Before shearing techniques are discussed, it is necessary to illustrate or define some of the common terms used in Christmas tree terminology (see Fig. 40 on page 33). Pines, spruces and firs produce a terminal stem called the leader and a major whorl of lateral limbs at the base of the leader each year. The point of attachment of the limbs in the whorl to the stem of the tree is called a node. On spruces and firs, a number of buds normally develops along the leader between the node and the terminal or end bud. The buds that develop along the leader of spruces and firs are called internodal buds and develop the next year into limbs that contribute strongly to foliage and limb density. An internode is the space on the stem between two nodes. Control of the internodal distance is critical to shearing success.

Species grown for Christmas trees in Ohio can be divided into two broad groups as far as proper shearing procedures are concerned: (1) the multi-needled pines with two to five needles in each cluster (bundle or fascicle) on the stem or branch and (2) the single-needle conifers such as spruces, firs and Douglas-fir. Shearing procedures and timing are different for the two groups.

The Pines—Pines normally produce whorls of lateral branches with no internodal buds along the stem. Unless there is genetic variability in the species or unusual weather conditions occur, most pines grown for

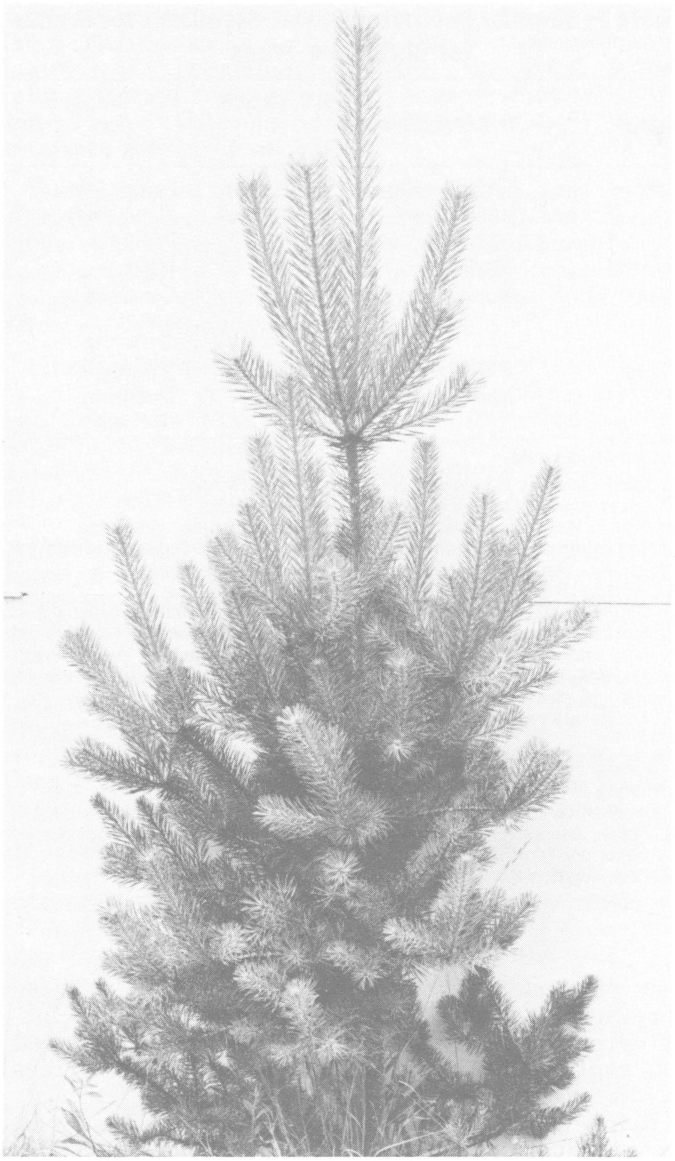


Fig. 38: Unsheared Scotch pine showing variations in outline and density.

Fig. 39: Unsheared Norway spruce showing variations in outline and density.

Christmas trees in Ohio commence growth in the spring, experience a single shoot growth period and then set buds. Normal bud set on an unsheared leader of Scotch pine consists of a terminal bud, upper lateral buds, lower lateral buds and interfascicular buds. Interfascicular buds are sometimes called dormant buds and are very small, tiny buds that occur between and at the base of the needles (Fig. 40). Their growth and development are normally controlled and suppressed by the terminal and lateral buds on an unsheared leader. Development of a sufficient number of healthy, vigorous interfascicular buds is the key to quality pine Christmas trees. When the terminal cluster is sheared off, the restraining effect on the development of the dormant buds is destroyed, and a number of the dormant buds located just below the cut will develop into shoot buds (Fig. 41). The number and vigor of buds that form depends on the time of year when shearing is done. The best possible time to shear the pines is just after height growth has been completed and before stem or branch tissue has hardened off and turned woody. At this time, the numbers of large, vigorous buds that develop below the shearing cut will be from two to four times greater than the numbers on uncut stems. Shoot growth from these buds the following year will be almost as much as that on unsheared trees. Additional limbs that arise from dormant buds add greatly to foliage density (Figs. 5 and 6).

