Developing Sheared Douglas-fir Christmas Trees

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Use pesticides safely!

- **Wear** protective clothing and safety devices as recommended on the label. **Bathe or shower** after each use.
- **Read** the pesticide label—even if you’ve used the pesticide before. **Follow closely** the instructions on the label (and any other directions you have).
- **Be cautious** when you apply pesticides. **Know** your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from pesticide use.

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Introduction

Over the past 30 years, Christmas trees have become an intensively managed horticultural crop. During this period, higher standards and increasing competition have given the edge to growers who are progressive and highly motivated. Whether you’re a large or small producer, your trees must have consistently high quality for successful marketing.

Before about 1960, virtually the entire harvest of Douglas-fir was from unsheared stands on sites where trees grow slowly. This slow growth resulted in generally well-proportioned “natural” trees.

During the 1960’s and 1970’s, growers learned how to shear Douglas-fir. By cutting back the leaders and lateral branch tips, they controlled and directed tree growth to improve tree shape, taper, and density.

These techniques enable the development of high quality trees on faster tree-growing sites. Shearing is also finding increased application, together with fertilization, on slower tree-growing sites that formerly produced only unsheared trees.

Douglas-fir now accounts for about 66% of the Christmas tree harvest in the Pacific Northwest and about 20% of the national total. Increased production has forced growers to look for markets in nearly every State of the Union and in foreign countries.

If you’re a new grower, you must consider—before you plant—if you’ll be able to market your trees. Millions of trees are sold each year, but wholesale competition will continue to be fierce, even with high quality trees.

Douglas-fir Christmas trees require 6 to 10 years growth before harvest, a period called the rotation. Over that time, you must invest an increasing amount of time and money in your trees.

As a new grower, you must learn from your cultural mistakes. Can you afford to do that? Do you have the time, interest, and motivation? Do you have any idea where you’ll sell your trees? It’s important that you spend time now to answer these and other questions realistically.

Many county Extension agents and consultants have tools to project costs and estimate returns for individual Christmas tree plantations. Spend some time analyzing your situation; do the numbers add up to what you expect?

Beyond exploring these personal and economic questions, our purpose in this publication is to acquaint you, as a prospective grower, with the major cultural points that you must consider, and master, to produce high quality trees that you can successfully market.

Developing a plantation

Selecting a site

Plantations should be established on open, well-drained, adequately fertile fields. Typically, such fields are located on hill-land farms, upland benches, or rolling lowlands formerly planted to crops like grain, berries, hay, and pasture.

Lands rated only marginal for other crops may, with proper management, produce excellent sheared Douglas-fir Christmas trees.

Sites that produce a medium rate of tree growth are often better suited for sheared Douglas-fir than either high or low quality sites:

- Trees on poor sites usually produce poor quality trees and require long rotations.
- Trees on better lands may produce excessively rapid, unwieldy growth with heavy suckers and stubs after shearing (some growers have learned to deal with this rapid growth, but it’s generally difficult for the novice).

Fortunately, a large share of the marginal farmlands in western Oregon and western Washington produce medium growth rates. Your county Extension agent or private consultant can help analyze prospective plantation areas for site classification as well as other characteristics that are important for producing high quality Douglas-fir Christmas trees.
Here are some points to remember:

**Avoid poorly drained fields.** Indicators of poor drainage are standing water during or shortly after prolonged rainy periods or floods, or the presence of water-tolerant plants such as wire grass, sedge, skunk cabbage, buttercup, and wild parsnip.

**Avoid frost pockets.** These are frequently found in valley bottoms, natural bowls, and extensive flat areas. Late spring freezes persistently occur in certain areas, and they can damage or kill the tender new shoots. Frost dieback lowers quality and prolongs the rotation.

**Consider if the site will be costly to prepare for Christmas tree production.** Certain weeds may be difficult to control. Previous activity on the land may require expensive cleanup. Because of the potential for strawberry root weevil, be especially cautious about planting Christmas trees in fields where strawberries or other small fruits were grown.

**Figure 1.—An example of a well-chosen site, with gentle slope, well-drained soil, good air drainage, and open surroundings.**

Preferred areas are gently sloping for good light exposure, air drainage, erosion control, and equipment access (figure 1). Thus, Douglas-fir usually responds best on southerly and westerly exposures. Slopes steeper than about 5% are capable of producing good trees, but they may suffer erosion—and access of equipment may be difficult or dangerous.

Sandy soils may produce adequate tree growth, but they may require reduced application of herbicides because of higher soil porosity.

**Avoid competition from larger trees.** Shade and root competition cause trees to lean and to produce weak branches and sparse needles, especially when the competing trees are within 100 feet south or west of the Christmas trees. *Armillaria* root rot may persist on some sites in rotting stumps and roots. Proper site selection and preparation reduce risk of disease.

**Consider adequate winter access and trespass control.**

**Recommended seed origins**

Forest geneticists have discovered significant inherited growth characteristics in Douglas-fir from different seed origins. These differences may affect both tree quality (bud numbers, branch angle, needle color, length, and appearance) and the number of years required to produce a marketable stand of trees.

- Plantations west of the Cascades, where most Douglas-fir Christmas trees are produced, should be planted only with seedlings from seed sources west of the Cascade mountains.
- East side and Rocky Mountain strains have slower growth rates and tend to be susceptible to frost damage and needle cast diseases.

Numerous west side seed sources have been tested, and the results have been mixed. In a test of 19 provenances, the source from Powell River, British Columbia, performed most impressively.

Many growers have had success with seed from Lake Cushman, Washington, and southeastern Vancouver Island. However, both low- and medium-elevation sources from the Willamette Valley also appear to develop well.

The most important point is to test several sources of seed and determine which develops best on your site and under your management style. You should know the origin of your seed precisely, and the source should be readily accessible.

Many source designations cover a wide area, and the biggest improvements in genetic quality will come from specific stands—and even certain parent trees—as we’ll discuss in “Alternatives,” page 3.

**Making your choice.** Traits of major interest to Christmas tree growers are vigor and the factors that together determine grade, bud density, needle color, length, and quality. You can improve these traits by selecting and testing certain populations or stands of seed trees.

Another important consideration is time of budbreak. Most low-elevation strains tend to break bud early. Selecting sources from elevations higher (1,000 to 2,000 feet) than your site will help avoid late frost and high populations of Douglas-fir needle midge.

