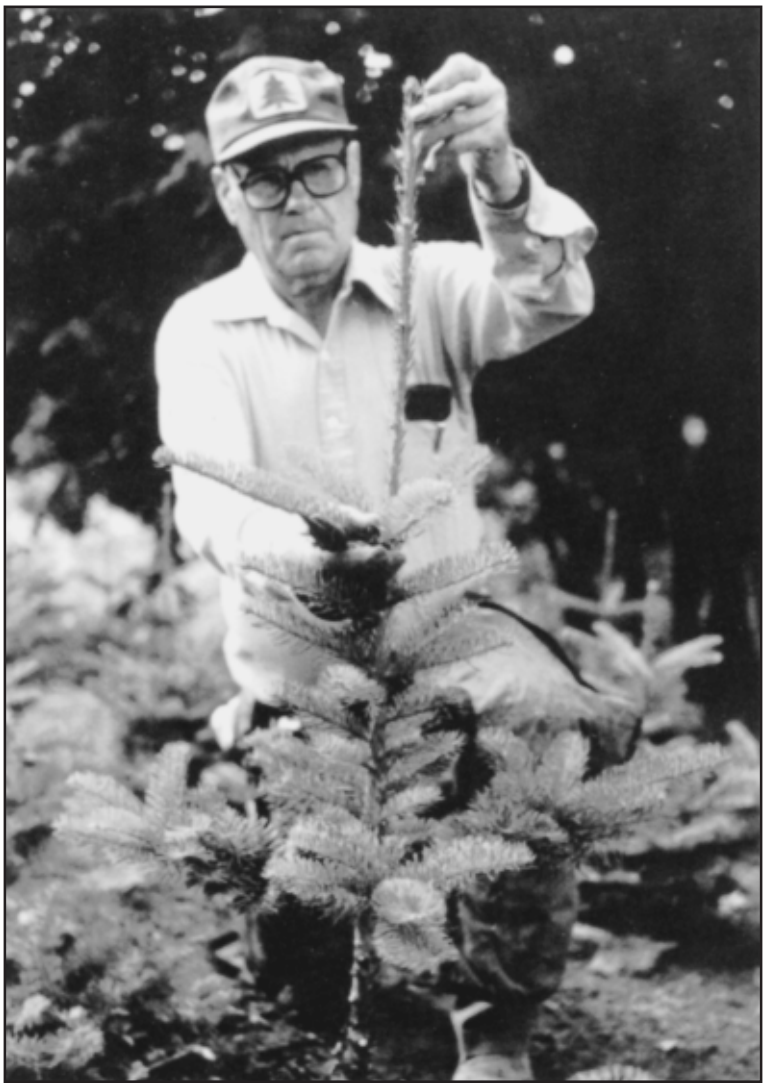
Developing High Quality True Fir Christmas Trees



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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.

Contents

Developing High Quality True Fir Christmas Trees

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Introduction

Each Christmas tree species requires special skill and specific knowledge to be grown successfully. True fir Christmas trees are no exception. In fact, the true firs, many argue, require more detailed knowledge, more specific site requirements, and more individual attention than other species.

This publication will help outline the growing of quality true fir Christmas trees—but it's not the final word. Site conditions, your seed source, and a host of other variables will determine how your trees respond and develop. Even growers with more than 30 years of experience readily admit that they're always learning when it comes to growing a true fir.

We begin by introducing the species and by suggesting points to help you decide if you really do want to grow true firs.

Then we outline important cultural activities for true fir production, emphasizing noble and grand fir.

What are true firs?

True firs are defined as all species of the genus *Abies.* About 50 true fir *(Abies)* species are scattered around the globe. Six are native to the Pacific Northwest, and three (noble, grand, and Shasta red) comprise the bulk of the commercial true fir Christmas tree harvest in the region.

True firs comprise just over 35% of the Christmas tree harvest in Oregon, Washington, and Idaho. Among these, one species—noble—commands well over half the production. Figure 1 lists the common species and their relative planting abundance.