In Ohio, the most appropriate time to shear the pines is from early to late June. Time of shearing varies with location in the state and other factors affecting tree growth. The shearing season usually begins 10 to 14 days earlier in the southern than in the northern half of the state. There are two key points to remember: 1) **pines**

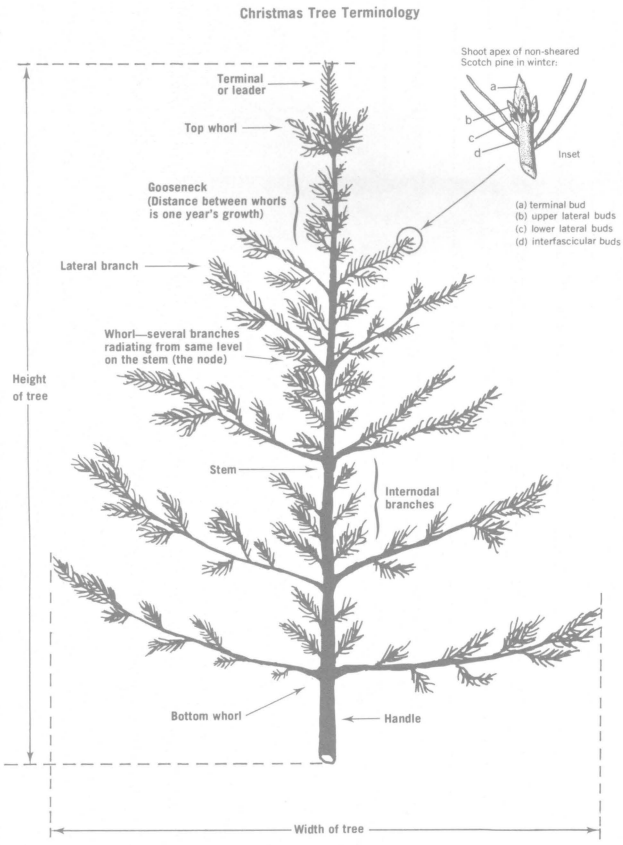


Fig. 40: Diagram of tree, including terms important to understanding Christmas tree shearing techniques.

are sheared during the growing season and 2) best results are obtained when trees are sheared just after completion of height growth. As trees are sheared progressively later in the summer, dormant buds have less and less time to mature and develop into strong, vigorous buds. Fewer buds develop, and growth the following season is reduced. A tree sheared in late summer produces only a few weak buds. Growth and foliage density may even be less than that on an unpruned tree (see Fig. 42 below, Figs. 43 and 44 next page). Poor results from late shearing vary somewhat for the different pines. Scotch pine is least affected, while white pine is most drastically affected. It is important that growers shear white pine as early as possible. Limbs of white pine sheared in mid to late summer will often die back (see Fig. 45 on page 34).

In shearing the pines, the leader or terminal shoot should be cut to the maximum length possible while still maintaining proper density and taper of the trees. Although leaders are usually cut to 12 inches, growth is variable. The usual range in sheared leaders is 10 to 14 inches. Shearing to shorter lengths can add one or more years to the length of time needed to grow a marketable tree. The cut on the leader should be made at a 45 degree angle to the stem's upright or vertical axis. The simple procedure of cutting the leader at this angle puts one needle bundle (fascicle) at a higher position on the stem and minimizes the problem of multiple leaders

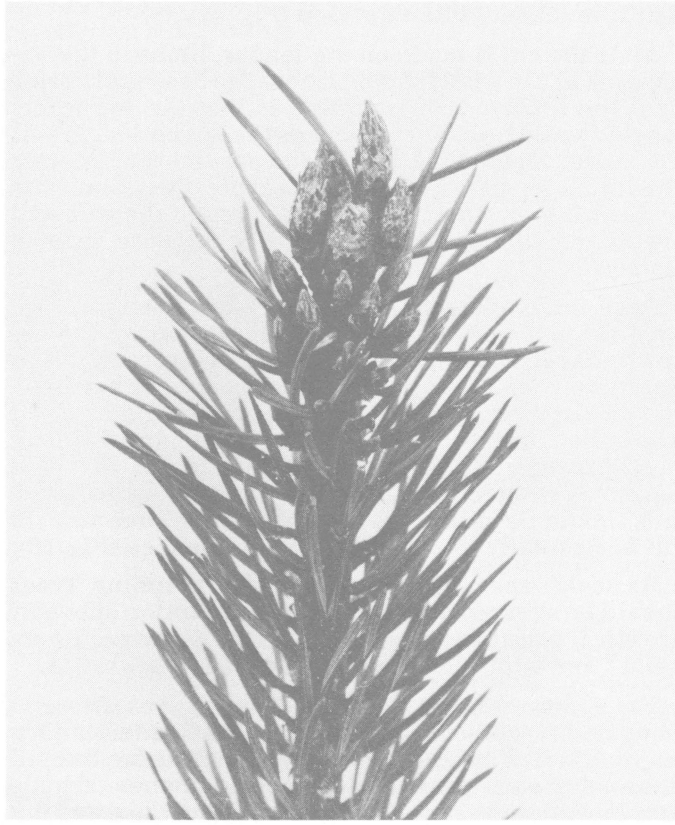


Fig. 41: New buds forming at base of needle bundles on a sheared Scotch pine terminal.