Female needle midges emerge from the soil around April 1; they fly and lay eggs until the middle of May. Trees that burst bud late may avoid some midge damage and needle cast diseases.

**Figure 1.**

This helps make insecticidal control more effective.

For western Oregon south of Roseburg, local seed sources are probably best adapted to the generally warmer and drier sites found in this area. By the same token, it would be unsafe to use these seed sources in the Willamette Valley or the Puget Sound Basin. A commonly used, but untested, rule of thumb for west side Christmas tree plantations is to select a seed origin not farther than 50 miles south or 150 miles north of the planting site.
However, if there’s a chance that your plantation might go into timber production rather than Christmas trees, we strongly recommend that you select a seed origin from the same tree seed zone and 500-foot elevation band.

Although nearly all sheared Douglas-fir is produced west of the Cascade Summit, a few suitable sites occur east of the Cascades. Examples are the better sites in northeastern Washington, northern Idaho, and the mid-Columbia area near Hood River, Oregon, where annual rainfall exceeds 14 inches.

*Rhabdocline* is such a serious fungal problem, however, that many growers have stopped planting Douglas-fir, especially in northern Idaho and northeastern Washington. In drier areas, growers can use irrigation to improve survival and growth rate—but gophers, birds, deer, and other pests may be attracted to these irrigated sites and cause some tree damage.

Just as west side seed sources are recommended for west side plantations, east side seed sources are recommended for east side plantations.

A provenance test was established in the White Salmon, Washington, area in 1972 to determine the best Douglas-fir seed sources for mid-Columbia conditions east of the Cascade Summit. The Leavenworth, Washington, strain rated highest overall in this test. It produced rapid growth and bright green needles similar to west side types.

The Coconino strain from New Mexico was the best of several Rocky Mountain strains tested. This seed source is characterized by the moderately slow growth, narrow crowns, and bluish needles typical of southern Rocky Mountain strains.

West side strains don’t tolerate the climatic extremes of heat, cold, and dryness typical of east side sites.

**Alternatives.** One alternative to the use of provenances or seed zones is collecting seed from individual parent trees. By testing the seed selected from many superior parents (progeny testing), you can determine those parents that consistently produce superior Christmas trees.

Seed orchards of such superior parent trees are being developed by grower organizations, and seed is becoming available in small quantities. A few individual growers are establishing their own seed orchards.

Yet another method of genetic improvement is to select superior trees developing in Christmas tree plantations and clone them, using stem cuttings. You can select trees both for vigor and premium quality and for certain characteristics like late budbreak and resistance to diseases and insects, then preserve them by cloning.

When you select many parents with the desired traits, you can find some that propagate easily and form the desired growth habit quickly (figure 2).

A number of Douglass-fir clones have been selected by Oregon State University and the Northwest Christmas Tree Association, and they’re presently being made available in small quantities to growers and nurseries.

Guidelines for propagating Douglas-fir stem cuttings are available from the Extension forestry agent who serves your county.

### Table 1. Trees per acre at various planting densities

<table>
<thead>
<tr>
<th>Planting density</th>
<th>Trees per acre</th>
<th>10% reduction for roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 x 4</td>
<td>2722</td>
<td>2450</td>
</tr>
<tr>
<td>4.5 x 4.5</td>
<td>2151</td>
<td>1936</td>
</tr>
<tr>
<td>5 x 5</td>
<td>174</td>
<td>1568</td>
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<tr>
<td>5.5 x 5</td>
<td>158</td>
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</tr>
<tr>
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<td>1440</td>
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</tr>
<tr>
<td>5.5 x 6</td>
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<td>1188</td>
</tr>
<tr>
<td>6 x 6</td>
<td>1210</td>
<td>1089</td>
</tr>
</tbody>
</table>

Figure 2—Douglas-fir trees vegetatively propagated by stem cuttings. These trees are 8 years old, 8 to 10 feet tall, of uniformly premium quality.

## Planting

### Preparing the ground

Fields should be deeply plowed, disked, and harrowed before planting. Old fields and pastures with heavy sod also require summer fallowing to break down the sod.

Some fields contain heavy growth of Canada thistle, bracken fern, trailing blackberry, or other hard-to-kill species. Control these before you plant by repeated cultivation or with selective herbicides.

Some fields contain a hard, root-resistant plow pan or hardpan layer just below the normal plowing depth. In this case, subsoiling or extra deep plowing greatly benefits root penetration and tree growth by breaking up the hard layer.

In addition to subsoiling, identify low spots or springs and tile them to provide adequate drainage—or simply don’t plant them.

### Designing and laying out the plantation

Recommended spacing is 5½ X 5½ feet for developing trees 6½ to 7½ feet tall, which are the most popular sizes. This spacing provides about 1,300 trees per acre after deducting 10% of the full stocking for an adequate road system (table 1). You can adjust this spacing if you want unusually narrow, wide, short, or tall trees—or if you need to accommodate various sizes of equipment.
Tree rows must be straight to permit equipment access. Some growers believe that planting in perfect squares or diamond patterns (check rows) has two advantages: It permits mowing or cultivating in two directions, and it provides a more pleasing appearance than random spacing within each row.

Figure 3.—It’s best to place roads in the early planning stages.

Before you plant, there are several other points you must consider when you lay out your plantation:

1. Unless the size of the operation and the availability of services justify helicopter yarding, you’ll need roads through the plantation (figure 3). You can provide adequate access by skipping the planting of three adjacent rows at intervals of every 30 to 50 rows; this will make harvest easier.

2. Leave enough space at the ends of rows to provide for turning equipment. Such weed- and grass-free zones are also useful as firebreaks, particularly next to public roads.

3. Build roads along contours whenever possible to reduce site disturbance.

4. Learn the nutritional levels of your soil before you plant Douglas-fir Christmas trees. Minimum levels of principal nutrients (nitrogen, phosphorus, potash, calcium, magnesium, and sulfur) are necessary for good growth.

5. Shortage of nitrogen causes stunted growth and yellowing of the needles. Deficiencies are most likely to occur in fields where continuous past farming has consumed available nutrients.

6. With the exception of nitrogen, nutritional elements are most effective if you incorporate them into the soil when you prepare ground before planting. Therefore, you should probably have a soil analysis to determine if serious deficiencies exist. For instructions on soil analysis procedures, see your consultant or county Extension agent. Be sure to include a statement with the soil samples that you intend to use the land for growing Douglas-fir Christmas trees.