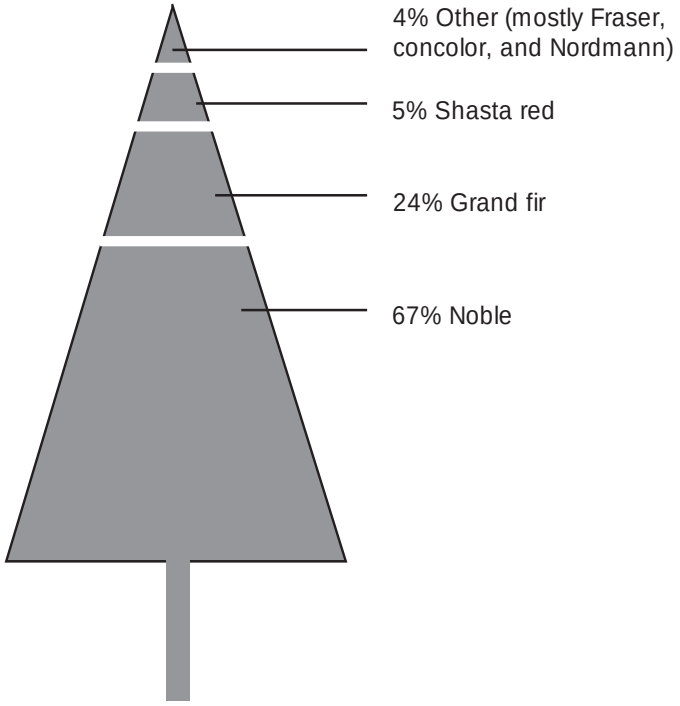

Figure 1.—Planting abundance of Northwest true fir Christmas trees (1990 estimate by Bernard S. Douglass).

How long until harvest?

The number of years until harvest varies, depending on species, size at harvest, age of seedlings, soil fertility, cultural practices, and other variables. In a relative sense, the true firs are slower growing than Douglas-fir. Table 1 outlines some average development rates, beginning with 2-year-old seedlings.

About 3 years are needed to harvest all the trees in a given field because trees develop at different rates. Practices like planting older seedlings or planting the best genetic selections tend to shorten the rotation. Weed problems or poor genetic or site selections are among the factors that may lengthen it.

What's the market climate for true firs?

Christmas tree production has expanded in every State in the country over the past 10 years. Where will these trees find markets? How hard will it be to sell trees? These are questions that you need to consider carefully before you plant; we'll consider them briefly in this section.

Consumer demand. Broadly, consumer demand for Christmas trees is divided among households that buy real trees, households that buy artificial trees, and households that don't use trees at all.

A 1989 national survey showed 38% of U.S. households used a real tree, 40% used an artificial one, and 22% had no tree. From 1978 to 1989, the percentage of households using a real tree declined by 5%. The use of artificial trees increased by 7%, particularly in the 55+ age group. These trends are discouraging to real tree growers.

To counter declining markets, various national, State, and grower efforts have been launched. Success will take time and grower participation.

Chal G. Landgren, Extension agent (forestry), Columbia and Washington counties, Oregon State University, and Bernard S. Douglass, Christmas tree consultant, North Plains, Oregon, in consultation with Extension specialists in Oregon, Washington, and Idaho. This publication was originally *Managing Your Woodland How to Do It Guide* No. 14 (1980), published by the U.S. Forest Service, Pacific Northwest Region. With USFS permission, it was reprinted as PNW 226 in 1982. It was slightly revised in 1986 and substantially revised for this edition.

Table 1.—Comparative development rates of four Christmas tree species, beginning with 2-year-old seedings

Species	Average growing seasons until harvest (years)
Douglas-fir	5-7
Grand fir	6-8
Noble fir	7-9
Shasta red	8-10

Supply. In the Northwest, true fir tree sales, expressed as a percentage of total sales for all species, have increased 1% a year during the past 10 years. This increase has been at the expense of other species, and it has led many new growers into planting true firs.

A number of polls over the past decade suggest that about twice as many trees are planted as are sold. The resulting oversupply has depressed prices for all species and greatly reduced demand for poor quality trees.