Fig. 42: Limb development and shoot growth the year after shearing on Scotch pine terminal sheared in mid June.

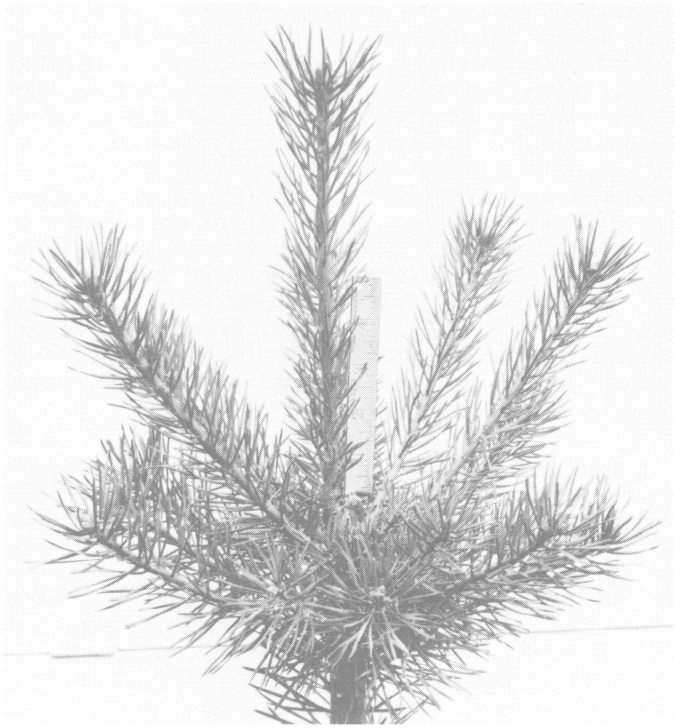


Fig. 43: Limb development and shoot growth the year after shearing on Scotch pine terminal sheared in mid July.

Fig. 44: Limb development and shoot growth the year after shearing on Scotch pine terminal sheared in mid August.

Fig. 45: Die-back of white pine terminal sheared during the winter.

(Fig. 46). If the cut is made straight across the stem at a 90 degree angle, two or more needle bundles may be equally close to the upper edge of the cut stem, and multiple leaders often develop (Fig. 47).

After the cut is made on the leader, limbs in the uppermost or top whorl should be cut 3 to 5 inches shorter than the leader. One guideline is that the top whorl length should be about two-thirds the leader length — if the leader length is 12 inches, the top whorl of laterals should be about 8 inches. In shearing operations, the leader and top whorl are the key parts of the tree and are extremely important in building the basic branch framework of a quality tree (Fig. 40).

Once the leader and top whorl have been sheared, proceed to shear around and down to achieve the desired shape. One way to side shear is to draw an imaginary line from the top of the leader (after it has been cut) to the outer limits of the basal whorl. Then cut off any branch that projects outside the imaginary line of the desired cone shape. Angle of cut on the side branches is not important, but if hedge shears are used, cuts should be parallel to the plane of the cone and not cut horizontally towards the stem of the tree (Fig. 48).

Basically, shearing pines is a matter of timing. Trees should be sheared at or soon after completion of height growth, if possible. Through shearing, the grower limits height and width to create the desired appearance.

The Single-Needled Conifers—The spruces, firs and Douglas-fir produce a terminal stem (leader) and a major whorl of lateral limbs (top whorl) at the base of the leader each year. In addition, a number of buds develop along the leader between the top whorl and the terminal or end bud. Buds located along the stem between the whorls are called internodal or side buds.

Fig. 46: Sloping cut on terminal of Scotch pine. One needle bundle is left near the apex of the stem. This favors development of a single new terminal after shearing.

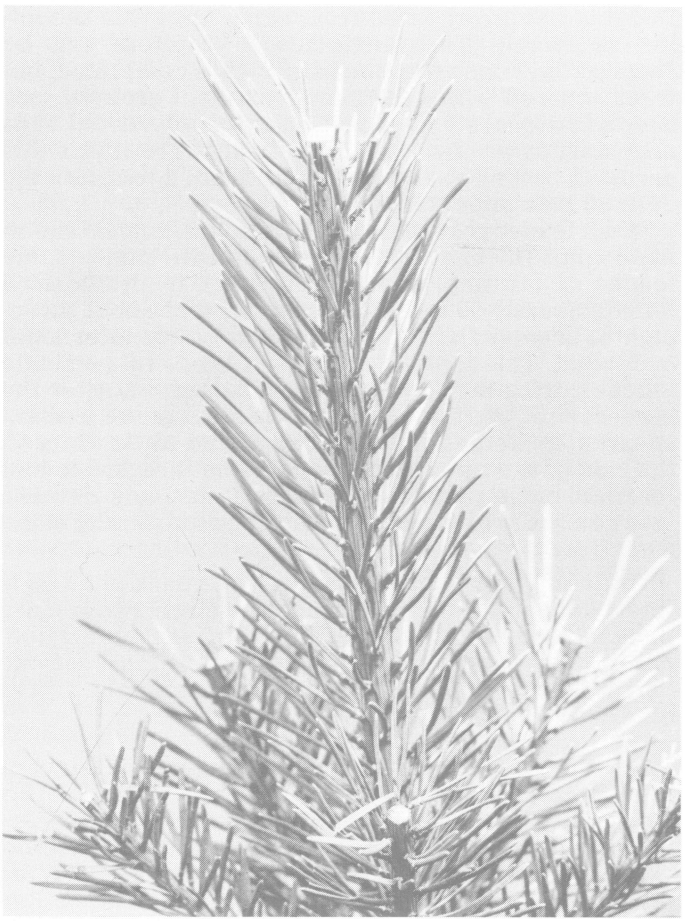


Fig. 47: Flat cut on Scotch pine terminal. Several needle bundles are left at the same height near the cut edge, favoring the development of multiple leaders after shearing.