Planting stock

Seedlings from a number of identified seed origins are available from a wide variety of public and private nurseries. Your Extension agent or consultant can provide information on nurseries and on procedures for ordering trees.

Order your trees well in advance of planting and arrange for delivery or pickup just before planting. Seedlings are packed in waterproof bags or boxes at the nursery and stored in cold rooms before pickup or shipping.

If you don’t plant trees within about 1 week after delivery, store them in a 35°F cooler or heel them in where there’s protection from root drying, direct sunlight, and drying winds. Temporary storage should be outdoors in a cool (but not freezing) shaded spot.

Some growers have improved tree survival and growth rate by purchasing 1-1 or 2-1 transplant stock that have developed 1 or 2 years in the nursery bed and an additional year in a transplant bed. Transplants can also be developed at home by replanting 2-year-old seedlings for use the following year as 2-1 seedlings. (see OSU Extension Circular 1196, Selecting and Buying Quality Seedlings, for further details on seedlings.)

Planting techniques

Adequate survival requires skillful planting techniques. Small acreages are usually planted by hand, using a power auger, shovel, or planting bar. However, you can save time and money on large jobs by planting larger areas with a tractor-drawn tree-planting machine (figure 4).

A single-row planting machine can plant 5,000 to 10,000 trees per day. Excellent survival can be achieved when good equipment is properly operated on well-prepared ground.

Machine planters cut deep channels into the soil—to avoid gullying, avoid machine planting on steep slopes. Planting across the slope is difficult and may be dangerous if you use equipment on side slopes. If you can devise methods to minimize channeling, you’ll avoid loss of trees and soil.

Figure 4.—Tractor-drawn planters can plant large acreages quickly and efficiently.
Douglas-fir Christmas Tree Terms

- Terminal bud
- Terminal leader
- Leader buds from whorl to uppermost bud
- Leader length is measured
- Lateral branches or limbs
- Internodal branch—this distance between whorls is the height growth for one year.
- Inpointing branch—Remove these
- Gooseneck—Abnormally long bare stem between whorls
- Shearing line for taper
- A whorl—group of limbs growing from the same level on the stem
- Handle—space from ground to lowest branch

Taper:
The relation of width to height

\[
\text{Taper} = \frac{\text{width}}{\text{height}}
\]

Figure 5.—Some Douglas-fir Christmas tree terms.
Early spring planting (February, March) is more common than fall planting, especially on heavy soils that are subject to frost heaving. Best growth and survival is experienced where trees are planted as soon after February 1 as favorable soil moisture conditions will permit.

If properly planned and carried out, fall planting can yield a dividend of extra growth the first year. This technique requires summer fallowing and developing a well-prepared planting bed.

Seedlings must be dug at the nursery and properly planted soon after lifting. Do your fall planting late enough to avoid drying the trees, but early enough for some root growth to occur while soil temperature remains warm.

Loss of planted trees is greatest during the first year. Retaining some of the seedlings of the same seed origin in a transplant bed provides a handy source of planting stock to replace dead trees during the first year or two after planting. Typically, as many as 10% of the seedlings may die. If you have greater losses, investigate to determine the cause.

**Preshearing care**

The primary objective the first year or two after planting is to keep your trees alive, healthy, and growing rapidly. We’ll discuss weed control on page 13. The following additional jobs are also necessary:

- Protect the seedlings from damage by fire, deer, livestock, and rodents. Fire trails, mowing, fencing, or baiting may be necessary.
- Replace dead, weak, or inferior seedlings with healthy stock. Most wholesale growers stop replanting after the second year to avoid uneven-aged stands. However, some growers continue replacing dead trees for another year or two; they use early, tight shearing to develop table-sized trees from later replacements.
- Remove all multiple leaders by cutting flush with the main stem. Retain a single leader on the basis of size, vigor, straightness, and number of buds.
- If the terminal bud dies or a leader is broken off at its base, a new leader will likely develop from a turned-up branch of the top whorl. However, multiple leaders tend to develop in this case. You can correct this by cutting back the tips of all the branches in the top whorl except the one you select to form a new leader.
- Occasionally, an entire tree will suffer major damage from freezing, grazing, vandalism, or equipment. Young Douglas-fir have a remarkable ability to recover from such damage if more than 20% of their original live branches survive. The established root systems enable the damaged trees to form new sprouts. These will often produce a Christmas tree quicker than a replanted seedling.

**Basal pruning**

Basal pruning is removing the lower branches between the bottom of the Christmas tree and the ground; it’s important for developing high quality sheared Douglas-fir. In describing this process, it’s important to have a good grasp of the terms, illustrated in figure 5 on page 5.

The selected bottom whorl should contain five or more well-distributed, vigorous branches (figure 6). Ideally, it should be located 10 to 12 inches above the ground in well-cared-for plantations where grass and weeds are effectively controlled.

The proper year to start basal pruning is important:

- If you do it when the tree is too small, it may shock the tree and appreciably stunt next year’s growth.
- If you postpone it too long, it may require the cutting of heavy, dense branches and raise pruning costs.
- Basal pruning too late may also allow insufficient time for the handle to heal over smoothly and the bottom whorls to overcome a suppressed appearance on their undersides.

A happy medium would be to defer basal pruning until the tree has attained sufficient size that pruned limbs won’t exceed about one-third of the total foliage. For most trees in a medium-growth plantation, this stage of development occurs after the third growing season, when the trees are about 3½ feet tall. Plantations on slower-growing sites would normally be basal pruned 1 year later or the year after shearing is begun.

Basal pruning should be high enough to avoid serious defects such as incomplete bottom whorls and crooked handles (portion of the trunk below the first whorl that’s cut with the tree). Cut the branches flush with the stem to avoid stubs and cutting too close to the stem.

When trees are young and small-branched, a hand-pruner is the most commonly-used basal pruning tool. Older, large-branched trees may require a saw.

**Shearing**

Shearing involves cutting back leaders and lateral branches to control the taper (width of a tree expressed as a percentage of its height), and to increase foliage density (figure 7). This technique was developed to control growth and produce an increased number of salable trees.

Without shearing, production of Douglas-fir Christmas trees would remain limited to sites where trees grow slowly.
Year to start shearing

Most trees in medium-growth plantations will be developed enough to start shearing after three growing seasons. Attaining rapid tree development depends on the factors described previously:

- choosing a site well-suited for Douglas-fir;
- intensive soil cultivation and weed control before you plant;
- selecting the best genetic sources available;
• using healthy, husky, uniform seedlings; and
• effectively managing competing vegetation.