Production costs and sales. True firs require longer than most other species to reach market size. This means increased costs for producers. There are tools available to help growers evaluate the profitability of a Christmas tree enterprise (see "For further reading").

These tools are limited by our incomplete knowledge of future tree prices and supply, but they do provide a helpful starting point. At a minimum, you could evaluate expected production costs against alternative investments and estimate how low tree selling prices could go before your enterprise is no longer profitable.

New growers continually *underestimate* the time and expense in growing Christmas trees. Specific answers are far beyond the scope of this publication, but some hard questions may be in order at this point:

- Will you still be around the area at harvest time in 8 to 10 years? (Consider how many moves you've made in the past 10 years.)
- Can you afford the expense of investing—let's say, $3.00-$4.00 or more—in each tree until harvest?
- What other things could or might you do with the land or the money?
- Do you have the spare time, interest, and knowledge to work on the trees yourself during the specific time the job must be done? Are reliable contractors readily available?
- Are you willing to devote time to learn new techniques to grow, culture, and market the trees?
- Do you have the time to oversee contractors or to devote about 3 days per acre of plantation per year of your own time?

Before you plant, it would be prudent to consider carefully the economic and time allocations needed to grow Christmas trees. Talk to established growers and buyers. Consider what options you might be giving up to grow a crop of Christmas trees successfully.

To summarize, in the climate of a maturing industry, marketing of trees is becoming the top grower concern. New and established growers need to consider marketing trees—even before the first tree is planted.

Characteristics of true firs

Each species has unique traits and potential for Christmas tree production. Let's review some of the commonly grown species.

Noble and Shasta red firs

These species have excellent needle retention and attractive foliage (figure 2). We group the two species together because their appearance, cultural responses, and site preferences are similar.

They grow naturally at 2,500- to 5,500-feet elevations. Branch and needle structure is stiff and strong enough to withstand heavy snows in their natural habitat. They have characteristic well-branched whorls with rather short internodal branches. Without culturing, there are open internodal spaces between whorls.

Figure 2.—Growing quality plantation noble fir requires skill and attention to detail.

The major assets of both noble and Shasta red firs are attractive, nonshedding needles and a stately appearance provided by a formal, uniform branching habit. They're easily decorated with hanging Christmas tree ornaments like colored glass balls and tinsel. They're also adaptable to flocking with artificial snow.

Noble fir is a native of high-elevation sites in the Cascades and Coast Ranges of Washington and Oregon. Its northern range limit is near Stevens Pass in the north-central Washington Cascades. Its southern range limit is the Umpqua-Willamette divide in southern Oregon, where noble fir blends and hybridizes with Shasta red fir.

Shasta red fir is a native of high-elevation sites in the Cascades and Siskiyou Mountains of southern Oregon and northern California. It forms a transition species between noble fir and California red fir, and it hybridizes with each where their ranges overlap.

Both noble and Shasta red fir species have produced beautiful, desirable plantation-grown Christmas trees when grown on suitable sites and properly cultured. Where one species grows well, the other is likely to succeed.

Noble fir usually grows slightly faster than Shasta red fir, but Shasta red fir is somewhat more tolerant of dry soil conditions.

Needles of noble fir are generally considered more durable than those of Shasta red fir. They're darker green, stiffer, and more densely arranged on the twig. On the other hand, Shasta red fir develops a narrower, more "self-shaping" crown than noble fir.

Grand fir

Grand fir grows naturally in western and eastern Washington, northern Idaho, and at many elevations in western and northeastern Oregon. It's also found in southern British Columbia, northwestern California, and western Montana.

Grand fir, like Douglas-fir, has many racial variations over its wide geographic range. These inherited differences include growth rate, disease resistance, needle retention, needle form, needle color, and other characteristics important to Christmas tree growers.

One example is the different needle arrangements of west side and east side strains. The west side strains usually have needles arranged in two single flat rows on the twig. Many east side strains have two double rows on each twig, and the needles sometimes spread upward, somewhat like a noble fir.