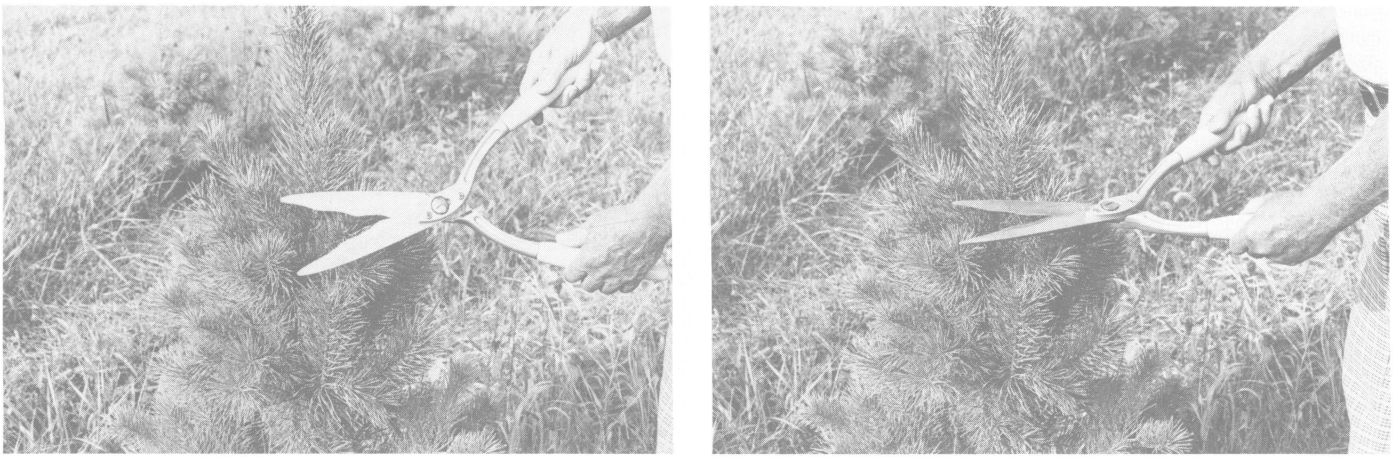


Fig. 48: When shearing with hedge clippers, blades should be kept parallel (L.) to the plane of the tree rather than perpendicular (R.) to the plane.

The internodal buds develop into small limbs that contribute strongly to foliage and limb density the following season. The buds on the leader of the single-needle conifers are already pre-set and are clearly visible at the time of shearing. When the terminal bud cluster on one of these trees is sheared off, there is no increase in the number of buds and limbs such as occurs on the pines. Shearing spruces and firs only stimulates existing buds to grow into stronger limbs. These limbs help to cover open areas and give the tree a more uniformly dense appearance.

Time of shearing is not so critical with the single-needle conifers as it is with the pines. The growing season for these trees varies depending on species, location in the state, topography, soil and weather conditions. Shoot growth normally occurs from about early to mid May until mid July to early August in Ohio. Results have been generally acceptable when spruces, firs and

Douglas-firs are sheared from early August to the following March. The single-needle conifers can be sheared any time after height growth is completed, but trees sheared while the shoots are still growing may have additional stem elongation or the internodal buds may start to produce additional shoot growth. If this occurs, a second shearing may be needed to retain the desired tree appearance.

When leader growth exceeds 12 inches, normal shearing begins. In shearing the single-needle conifers, the leader or terminal shoot is cut back to the desired length, usually 10 to 14 inches, at a point about three-eighths to one-half inch above a single, large internodal (side) bud. This top bud usually develops into a single leader during the following growing season. After the leader is cut, the top whorl and the sides of the tree are sheared to the desired cone shape and taper. Cuts on the side of the tree can be made without regard to bud location on individual limbs. Existing buds develop into new limbs to increase density and uniformity of the tree.

Caution: When shearing leaders, cut back to a **single** internodal bud. If the cut is made just above two or more buds located around the leader at the same elevation, multiple leaders may develop. If a grower must use one bud of a cluster, the other buds should be snipped off or otherwise removed.

Scheduling Shearing Operations: Where a variety of species and sizes is being grown, operational priorities should be established to obtain best results from shearing. Two basic principles related to shoot growth on sheared pines apply: 1) shearing pines as early as possible results in more time for the interfascicular buds to develop and mature. Large, healthy, mature buds produce shoots the following year that are sufficiently long to allow normal shearing and 2) after shearing, a minimum of 12 to 14 inches of leader growth is needed the following year if acceptable taper is to be maintained. In young plantations such as those only 2 to 3 feet in height, new leader growth just begins to exceed 12 inches. To have more than 12 inches the following year, young trees should be sheared first so the number of buds and vigorous limbs produced will be maximum, and growth the following year will allow for normal development. Because white pine is very sensitive to time of shearing, small white pine should be given top priority in the shearing schedule. Larger Scotch pine should probably be the last group of trees sheared during the summer.