To be ready for side shearing, a tree should be more than about 4½ feet tall, and it should have more than 50% taper (crown width more than half its height).

**Year to start leader pruning**

The proper year to begin is determined by tree growth, not age. Some trees are likely to be ready to start leader pruning the same year that you begin side shearing (figure 8). However, most trees won’t be ready until the following year.

Growers have devised numerous schemes for developing sheared trees. For the popular 6½- to 7½-foot trees, a good rule of thumb is to defer leader pruning until total tree height first exceeds 4½ feet.

Then, as a part of the shearing operation, cut the leader back enough to reduce the tree height to 4½ feet. The actual point you cut will depend on where buds are located on the leader.

You can prune trees with ample leader buds as much as 6 inches taller than this recommended height range, but cut back those with sparse buds to ensure filling of the tree.

If you want trees either taller or shorter than the 6½- to 7½-foot average, plan a corresponding increase or decrease in sheared tree height after the first year’s shearing. After the first year’s leader pruning, maintain an annual pruned leader length of about 12 inches each year until harvest.

The method just described is commonly called the 4½ or 5’ method. Another method, called 20”-16”-12” or progressive leader shortening, progressively shortens the leader and works in the following way:

1. Defer leader pruning until leader length first exceeds 20 inches.
2. Prune the leader back to about 20 inches.
3. Every year thereafter, shorten the leader by about 4 inches to a minimum leader stub length of 12 inches.
4. Thus, the leader is progressively shortened each year from 20 inches the first year, to 16 inches the third year, and to 12 inches every year thereafter until the tree is ready to harvest.
The principle of both the 20”-16”-12” and 5’ methods of progressive leader shearing is to maintain relatively wide internodal spacing near the base of the crown, where you can anticipate several years of growth to fill in the open spaces. At the same time, maintain progressively shorter spacing toward the top of the crown, to develop uniform density from top to bottom.

Although both methods usually produce about the same quality 6½- to 7½-foot trees in the same growing period, we find that the 5’ method has several advantages:

1. It’s relatively simple to apply and explain to inexperienced shearing crews.
2. Most workers have little difficulty in cutting back a tree to a specific height and then cutting the leader to a 12-inch stub during a later shearing — workers may be confused by a complicated schedule that calls for a different pruned leader length every year.
3. The 4½- and 5-foot systems work on either fast- or slow-growing sites. For example, if leader growth on marginal land never reaches 20 inches, you can’t use the 20”-16”-12” method.
4. Finally, the 4½- and 5-foot systems give more uniform height at harvest. A 20-inch leader can develop at various heights on individual trees; this would cause corresponding tree height differences at time of harvest.

**Time of year**

Douglas-fir has a long shearing season. It begins in the middle of July when the branches are fully elongated and buds on the new growth become fully visible, and extends until the buds start to open the following spring.

An exception to the long shearing season is the final shearing before harvest. For this, July 15 to August 30 is the preferred period. Late summer or early fall shearing allows enough time for the sheared stubs to callus over and sheared branches to assume a more natural appearance before harvesting.

Buyers are easier to please if the trees are in good shape at this time. If you plan to shear by hand, the branches are softer and easier to cut in summer than in winter.

Shearing too early in the season sometimes stimulates late summer growth, called lammas growth, especially when summer rains occur. The resulting irregular, excessively long branch tips may require touching up to restore good proportion during the year of harvest.

Shearing date may have a significant impact on pest populations, especially spruce spider mite. This mite lays eggs in the fall that hatch the following spring. If you delay shearing until fall, you can shear off many of the overwintering eggs with foliage and destroy them.

**Tools**

Shearing knives and power clippers are common shearing tools (figure 9). Either of these tools in experienced hands will produce professional quality shearing.

Knives remain the tool of choice, especially in the year of harvest. Knife shearing is accomplished by long, sweeping downstrokes with a thin, sharp shearing knife 14 to 18 inches long.

Many growers preshear the leader and top whorl with a hand pruner as a separate operation. This way, it’s easier to correct defective tops and cut individual branches to desired lengths.

It’s essential that you use leg protectors, on each leg, when you shear. Another safety measure is leaving two rows of trees between members of the shearing crew.
During the harvest year, you can adjust the pruned length to make it conform visually with the overall height and taper of the tree.

Cut the leader so that the cut is about \( \frac{1}{4} \) inch above the selected top bud (figure 10). Remove buds within 1\( \frac{1}{2} \) inches of the top bud. This allows the top bud to form next year's leader and the internodal buds below it to develop into lateral branches.

Alternatively, cut at a point about 1\( \frac{1}{2} \) inches above the internodal bud, which will form the new leader. This stub helps prevent dieback of the top bud, provides a bird perch to avoid breaking the bud, and provides a tying post to straighten the new leader if it doesn't grow erect.

When you prune the leader, you must also prune the tips of the lateral branches of the top whorl to restore proportion and prevent formation of multiple leaders. Typically, the laterals are cut about \( \frac{1}{2} \) as long as the top. Leave the laterals long enough to contain at least four buds on each branch. Remove any bud occurring on the top side of a sheared branch tip to prevent formation of an inpointing branch.

Always keep in mind that the top portion of the crown should resemble a miniature, symmetrical, cone-shaped Christmas tree. This will form a guide or starting point for the side shearing.

After you prune the leader and top whorl, the tree is ready for side shearing. Your objective is to extend the taper you established by top shearing downward in a straight line to the bottom whorl and form a uniform, near-perfect cone shape.

Percent taper is the width of the crown expressed as a percentage of its height. Taper should be quite narrow (about 50\%) for intermediate shearing, but it may increase to about 60\% for the final shearing before harvest. This final widening permits light, skillful finish shearing, which should appear natural and free of heavy stubs.

Once you’ve started, you must continue shearing each year until the tree is harvested. After three or four shearings, trees lose their distinct whorled appearance as the growth of internodal branches stimulated by shearing fills in the spaces. Tree grade is reduced if gaps or spaces form in a tree, caused by incomplete filling.

We’ve stated the objectives of shearing in a general way. Translating these objectives into high quality Christmas trees is quite another matter:

1. Tree seedlings aren’t all the same and aren’t all well-adapted to Christmas tree production.
2. Growers have different ideas about how to solve the problems with trees that they encounter.
3. Buyers, whether wholesale or retail, have a range of preferences in trees. Ask the people you plan to sell trees to about the type of tree they want.