Grand fir from suitable seed origins are beautiful Christmas trees. They're usually priced on the Christmas tree market between noble fir and sheared Douglas-fir.

Exotic firs

Fraser fir *(Abies fraseri)* from the southern Appalachian Mountains is a popular and attractive Christmas tree of the eastern United States. It grows quite well in Oregon and Washington and develops, once established from 4- or 5-year-old seedlings, at about the same speed as noble fir.

In the Idaho panhandle area, Fraser fir grows at about the same rate as grand fir. It's very susceptible to damage by the balsam woolly adelgid on the west side of Oregon and Washington.

Some promising overseas exotics are from the high mountains of Turkey or adjacent Asia Minor countries and include Turkish fir *(Abies bornmuelleriana)* and Nordmann fir *(Abies nordmanniana)*.

Getting the best trees on the best site

Many problems with true firs can be traced to either planting trees of a poor quality seed origin or planting true firs in the wrong sites.

The best seed

Good prospects for true fir Christmas trees show dark green color, plentiful buds, ample but not excessive growth, good form, and resistance to diseases and insects. Most of these characteristics are at least partially inherited. Make every effort to obtain only seedlings grown from the best, proven, seed origins.

These seed origins may be described in a number of ways. The most reliable (and most expensive) seed is that from a specific tree of proven quality.

The more common practice is to rely on seed collected from a known area, or provenance. These may be listed by seed zone or specific site location. As a general rule, the more specifically you can describe the seed collection area, the more repeatable and consistent your future trees growth characteristics will become.

As you think about this pattern, it begins to make sense. Trees exchange pollen and produce seed over a rather small area. Important inherited growth characteristics may be found only in seed collected from that area.

Let's consider some of the best seed sources.

Noble and Shasta red firs. The three best noble fir seed origins or provenances identified in a 1970-1975 test, in descending order for overall quality and vigor, were:

- the Siletz River drainage in the north-central Oregon Coast Range;
- the Kalama River drainage near the southwestern slope of Mt. St. Helens in southwestern Washington; and
- Baw Faw Peak in the south-central Washington Coast Range.

These top-rated seed origins developed good trees over a wide range of climates, latitudes, elevations, and soil types in five western Washington and western Oregon test plots.

Noble seeds or seedlings from proven mother trees are also available from the Northwest Christmas Tree Association and from selected nurseries.

The best Shasta red fir seed origin is the Siskiyou Mountains south and west of Grants Pass, Oregon. No other Shasta red fir source was equally satisfactory for overall growth rate and quality.

To summarize the importance of proper genetic selection, one of the test plot evaluators—an experienced and successful noble fir grower—summed up his observations this way: "Regardless of how good my site or how much effort I put into culturing, I'd lose my shirt trying to develop Christmas trees from unsuitable seed origins" (figure 3).

Grand fir. A Christmas tree provenance test was established in 1968 to test and compare 24 grand fir strains from Oregon, Washington, California, Idaho, and Montana.

Evaluations were made on five test plantings in western Oregon and Washington and northern Idaho. They were based on vigor, Christmas tree form, needle attractiveness, insect and disease resistance, and lateness of flushing.

The highest-rated seed source in all test plots was that from east of Grangeville in the central panhandle of northern Idaho. This source is often called the "Clearwater" source at nurseries.

Next best seed sources, in descending order, were near Pend Oreille, Idaho; Hamilton, Montana; and Pomeroy, Washington.

An interesting observation was that strains from east of the Cascade summit produced better Christmas trees in *west side* plantations than the native west side strains. Needles on the better east side strains were noticeably superior for density, upright arrangement, retention, and color.

The best growing sites

Each species has particular sites on which it thrives—and sites that you should avoid.

Noble and Shasta red firs. These two high-elevation true firs require more moisture and cooler growing conditions than grand fir, Douglas-fir, and pines. Noble and Shasta red fir require well-drained soils to prevent root rot diseases.