Between the smallest white pine and the largest Scotch pine on the Christmas tree farm, shearing operations during the summer should proceed in accordance with the species and/or size classes of trees, starting with the younger, smaller trees and then progressing into the larger size classes. Red and Austrian pines are less affected by delayed summer shearing than white pine but more so than Scotch pine. Thus, smaller red and Austrian pine should be sheared before smaller Scotch pine.

Depending on location within the state, site factors and weather conditions, all shearing of white pine should be completed by early to mid July, red and Austrian pine by mid to late July and Scotch pine by late July to early August. However, shearing should not be delayed. Results are **best** when all pines are sheared just after completion of height growth.

Once the rush of the pine shearing season is over, shearing on the single-needle conifers can proceed at a more leisurely pace. Spruces, firs and Douglas-fir can be sheared with good results from late July or early August and continuing until just before new growth starts the following spring.

Table 8: Examples of Time Requirements for Different Shearing Practices[1]

Type of Shearing or Pruning	Time Requirements, Hours per 1,000 Trees	
	Equipment	Labor
Shearing, Knives:		
Trees under 3 ft.	0	18.45
Trees 3 to 5 ft.	0	20.75
Trees over 5 ft.	0	23.67
Shearing, Hedge Shears:		
Trees under 3 ft.	0	16.43
Trees 3 to 5 ft.	0	25.69
Trees over 5 ft.	0	33.15
Shearing, Hedge Shears and Pruning combined:		
Trees under 3 ft.	0	23.40
Trees 3 to 5 ft.	0	29.07
Trees over 5 ft.	0	33.59
Pruning Only	0	15.73

[1]Information taken from: Leuschner, W. A. and W. A. Sellers. 1975. The economics of producing and marketing Christmas trees. Virginia Polytechnic Institute and State University, Division of Forestry, FWS-1-75. 47 pp.
Rates listed are for comparison only and can be expected to vary considerably from one Christmas tree operation to another.

Examples of time required for shearing different size trees and using different types of equipment are presented in Table 8.

Tools for Shearing and Shaping: A number of different tools can be used for shearing and shaping Christmas trees (Fig. 49). Hedge shears with 8 to 12 inch blades and handles of varying length are excellent for use in shearing operations and are preferred by many growers, particularly for shearing some of the single-needled conifers. Lightweight knives with 14 to 16-inch blades are also excellent tools for shaping trees. Work can generally be done more rapidly using knives than hedge shears. In using knives, two factors should be considered: 1) they are most effective for shearing relatively soft wood. To be effective, shearing should be done relatively soon after completion of height growth, regardless of species and 2) to be effective, knives must be very sharp; therefore, they can be dangerous. Shearers should wear protective leg, knee and thigh guards. It is easy to overshear trees with knives, especially the single-needle species. Some growers use knives for pines and shears for other species. A number of motorized shearing devices also has been developed, and some growers find them to be fast and effective tools for shaping trees. Hand pruners are also used in many shearing operations, primarily to cut out defects, large limbs or old wood and in many cases terminal shoots when knife shearing.

Regardless of which tools are used, they should have quality blades that stay sharp with minimum care. Blades should be kept free of pitch with kerosene, fuel oil or mineral spirits.

Fertilization of Established Plantings

Although fertilization at planting time is not generally recommended, fertilization later in the Christmas tree rotation can often be beneficial. Christmas trees are essentially a foliage crop, and luxuriant foliage with good color is a definite asset when trees are sold.

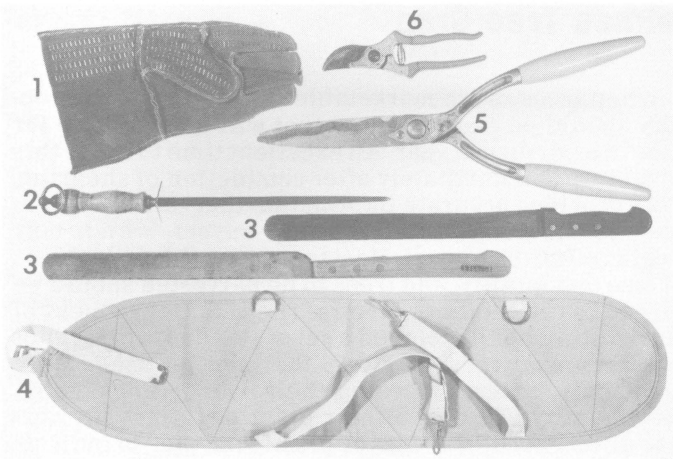


Fig. 49: Common equipment used when shearing Christmas trees: 1) protective glove used on hand not holding knife when shearing with knives; 2) honing steel used to sharpen shearing knives; 3) short and long handled shearing knives; 4) protective leg guard used when shearing with knives; 5) hedge clippers and 6) pruning shears used for cutting terminals and/or heavy woody growth.