Lightweight clippers, powered by electric or gasoline motors, are being used more frequently for shearing as the technology improves. Both rotary and sickle-bar types are available.

Machines provide a lower-cost alternative to knife shearing and produce a straight shearing line that’s important to producing sheared Douglas-fir. At times, shearing machines cause a slight dieback of the branch tips.

Carry a hand pruner while you shear. This is the most effective tool to cut back leaders and top whorls, to remove suckers and multiple leaders, and to correct inpointing branches and other defects.

Techniques
Some growers preshear the leaders and top whorls with a hand pruner as a separate operation from side shearing. Others do both jobs as a single operation. Either way, basic techniques are the same.

Pruning leaders
The pruned length of the leader will depend on the height of the tree. The first leader pruning will leave a leader of variable length to obtain a tree height of about 4\( \frac{1}{2} \) feet. Thereafter, until harvest, shorten the leader each year to about 12 inches.

Lightweight clippers, powered by electric or gasoline motors, are being used more frequently for shearing as the technology improves. Both rotary and sickle-bar types are available.

Machines provide a lower-cost alternative to knife shearing and produce a straight shearing line that’s important to producing sheared Douglas-fir. At times, shearing machines cause a slight dieback of the branch tips.

Carry a hand pruner while you shear. This is the most effective tool to cut back leaders and top whorls, to remove suckers and multiple leaders, and to correct inpointing branches and other defects.

Techniques
Some growers preshear the leaders and top whorls with a hand pruner as a separate operation from side shearing. Others do both jobs as a single operation. Either way, basic techniques are the same.

Pruning leaders
The pruned length of the leader will depend on the height of the tree. The first leader pruning will leave a leader of variable length to obtain a tree height of about 4\( \frac{1}{2} \) feet. Thereafter, until harvest, shorten the leader each year to about 12 inches.

Figure 10.—One method of pruning leaders is to cut the shoot just above the new terminal and remove any buds within about 1.5 inches below it, to ensure the terminal is the dominant shoot.
Studying the way trees develop, then adapting your methods to that pattern of growth, is the “art” of shearing. In the next six sections, we’ll address some of the common problems you’ll encounter when you shear trees.

**Preventing multiple leaders.** You can’t eliminate multiple leaders on vigorous sheared Douglas-fir, but you can minimize them in one of three ways:

1. Leave a gap of an inch or two between a lone bud on the sheared leader and an internodal cluster of buds below it. Growth will tend to concentrate in the top bud and the lower internodal buds. If a bird breaks off the top bud, you’ll have to correct multiple leaders arising from the lower buds!

2. Cut the leader during its late succulent stage, about mid-July. The retained bud near the top of the leader stub will gradually develop a more upright position during the course of the growing season (figure 11). This encourages more upright growth of the new leader and improves its resistance to bird and wind breakage while succulent.

3. Shear all the top portion of the tree, except the desired leader, during the late succulent stage in July. This encourages dominance and upright growth of the single retained leader. Shorten it to about 12 inches once it has assumed a normal vertical form later in the summer.

**Correcting multiple leaders.** Multiple leaders develop as the tree becomes larger and more vigorous, and they can make leader pruning quite complicated (figure 12). Typically, the first leader pruning is a simple operation because it merely shortens a single, natural leader. The second leader pruning, too, is seldom complicated.

The third and fourth leader prunings, however, may involve problems and difficult choices where several multiple leaders and (perhaps) some heavy suckers have formed.
Prune a tree with two or more erect leaders to leave only one centrally located, upright leader. The best one to save is normally the lowest one on the stem. Completely removing its competitors higher on the stem prevents short, heavy, upright stubs. It also gives the top of the tree a more compact appearance.

Suckers sometimes form from unsheared internodal branches below the main leader, and they may be more vigorous than the true leaders. Merely shortening their tips, instead of completely removing them, forms heavy unattractive stubs.

In some instances, a sucker may be more upright and centrally located than the true leader. In this case, you could cut off the true leader and use the sucker instead.

Leader straightening. Next year’s leader, arising from the top bud of a pruned leader, doesn’t always grow erect. It may have a noticeable offset, called a dogleg, where the top bud turns upward to form a new leader. This condition shouldn’t cause alarm before the harvest year—bent or crooked leaders usually either straighten themselves, or they’re hidden by new growth.

However, doglegs may cause noticeable top defects on trees ready for harvest unless you take corrective action when the trees receive their final or finish shearing.

You can often deal with doglegs, simply and effectively, by tying them tightly with plastic ribbon against a 2-inch long leader stub left for this purpose, or by using a splint to straighten the leader.

Sometimes, a doglegged leader is too rigid to straighten. In this case, cut it off and tie a flexible internodal branch below it to a vertical position by the same method. You can also use this procedure to replace a leader too high on the tree for good proportion and density, or to replace a leader broken by birds or wind.

Replacing undesirable leaders. Some trees develop unusually coarse and vigorous leaders a year or two before they attain harvest size. Such leaders are sometimes abnormally large in diameter and very sparsely budded for a foot or more above their bases.

Cutting them back in the usual manner to a 12-inch stub results in too few buds to fill the top of the tree with branches. This scarcity of buds causes an open “hole” in the upper crown of the tree.

Another serious problem is that the few buds that do occur on this heavy leader stub grow too much and develop, in turn, into large, coarse, doglegged multiple leaders. This problem, once it starts, tends to perpetuate itself until you correct it.

Correct the problem by removing the large leaders. Then bend upward a flexible internodal branch about 2 inches below the point of cut and bind it firmly against the 2-inch stub with two or three tight wraps of plastic ribbon. Last, cut the upturned internodal branch back to proper length, about 12 inches, to form a new leader.

Unlike the leader that you removed, this new leader is usually well-budded and small enough not to grow excessively the following growing season. Cutting back the large natural leader actually enhances the tree’s development by directing growth into the lower portion of the crown.

Don’t forget to remove the stub and plastic ribbon after the tied leader has become set in a vertical position!

Bare or blank spots in a tree. Here, you’ll need to use considerable judgment. First, it’s important to determine if there are enough buds and branches to fill the hole from the side. If there are, it may be possible to slow height growth so that bare spots can fill.

If the bare spots would make filling difficult, you may need to cut off the top of the tree above the bare area and tie up a lower branch to form a new top, as described above.