The best growth response can generally be expected on gentle slopes with northerly to easterly exposures not subject to severe summer heat and drought. Late winter frosts can also damage buds. The tree's ability to survive on southerly and westerly exposures improves with higher elevations, increased summer rainfall, and moderate temperatures. Preferred sites are well-drained locations over 800 feet in elevation.

Opportunities to establish noble fir plantations east of the Cascades are limited by excessive heat and dryness. Even if the trees are watered frequently, low humidity and temperature extremes will cause poor growth and dieback.

Cool, moist conditions preferred by these species don't imply overhead shade. Like all other Christmas tree species, they develop best under open sunlight without root competition from larger trees, brush, grass, and weeds.

Shasta fir is somewhat more tolerant of dry soil conditions but more sensitive to root diseases on poorly drained soils. Shasta is also somewhat more sensitive to rust diseases where bracken fern is the alternate host. With any true fir, it's best to remove ferns in the immediate area.

Figure 3.—Genetically superior seed origins outperform poor selections (right) for growth rate and form.

Grand fir appears to respond equally well on high- or low-elevation plantations, but prefer cooler, moist sites. Level to gently sloping northerly and easterly exposures are usually favorable for low-elevation plantations.

Grand fir will tolerate wetter soil conditions than Douglas, noble, or Shasta red fir. Some growers use grand fir to fill in moist portions of their fields. It also tolerates shady areas of a plantation—for example, along the fringe of adjacent stands of timber.

This is not to say that grand fir *prefers* wetter soils or shade. They merely *tolerate* it better than most other species.

Grand fir, like other Christmas tree species, develops its best quality in open sunlight and on well-drained soils. On some lower elevation sites, grand fir seems to develop a needle dieback problem on current-season needles.

In northern Idaho, grand fir does well on level fields and on north and east slopes if rainfall exceeds 25 inches annually and weeds are controlled. Growers generally avoid south and west slopes in this area.

Problems of true firs

A variety of pests try to consume or degrade your tree before harvest. Diseases, insects, competing vegetation, animal damage, and excess water are all potential "pests."

Let's briefly look at each of these problems.

Diseases and insects

Pest problems can develop in a number of ways. The change may come quickly and without warning, or a problem may develop slowly over years. Regardless of how a problem develops, the keys in prevention are—learn about the pests, monitor your fields, and avoid planting in problem areas such as "wet spots."

Table 2 lists common insects; table 3 lists common diseases.

Table 2.—True fir insect problems

Insect	Hosts	Description / damage	Comments[a]
Balsam woolly adelgid *Adelges piceae*	True firs (mostly Fraser, grands, and nobles)	White cottony tufts on underside of branches or on trunks around bud break. Difficult to control. Crawlers difficult to see without hand lens. Causes "gouts" or swollen knobs and distorted tops and branches. Several generations possible each year. Fraser fir extremely susceptible.	Use high-pressure spray equipment. Spray near budbreak.
Balsam twig aphid *Mindaris abietinus*	True firs (grand very susceptible)	Small greenish aphids in tops or along branches. Secrete honeydew. Causes twisting, stunting, or matting of new growth. Watch carefully and spray field when noticed. Spot-spraying will miss some. Use hand lens for early detection.	Monitor closely.
Bow-legged fir aphid *Cinara curvipes*	All true firs	Large shiny black aphids in colonies on main stem,beginning in early spring. Causes black sooty mold. Generally not serious. Spray if widespread on harvest size trees; otherwise, ignore or spot spray.	
Root weevils	All species	Patches of yellowing trees visible in early spring. Dig around trees to search for small white larvae. If you find 4-6 per shovelful, problem is serious. Adult weevils emerge May-June and feed at night. Feeding damage minor compared to root damage by larvae.	Very difficult to control.
Silver spotted tiger moth *Halisidota argentata*	All species	Tiny brown larvae present in late fall. Damage visible in early spring from cluster of caterpillar larvae feeding on branches in scattered individual trees. Generally more unsightly than serious. If needed, spot spray only.	
Spider mite *Oligonychus ununguis*	All species	Tiny, 8-legged, green to brown mites. First appear in early spring; present throughout summer.May require multiple sprays if serious. Damage to leaders and upper whorls most evident in late summer. Small amber-colored eggs and webbing also present. Hand lens a must.	Best to spray in early spring after early hatch and before new eggs appear. Watch very closely for proper timing.
True fir aphids Possible *cinara sp.*	Grand, noble, and Fraser fir	Small greenish to grey aphids that concentrate on interior of lower crowns. Generally attract many bees. Exude honeydew that causes "shiny" appearance and is sticky to the touch. Promotes black sooty mold. Very serious if attacking trees within 2-3 years of harvest.	
Eriophyid mites *Nalepella sp.*	Fraser, noble and grand fir	Occasional problem. Very tiny, cone-shaped, light-colored individuals. Branch tips may appear "fuzzy" before budbreak if populations high. Trees may show gradual discoloration of new and interior growth; later, they may have burned appearance, and needles may drop. Hand lens required.	Natural predators provide control.