Good moisture and nutrient relations are of prime importance in producing trees having desirable foliage characteristics. Earlier discussions have emphasized the importance of site evaluation, species selection and control of competing vegetation on nutrient and/or moisture relationships. In this section, the potential of using fertilization for improving foliage characteristics in established plantings is discussed.

As with any crop, it would be very desirable to be able to prescribe fertilization needs of Christmas trees on the basis of soil and/or foliar analyses. However, adequate standards for making such diagnoses are not yet available. As a consequence, fertilization needs must be judged largely on the basis of indirect indicators.

Species and site characteristics often serve as a general guide to fertilization in established Christmas tree plantations. On sites with adequate water, species having relatively high site requirements such as some of the spruces, true firs, Douglas-fir and white pine may respond favorably to fertilization on coarse to moderately coarse textured soils (sands to sandy loams) and possibly even on medium to moderately fine textured soils (loams to silty clay loams). Scotch pine does not need fertilization on most sites, but it may benefit from fertilization on relatively dry, infertile areas and may show considerable foliar response to fertilization on a wide variety of sites. It is generally more difficult to obtain favorable response to fertilization with most species on either very dry or wet soils.

Thin, open growth of herbaceous vegetation on sites can also be used as an indicator of fertility needs, especially on areas where there is adequate soil moisture.

A number of materials can be used for fertilizing established Christmas tree plantings. In the absence of more adequate standards for diagnosing needs, applications of balanced fertilizers having 1-1-1 ratios such as 10-10-10 or 15-15-15 are probably as good as any other material. Where nitrogen may be deficient, fertilizers with 2-1-1 ratios (such as 12-6-6 etc.) are appropriate. Applications of high-analysis nitrogen compounds such as urea (45-0-0) or ammonium nitrate (33.5-0-0) can improve foliage characteristics when applied one or two years prior to harvesting. Research in Ohio indicates that foliage density of Norway and white spruces, Douglas-fir, Fraser fir and Scotch and white pine growing on a variety of sites improved significantly when fertilized with 150 to 225 pounds of actual nitrogen per acre treated. If individual trees are fertilized, from three ounces to one pound of the above formulations will be needed, depending on size. Care should be taken when using high-analysis nitrogen compounds to avoid excess stimulation of succulent growth that may be subject to winter injury. Excess applications of soluble nitrogen compounds can also severely injure or kill small trees, particularly on sandy soils.

Applications of fertilizers to established Christmas tree plantations should be carried out in conjunction with good weed control practices, including judicious use of herbicides in bands or spots around trees. Band applications of fertilizers are generally more desirable than broadcast applications because less material is used and it is placed only in areas where it is needed. Banding also avoids excessive stimulation of herbaceous growth between rows. Methods of banding vary. Hand applications can be used by applying a circular band of fertilizer 8 to 12 inches from stems (Fig. 50), or mechanical equipment can be used. Early spring is probably the best time to apply fertilizers in established Christmas tree plantings. Costs of fertilizer applications vary. Table 6 lists examples of time requirements for equipment and labor using hand and tractor applications.

Protecting the Christmas Tree Planting

As noted in the section "Choice of Species," a number of insects and diseases may attack the species grown for Christmas trees.These pests are usually fairly specific in their symptoms and identification. Additionally, control measures using various insecticides and fungicides are very specific and are subject to the same labeling and use restrictions discussed for herbicides. Therefore, detailed information on identification and control of insects and diseases will not be covered in this manual. Information that is updated periodically can be obtained through the Ohio Cooperative Extension Service from local county agricultural extension agents.

Fig. 50: Hand application of fertilizer in a band around an established Fraser fir.

Harvesting the Christmas Tree Crop

Harvest of the Christmas tree crop should be planned and carried out as carefully as other management procedures discussed in the previous sections. Unless trees are harvested properly, they may not reach the buyer in good condition.

Size and shape of trees rather than age determine the year they are to be harvested. Rate of growth may vary considerably depending on species, site quality and cultural practices. If there is a market for small 3- to 4-foot "table" trees or small balled live trees, harvest may begin four or five years after planting. However, demand is generally greatest for trees 5 feet or greater in height, and this height is usually not reached until six to eight years after planting.

Fig. 51: Digging a balled tree using a mechanical digger.

When trees reach marketable size, a detailed inventory should be made of those that will be available for sale in a particular year. An excellent time to make this inventory is immediately after completion of shearing. This provides accurate information that can be used to answer inquiries from potential buyers, which may begin in July or August. Most trees are sold on the basis of size and quality, and trees to be harvested should be tagged to reflect those factors. The U.S. Department of Agriculture has developed a set of standards for grades of Christmas trees (Table 7) that can be used. More commonly, growers develop their own "grades" to reflect quality of trees in their plantings. Many growers use different colored tags or plastic flagging to indicate size and/or quality.

Tree freshness is an important factor affecting marketability. The time between harvest and final sale should be as short as possible. Obviously, the freshest tree would be one harvested the day before it is brought into the home. In most cases, this is not possible. Harvest for shipment to out-of-state markets must begin earlier in order to get trees to their destinations for retail sales, which commonly begin in late November or early December.