Adjusting tree density. There’s a wide range of preferences in tree density. Producing a denser tree requires earlier leader shortening and, therefore, more years to grow to a given height.

It’s important to know the type of tree density you want to produce, then experiment with various methods to reliably attain it.

Figure 13.—Douglas-fir Christmas trees being sheared in the 3rd growing season.
Year-by-year cultural schedule: Planting to harvest

Tree growth varies depending on site, cultural conditions, planting stock, etc. The following schedule provides only a general guide of cultural timing.

1st and 2nd growing seasons
During the first 2 years, concentrate mainly on keeping the trees alive and vigorous. Prune only to remove multiple leaders and suckers. Select the best of the multiple leaders based on vigor, erectness, and bud set. Cut all others flush with the main stem.
Replace any dead trees during the next regular planting season. Replacements made after this year aren’t likely to catch up with the other trees in time for harvest.

Weed control in the plantation is essential, especially early in the rotation. Whatever system you choose, from living mulch to broadcast spraying, it must prevent competition between weeds and trees.

Soil-active residual herbicides still form the foundation of most growers’ weed control programs. These herbicides effectively control weeds through the growing season.

Application rate and product recommendation will depend on factors like soil type, plantation age and size, amount of interplanting, and the type and severity of weed problems. Generally, these herbicides are applied between mid-March and the first part of April.

Christmas tree advisors and pesticide consultants can help design a program for your specific situation.

After the 3rd growing season
By this time, some of the fastest-growing trees might attain heights of 4½ to 5 feet. These are now ready for their first leader pruning (figure 13). Prune the leader sufficiently to form a 4½- to 5-foot tree.
At the same time, shear the side branches to form a near-perfect 50% cone between the sheared top of the leader and the bottom whorl of branches. Remove inpointing branches, suckers, and other defects at the time of each shearing.
Basal prune to form a clean handle but avoid removing more than about ⅓ of the total foliage. Continue to control weeds.

4th growing season
Once you start shearing, you must shear each year until you’re ready to harvest. Leaders of trees being sheared for the first time should be shortened enough to reduce tree heights to 4½ to 5 feet. Trees that you pruned to 4½ to 5 feet the previous year should have their leaders shortened to about 12 inches this year, and every year thereafter, until you’re ready to harvest.
Continue to control weeds. Mowing or spot spraying between rows may also be necessary to control hard-to-kill grasses and weeds that shade the bottom whorls.
Basal prune the slower developing trees that were too small last year.

5th growing season
Continue leader pruning, side shearing, correcting defects, and spraying or mowing. Most trees aren’t yet ready to harvest; shear them to a 50% cone.
However, a few trees will probably be ready to harvest this year after only three consecutive shearings. Carefully finish-shear them in late summer or early fall as follows:

a. Cut the leader in proportion to the rest of the crown to form a sheared cone, usually 8 to 12 inches.
b. Side shear lightly to form a near-perfect cone. Shearing lightly will increase the percent taper from about 50% for previous shearings to about 60% for the last shearing. This widening will eliminate most of the visible stubs.

6th and 7th growing seasons
Continue the same cultural treatments described for the 5th growing season. Most growers should plan to harvest all remaining marketable trees after the 7th growing season. If you have leftovers that don’t shape up properly, sell them at a reduced rate or discard them—the cost of keeping them is too high.

Marginal, slow-growth sites will likely require 8- to 9-year rotations instead of 7 years. In some cases, nitrogen fertilizers may stimulate growth on these sites.

Figure 14.—Broadcast spraying reduces or eliminates competing vegetation.
Managing pests

Weeds and vegetation

Managing vegetation and preventing soil loss is important to successful, long-term production of Christmas trees. To control weeds effectively, it’s best to plan and begin your program before you plant.

Otherwise, weeds may reduce tree quality through competition, require additional control practices, or cause soil deterioration and species shifts—often toward species more difficult to control.

Newly planted trees survive or grow poorly if there’s excessive competing vegetation. Weeds are detrimental in several ways:

- they compete for moisture and nutrients from the soil;
- they shade and suppress the growth of seedlings;
- they create a fire hazard; and
- they provide habitat for mice, rabbits, gophers, root weevils, and other pests.

On the other hand, most plantations are on sloping ground, so they’re subject to soil erosion. Loss of topsoil is a serious threat to productivity of many Christmas tree sites. Give strong consideration to managing vegetation to suit two contrasting problems: high quality tree growth and soil retention.

Planning a program of soil conservation before you plant will greatly improve your chances of a successful, effective effort. We outlined some options in “Preparing the ground” (page 3). More information is available in PNW 219, Weed Control in Home Orchards and Vegetable Gardens, and from your county Extension agent or consultant.

Currently, the most common weed control practice in Christmas tree plantations is to kill or suppress all weeds, especially during the first half of the rotation.

Broadcast spraying. Apply soil-active herbicides during dormancy by broadcast spraying, using air or ground equipment. Spot treatment as weed problems develop during the growing season is also important.

The advantage of broadcast spraying is that application is simple and competition usually is eliminated (see figure 14 on page 13). However, various problems occur (such as soil erosion and various subtle changes in soil structure and tilth), and these may affect tree growth or quality over time.

Strip spraying, or using herbicides to remove weeds in the tree row, is the most common alternative to broadcast spraying. It results in vegetation between rows that you must control by mowing, cultivation, or (possibly) chemical mowing.

Problems can result from the vegetation prevalent in the strip:

- Repeated use of equipment for mowing may compact the soil, reducing tree growth and quality.
- Repeated use of the same or similar chemical results in shifts to tolerant or resistant weed species.

Living mulch, or managed ground cover, is another method of weed control. Developing some type of ground cover in Christmas tree plantations is important, but it requires increased management and decisions.

Ground covers:

- reduce soil erosion,
- decrease compaction,
- aid movement of equipment,
- improve soil organic matter and water infiltration, and
- (in some cases) provide alternate hosts and over-wintering sites for important predators of pest aphids and mites.

Problems with ground covers include:

- difficulties in establishing and managing the vegetation,
- substantially reduced Christmas tree quality if the ground cover competes with the trees for water, and
- possible habitat for pests that can kill or damage trees—or increase the fire hazard.

Living mulches aren’t yet in broad use in the Christmas tree industry, but the components for developing living mulches are available. Several dwarf grasses and legumes have been tested for their suitability in minimizing competition with Christmas trees while also being competitive enough to suppress weeds.