[a]See current *PNW Insect Control Guide* for spray recommendations. Adapted from Tompkins, D., "Monitoring Plantions for Pests," *Christmas Tree Lookout* 23(1) winter 1990, p.16.

Table 3.—True fir disease problems

Disease	Host	Description / damage	Comments[a]
Current season needle necrosis	Grand and noble firs	Tan-colored bands across needles in June / July. Entire needles may turn coppery red later in summer. Some drop, but remaining affected needles make trees unsalable. Appears to be a physiological problem.	Some seed sources more prone to damage. Shading and calcium have reduced damage under controlled conditions.
Grovesiella canker *Grovesiella abieticola*	True firs. Most susceptible trees (in order): concolor, Shasta, noble, grand	Found on trunks and lower stems of young trees. Check off-color trees in spring for swollen cankers on trunk or on suspect branches. Small black fruiting bodies may be on surface of cankers. Branches or entire tree may be killed by girdling. Stem diameter often enlarged above infection.	Cut and destroy diseased branches and trees. No chemical controls known to date.
Interior needle blight	All true firs	Browning of interior needles of lower crowns most prominent in fall. Needles remain firmly attached. On noble fir, associated with fungus *Mycosphaerella.*	Improve air circulation through cultural practices. Prune out affected branches.
Phytophthora root rots *Phytophthora spp.*	True firs (Shasta, white, noble, and Fraser most susceptible; grand fir and Nordmann least susceptible)	Symptoms occur throughout the year. Faded trees, dead and dying branches, reduced growth—together or singly. Canker generally visible by peeling bark from base of trunk. Most serious in poorly drained areas.	Cut out and destroy affected trees. Improve drainage, avoid susceptible hosts, and plant only healthy seedlings.
True fir rusts *Uredinopsis pteridis* *Pucciniastrum goeppertianum*	True firs (especially grand and Shasta fir)	In Oregon, *U. pteridis* most common, while in Washington, *U. pteridis* and *P. geoppertainum* are both present; alternate hosts are bracken fern and huckleberry, respectively. Tubelike fruiting bodies found on lower side of needles in late spring to early summer. *Uridinopsis* has a salmon-colored phase on current needles and a white tubelike phase on current and older needles. *Pucciniastrum* spores are yellowish. Severe infections will result in needle drop.	Destruction of alternate host for at least 1,000 feet from trees. Fungicides are now available for partial control.

[a]Check current *PNW Disease Control Handbook* for current control recommendations.

Learning. There are a number of sources useful in learning more about pests. Some are listed under "For further reading," inside back cover. Others include insect and disease guides, Extension agents, other growers, professional consultants, State inspectors, and numerous other public and private sources.

Monitoring is the other key in solving and avoiding pest problems. Monitoring is simply a systematic method for looking over your plantation at regular intervals. You should have a 10X (minimum) hand lens, pruners, a pocket knife to look for cankers, and perhaps a shovel if you suspect root problems.

Randomly check trees in your field, paying particular attention to trees along the plantation edge, off-color trees, or sickly trees.