Harvesting of balled, live trees may begin after completion of growth in late August or early September if soil moisture conditions are favorable. These can be harvested earlier because trees are dug by hand or machine (Fig. 51) with part of their roots intact. After digging, balls are wrapped in burlap (Fig. 52). Trees can be kept alive by periodic watering of the balls. As noted in the section on plantation layout, additional space is usually needed between rows if trees are to be machine dug.

Harvesting cut trees for shipment to out-of-state markets may begin in late October or early November. Such early harvesting may also be desirable to avoid adverse weather conditions that often occur in late November and early December. Cutting for sales to local markets

Fig. 52: Balled-and-burlapped tree after digging.

Table 9: Examples of Time Requirements for Various Harvesting Operations[1]

Type of Operation	Time Requirements, Hours per 1,000 Trees	
	Equipment	Labor
Tag Trees for Harvest	0	4.55
Clearcut Stand: 12 HP Tractor mounted saw	3.30	3.30
Partial Cutting Stand With:		
Bow saw	0	40.00
Chain saw	19.47	19.47
12 HP tractor mounted saw	7.77	7.77
Transport Trees to Roads		
Hand	0	34.75
30 HP tractor and trailer	10.24	35.52
Loading on Trucks:		
Roadside	0	32.00
Retail lot	0	17.08
Truck to Retail Lot	32.66	58.97
Baling:	20.89	20.89

[1]Information taken from: Leuschner, W.A. and W. A. Sellers. 1975. The economics of producing and marketing Christmas trees. Virginia Polytechnic Institute and State University, Division of Forestry, FWS-1-75. 47 pp.

Rates listed are for comparison only and can be expected to vary considerably from one Christmas tree operation to another.

can often be delayed. It is particularly important to delay harvest of the spruces (particularly Norway and white) as late as possible, because, as noted in the section on species selection, needle retention on cut trees of those species is very poor.

Trees can be cut using any of several different types of saws (Fig. 53). Small hand bowsaws or pruning saws may be suitable for small operations. Small gasoline powered chain saws are generally faster and more efficient. One of the more popular saws for harvesting is a power driven circular saw mounted on the end of a wand or boom. This enables the cutter to remain upright during cutting. Circular saws mounted on the front of small, walk-behind tractors such as those used for mowing are also efficient for cutting trees. Examples of relative time required for cutting trees using different methods are presented in Table 9.

Following cutting, trees are moved to roadways (see section "Plantation Subdivision into Planting Blocks") for baling and movement to storage or shipment areas. Attempting to move and store any quantity of trees without some type of tying or baling greatly increases handling costs and may also increase possibilities of damage to trees. A number of different types of balers

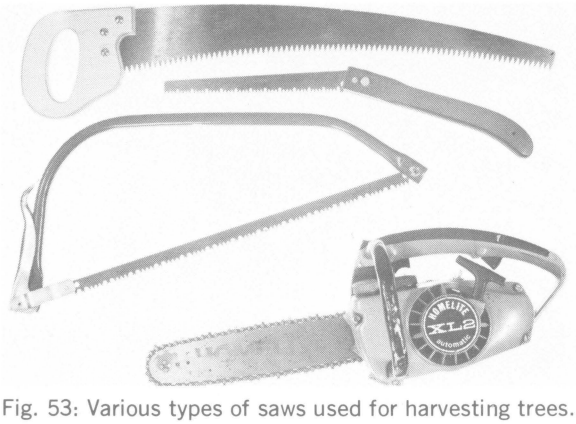


Fig. 53: Various types of saws used for harvesting trees.

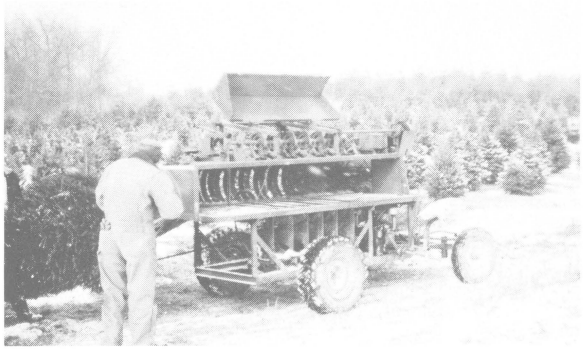


Fig. 54: Self-propelled "clamp" type twine baler used for bundling Christmas trees.