Figure 15.—Christmas tree growers continually inspect their fields for early signs of pest infestation. Carrying a hand lens is essential.
Once established, weed species may begin to invade the ground cover. You must observe these changes and make the appropriate management decision about how to proceed. As an alternative to planting a cover crop, some growers manage selected weeds that offer minimal competition with trees.

In each of these cases, cultivation, mowing, and sublethal doses of herbicides are options for controlling between row vegetation.

For more information about weed management and living mulches, see PNW 219, Weed Control in Home Orchards and Vegetable Gardens, and EC 1258, Living Mulch Options for Precision Management of Horticultural Crops.

**Chemicals.** This publication doesn’t recommend herbicides for specific situations. These choices change frequently. For the latest information, see your county Extension agent or consult the latest edition of the Pacific Northwest Weed Control Handbook.

**Diseases**

There are a number of diseases of Douglas-fir that can also cause problems in Christmas tree plantations.

These diseases and their control are described in table 2 (pages 16–17).

**Insects**

Insect outbreaks often occur in Douglas-fir Christmas tree plantations, resulting in significant tree damage. Learn to recognize the insects in your plantation and monitor their populations.

By routinely checking insect populations, you retain more options for effectively controlling the pests and reducing costly tree damage and chemical applications (figure 15).

Table 3 (page 18) lists common insect pests of Douglas-fir.

**Planning the next crop**

Most growers clear their field of trees before planting the next crop. A Douglas-fir plantation should be harvested within a 3-year period. After that, remove cull trees, cut stumps flush with the ground, and remove any live branches or suckers from the stump.

For establishing the next crop of trees, either remove the stumps or replant between the stumps. Consider one of these four methods:

1. Plow the stumps under with special, heavy plows pulled with a crawler tractor. Some of the stumps are buried beneath planting depth; others remain on or just under the surface and can be windrowed with a spring-toothed cultivator.
2. Disk with a huge land-clearing disk pulled with a large crawler tractor. Two diskings at right angles to each other are normally required. This procedure breaks up most of the roots and stumps, and it mulches the soil to a depth of 12 inches or more. Remove remaining large chunks as in the first method.
3. Use a heavy duty rototiller or stump grinder to pulverize most of the stumps and roots after several passes.
4. Remove the whole stumps with a bulldozer and pile them for burning (probably most expensive method).

If you decide to leave the stumps in place and plant midway between them, the stumps will rot out in about 4 years. This procedure is common on U-cut operations where it’s desirable to maintain maximum production with an uneven or mixed-species stand. It’s also used where heavy stump-removal equipment is unavailable or too costly to hire.

Some growers plant a new seedling midway between trees that are planned for cutting during the next harvesting season. This can interfere with shearing and equipment access, but it may gain some time on the next rotation.

Most growers prefer to remove the stumps and start over with a new, even-aged plantation. This practice provides an opportunity to eradicate herbicide-resistant plants, which tend to gradually invade old plantations.

Cultivation between rotations also provides the opportunity for some soil and site improvement. For example, you could grow a cover crop, then till it into the soil to improve organic matter. You can use subsoiling between rotations if you suspect that compaction may be a problem in your fields.

In rare instances, stump culturing is practiced on plantations by leaving a few branches or sprouts on the base of the stump. This type of management could preserve an unusually desirable and hard-to-replace seed source or elite trees established from grafts or rooted cuttings. However, stump cultures in plantations are more difficult and costly to maintain than newly planted seedlings, and they’re not generally recommended.
<table>
<thead>
<tr>
<th>Disease</th>
<th>Description</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swiss needle cast (Phaeocryptopus gaumanii)</td>
<td>Infection takes place on new growth shortly after budbreak. By the following spring, black pinpoint fruiting bodies can be distinguished on the underside of the needle. A 10 or 20x hand lens is useful to spot this diagnostic feature. Needles begin dropping as water stress develops during the summer. In severe cases, only current year's needles are present. Even mildly infected trees may have unacceptable needle loss during the stress of transport and marketing.</td>
<td>General resistance within provenances hasn't been identified. Swiss needle cast is widespread, and it’s often worse in fields subject to high humidity or with poor air drainage. Remove severely infected trees from the field. Chemical treatments are effective if properly applied, starting just after budbreak. Growers often spray yearly beginning 2 or 3 years before harvest to ensure sufficient needle retention. Fungicides aren't needed during the first few years' growth.</td>
</tr>
<tr>
<td>Rhabdocline needle cast (Rhabdocline pseudotsugae)</td>
<td>The first visible evidence of the disease appears in autumn or early winter as minute yellow spots on the upper and lower surfaces of the current year’s needles. Usually, the spots are more abundant near the apex of the needle. The spots become larger and darker during the winter months. By the spring, many of the spots coalesce and become deep red-brown in color, “mottled.” In the late spring or early summer, the fruiting bodies of the fungus appear on each side of the midrib on the lower surface of the needle. The epidermis of the needle splits, exposing an orange to orange-brown fungal structure. Spores are released during the spring concurrently with the unfolding of new shoots. Rhabdocline causes economic loss by damaging the needles, rendering the trees unsalable. Slightly affected trees that are sold may suffer serious needle yellowing and drop during shipping.</td>
<td>Rhabdocline occurs mainly in seed sources from east of the Cascade Mountains. Avoid these sources for planting in west side plantations. Otherwise occurs only sporadically on west side. Remove infected trees from the plantation. Chemical control is available. Applications should start just after budbreak when the new growth is 1 to 2 inches long.</td>
</tr>
<tr>
<td>Disease</td>
<td>Description</td>
<td>Control measures</td>
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<tr>
<td><strong>Needle rust (Melampsora occidentalis)</strong></td>
<td>Yellow pustules can be found in late spring or early summer on the lower needle surface. The area above the pustule, on the upper surface, will be light green. Needle damage disfigures the tree; in severe cases, stem cankers may form, and some stem dieback may occur.</td>
<td>The alternate host for this rust is the black cottonwood and other poplars. Fruiting bodies containing spores overwinter on fallen leaves and infect Douglas-fir the following spring. Removing neighboring cottonwoods and poplars is an effective cultural control where feasible. Chemical control shortly after budbreak is effective.</td>
</tr>
<tr>
<td><strong>Stem cankers (Phomopsis)</strong></td>
<td>Cankers appear sunken and often elongated. They may occur on either trunk or main branches. Once girdled, the portion of the tree above the canker dies. If the dead tree is left in the plantation, black fruiting bodies appear the following spring and give a distinct black, sooty appearance to the tree.</td>
<td>No chemical control is available. Cultural practices that favor good plant growth are the primary defense. Prompt removal of dying branches and trees is necessary to reduce inoculum.</td>
</tr>
<tr>
<td><strong>Armillaria root rot (Armillaria mellea)</strong></td>
<td>At or just below ground level, white, feltlike masses of fungus are found growing near the crown between the bark and wood. Scattered through the soil are black, stringlike strands, called rhizomorphs, which may grow through the soil for some distance; they may be a means by which the fungus spreads from plant to plant. The first visible plant symptoms are decline and dieback involving yellowing, wilting, and death of the leaves. In the fall, honey-colored mushrooms may appear on the crown of infected plants. These discharge vast numbers of spores that become widely distributed.</td>
<td>Armillaria can survive for years on dead plant tissue. Where Armillaria may pose a problem, proper site selection and cleanup reduce the risk of disease. Plants that are growing vigorously as a result of good site and cultural practices are less susceptible to Armillaria. Surface watering during the summer may favor growth of the fungus.</td>
</tr>
</tbody>
</table>