You must carefully inspect during monitoring—look at old and new needles, pull away branches so you can check the tree stem, and look at the base of the tree. Look under needles. Observe needles with your hand lens.

Monitoring should be most active from just before budbreak through about August. This is the period when pest problems can develop quickly.

Animals

Cattle, horses, and sheep are not compatible with Christmas tree growing. They browse the succulent tips, trample seedlings, and damage the branches by rubbing. Fencing costs can be minor when compared with potential losses to such damage.

Deer and elk do similar damage, particularly where plantations are adjacent to wooded areas. Your State Fish and Wildlife Department can offer advice on protecting your tree farm from animal damage.

Small rodents are frequently more damaging than any other types of animals. Mice may girdle smaller trees near the groundline, and pocket gophers may eat and girdle the roots.

The best solution in either case is to control the grass and weeds that provide feed and cover. Heavily gopher-infested areas may also require intensive baiting, trapping, or fumigation.

Competing vegetation

True firs are quite sensitive to weed competition. Problems with weeds and grasses in the fields include:

- grass that provides a habitat for mice, gophers, and rabbits, which damage or kill trees;
- vegetation that may deplete moisture and nutrients from the soil; and
- shading of lower branches, which may suppress and deform growth.

Experienced growers often mention that in the long run it's less expensive to control problem weeds and develop soil retention strategies *before* planting than to correct a problem once the trees are planted.

For example, if your field shows large areas of Canada thistle, pigweed, blackberries, alfalfa, or other persistent problems, strongly consider delaying planting until you control the problem vegetation.

Once you plant the trees, there are a number of methods useful in controlling weed growth. We'll discuss some common methods.

Broadcast spraying. This is by far the most prevalent weed control method. Here, essentially all vegetation except the trees is eliminated or severely suppressed. Application of the herbicides is by aircraft or ground spraying.

A wide variety of herbicides can be (and are) used, depending on the site. Commonly, soil-active herbicides provide the basic weed and grass control. Problem weeds that develop later are controlled on a spot-treatment basis as necessary.

PNW 219, *Managing Weeds and Vegetation in Christmas Trees*, lists a wide variety of procedures to control weed problems. The latest edition of the *PNW Weed Control Handbook* lists currently registered weed control products.

Strip spraying. Here, a strip along the tree rows is sprayed with herbicides. Then you control the unsprayed vegetation between rows by mowing or cultivation. This method minimizes the amounts of herbicides used and helps arrest soil erosion, but increases the amount of time needed to control weeds.

Living mulches. Another method of controlling weeds includes the planting of vegetation that minimizes interference with trees. Dwarf grasses, various trefoils like Kalo, and clovers have all been tried.

Here are some benefits and liabilities of the practice:

Benefits:
- improved "trafficability,"
- decreased soil loss, and
- improved soil organic-matter content.

Liabilities:
- difficult to establish,
- may encourage rodents to enter the field,
- doesn't eliminate the need for mowing, and
- may cause moisture stress on dryer sites.

Erosion

A serious—often insidious—problem for tree growers is soil loss. Since trees are often grown on hill slopes with competing vegetation removed, the soil loss can become severe. Frequently, soil loss isn't recognized until the problem has progressed to a danger point.

Prevention strategies have been, and are being, developed, but there's no perfect solution. Some growers are experimenting with living and dead mulches, mowing existing vegetation, and planting annual grass to reduce soil loss.

Others are working with soil-retaining devices like hay bales or fibre mats. Some growers simply avoid planting trees on steep, highly erodible soils.

Figure 4.—Roads are needed for harvest and for yearly activities. Consider these needs before you plant.

Figure 5.—Plant trees, whether you use machine or hand tools, in well-spaced, straight rows.

Growing true firs

Field layout

Before you plant, consider how you're going to harvest the trees. Commonly, roadways (15 feet wide or more) are laid out every 20 to 30 rows or so to allow for equipment access (figure 4). Perimeter roads are less useful than roads in the midst of your plantation because the latter allows access from two sides.

Tractors and equipment also require turning areas at the end of rows, so leave room.