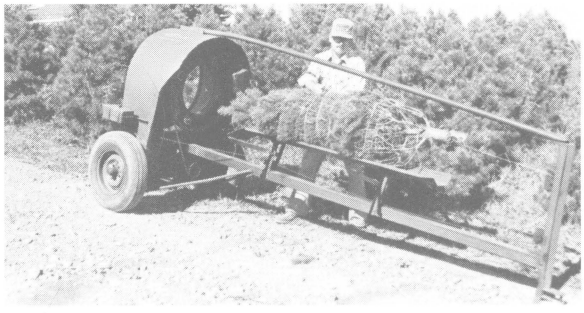


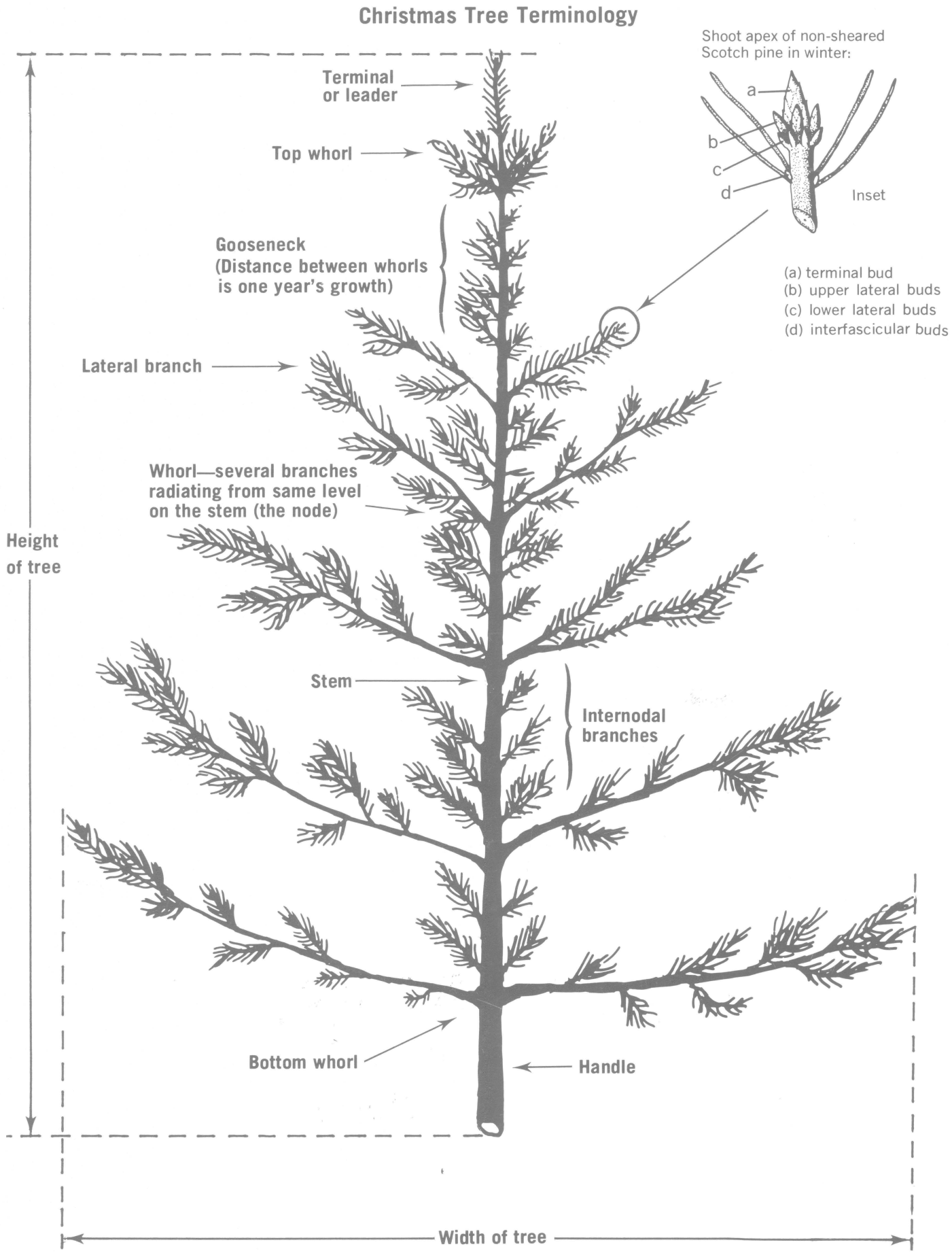
Fig. 55: "Cone" type twine baler used for bundling trees.

are available commercially (Figs. 54 and 55). Trees are usually compressed by mechanical arms or as they pass through a cone-shaped device. They are then tied or covered with plastic netting. After such baling, trees stack much more closely for storage and shipment (Fig. 56).

After cutting, regardless of the time period, trees should be stored properly until they are shipped or sold. Low temperature, high humidity and protection from sun and wind are desirable for keeping trees fresh after cutting. An old building or shed is ideal for this purpose. Storage under older conifer stands may also provide good conditions. Occasional spraying helps retain tree freshness. Tests indicate that needles having a moisture content of 100 percent or more do not support combustion.

Transport to markets is most commonly done by truck. As noted previously, it is much easier to load and pack baled trees. At least twice as many baled as opposed to unbaled trees can be loaded in the same space. Some type of conveyor or elevator can be very helpful, particularly if larger vehicles are to be loaded.

Fig. 56: 1) unbaled Scotch pine; 2) baled Scotch pine; 3) unbaled white pine and 4) baled white pine.


Christmas Tree Terminology
Shoot apex of non-sheared Scotch pine in winter:
a
b
c
d
Inset
(a) terminal bud
(b) upper lateral buds
(c) lower lateral buds
(d) interfascicular buds
Terminal or leader
Top whorl
Gooseneck (Distance between whorls is one year's growth)
Lateral branch
Whorl—several branches radiating from same level on the stem (the node)
Height of tree
Stem
Internodal branches
Bottom whorl
Handle
Width of tree