*Consult the PNW Disease Control Handbook, latest edition, for current cultural and chemical options.*
<table>
<thead>
<tr>
<th>Insect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coneworms (Dioryctria spp.)</td>
<td>Small cream-brown moth larvae. Bore into stems, especially around wounds.</td>
</tr>
<tr>
<td>Conifer aphids (Cinara spp.)</td>
<td>Large dark-colored aphids. May distort stems.</td>
</tr>
<tr>
<td>Cooley spruce gall adelgid (Adelges cooleyi)</td>
<td>Appear as small cottony tufts on adelgid undersides of needles. In severe cases, may cause yellowing, distortion, and premature needle drop. Must be controlled in crawler stage. Usually in late May.</td>
</tr>
<tr>
<td>Douglas-fir needle midge (Contarina spp.)</td>
<td>Adult is a small midge (fly). Larvae mine needles, often appearing as a purple node above which the needles are distorted. Time chemical applications to coincide with emergence budbreak. See OSU Extension Circular 1373 for further information.</td>
</tr>
<tr>
<td>Eriophyid needle mites</td>
<td>Very tiny white, worm-shaped mites. Found along stem and needle bases. Infested foliage takes on an olive green color; older needles drop prematurely.</td>
</tr>
<tr>
<td>Root weevils (mainly strawberry root weevils)</td>
<td>Larvae are cream-colored, “C”-shaped grubs that feed on roots, sometimes girdling them. Adults feed on needles, causing characteristic notching. Direct controls at adults.</td>
</tr>
<tr>
<td>Spruce budworm</td>
<td>Green-brown larvae up to 1” long. Feed on foliage and buds of fir, spruce, and Douglas-fir. Good biological control with Bacillus thuringiensis.</td>
</tr>
<tr>
<td>Spruce spider mite (Oligonychus ununguis)</td>
<td>Dark green mite. Will stipple and bronze needles, beginning at the base. Overwinters as red-orange eggs.</td>
</tr>
<tr>
<td>Tussock moths</td>
<td>Caterpillars with tufts of hair (“tussocks”). Larvae may be found in large numbers under webbing on branches.</td>
</tr>
</tbody>
</table>

*aConsult the PNW Insect Control Handbook, latest edition, for further cultural and chemical options.*
Sources of assistance and information

Most growers in the Pacific Northwest belong to one of these associations:

- Northwest Christmas Tree Association
- Puget Sound Christmas Tree Association
- Inland Empire Christmas Tree Association
- Southern Oregon Christmas Tree Association
- National Christmas Tree Association

Meetings, field tours, culturing demonstrations, and current literature are provided for members. You can obtain further information from the association secretary.

The Extension Services of Idaho, Oregon, and Washington provide short courses for Christmas tree growers. The Extension agent who serves your county can provide information on time, place, and agenda of these training sessions.

For further reading

OSU publications and videotape

These publications (including the one you’re holding, PNW 227, Developing Sheared Douglas-fir Christmas Trees, $1.75) and videotape are available from:

Publications Orders
Agricultural Communications
Oregon State University
Administrative Services Bldg. 422
Corvallis, OR 97331-2119

Shipping and handling: Unless otherwise noted, please add 50¢ for orders up to $3.50. For orders between $3.50 and $100, add 15% shipping and handling. For orders of $100 or more, or for 100 copies or more, please call Agricultural Communications (503-737-2513) for a quote on reduced shipping rates.

Cleary, Brian D., and David R. DeYoe, Seedling Care and Handling, Oregon State University Extension Circular 1095 (Corvallis, reprinted 1991). 25¢

Landgren, Chal G., Shearing and Culturing Christmas Trees, Oregon State University Extension Service videotape VTP 005, 65 minutes, VHS (Corvallis, 1991), $30 plus $3 shipping and handling.

Landgren, Chal G., and David R. DeYoe, Selecting and Buying Quality Seedlings, Oregon State University Extension Circular 1196 (Corvallis, 1986). $1.50

Landgren, Chal G., and Bernard S. Douglass, Developing High Quality True Fir Christmas Trees, Pacific Northwest Extension Publication PNW 226 (Oregon State University, Corvallis, revised 1992). $1.75

Pacific Northwest Weed Control Handbook
Pacific Northwest Insect Control Handbook
Pacific Northwest Disease Control Handbook

Each is a Pacific Northwest Extension publication, published annually; use the latest edition. Single copy of each handbook, $15 plus $2.25 shipping and handling. Also available from: Bulletin Office, Cooperative Extension, Cooper Publications Bldg., Washington State University, Pullman, WA 99164-5912, for $17.25 postpaid.

Proebsting, William M., and Donald Hanley, Growing Christmas Trees in the Pacific Northwest, Pacific Northwest Extension Publication PNW 6 (Oregon State University, revised 1985). 75¢


William, Ray D., Living Mulch Options for Precision Management of Horticultural Crops, Oregon State University Extension Circular 1258 (Corvallis, 1987). 50¢


Other publications


Hanley, Donald, James Freed, David Baumgartner, and Richard Carkner, Conversion of Christmas Tree Lands to Timber Stands, Washington State University Cooperative Extension publication EB 1479 (Pullman, 1989). $1

Computer program

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