Areas must also be left for parking, turning, truck loading, equipment, and tree storage.

To maximize productivity, it's best to run rows the long direction in the field to minimize the time you spend turning the equipment at the ends of the rows. If you need to operate tractors on hill slopes, rows should be as straight up and downhill as possible—operating the tractor on a steep sidehill could be dangerous!

Row spacing is always an issue of debate among growers. The tradeoff is between producing the maximum number of trees per acre while still allowing access to the trees and providing ample growing room for mature trees.

Spacings of 5.5 X 5.5 or 5 X 5 are perhaps the most common today. Wider spacing (5 X 6 or 6 X 6) is preferred with production of larger trees or where equipment operation is a consideration.

Spacing could also be determined by equipment requirements. For example, allow a minimum of about 1 foot on either side of tractor wheels. Larger equipment will require wider row spacing. For this reason, most growers prefer narrow-width tractors.

Table 4 lists the number of trees needed to occupy an acre at various common Christmas tree spacings.

Seedlings

You'll need to order seedlings (or contract-grow them) far in advance of planting. We discussed seed origins previously ("The best seed," page 3). EC 1196, *Selecting and Buying Quality Seedlings,* discusses additional information useful in purchasing, storing, and planting trees.

On well-prepared, large, flatter fields, machine planting is the most cost-effective method. The planting machine is pulled behind a tractor, and trees are planted at the desired interval (figure 5). Machine planting may work poorly on heavy, clayey soils, and some machines don't plant older, large-rooted (2:1, 1:2) seedlings well.

On smaller plantings, hand planting is preferred. A narrow, long-bladed planting shovel is the common tool of choice among Christmas tree growers.

Before planting, growers commonly will premark fields to indicate proper planting locations and row direction.

Check-row planting, where the trees form rows in two directions, is the most precise method of field layout. Here, the rows are established by scoring newly cultivated ground in two directions. Trees are planted where the score marks intersect. Check rows can also be established using marked wires stretched along parallel lines.

Some growers don't believe check row planting in perfect squares is necessary. Instead, they plant trees at desired intervals along straight, properly spaced rows.

Table 4.—Trees per acre at various planting densities

Planting density	Trees per acre (full spacing)	10% reduction for roads
2.5 X 5 (tabletop trees)	3485	3136
3 X 6 (tabletop trees)	2420	2178
4 X 4	2722	2450
4.5 x 4.5	2151	1936
5 X 5	1742	1568
5.5 X 5	1584	1426
5 X 6	1452	1306
5.5 X 5.5	1440	1296
5.5 X 6	1320	1188
6 X 6	1210	1087

Growers have designed numerous ingenious methods to achieve straight rows: jigs, stake guides, tractor-pulled markers, cable or rope markers, and others. The time you spend obtaining straight rows and good field layout is well spent—just ask growers with crooked rows about the problems they found during the 5 to 10 years until harvest.

Seedlings are available from numerous sources; State Forestry offices and most Extension offices with forestry agents will have lists of nurseries.

The planting period in spring varies by location, but February-March is a good target in western Oregon and Washington. April planting is preferred in Idaho. Fall (October) planting is somewhat more risky, but it has worked well for some growers.

Fertilization

The need for fertilizer is site-specific, and some fields won't require fertilization at all.

In general, use fertilizers only when you have controlled other problems. For example, yellowish chlorotic trees and poor growth can be caused by excessively wet soil or competing vegetation. So don't consider fertilization until you correct these other problems.

Soil tests and foliar analysis are useful in identifying some gross deficiencies in nutrients in the soil. Knowing about the past history of the parcel is also helpful in identifying potential problems, such as poor drainage or root-restricting soil layers.

Soil tests before planting are helpful; some nutrients, such as calcium, may require incorporation into the soil before you plant trees.

Except in rare cases, nitrogen will be the major fertilizer compound used to improve tree growth and color. Common fertilizers are urea, ureasul, ammonium nitrate, or ammonium sulfate.

When you use nitrogen fertilizers, avoid fertilizing first-year plantings.

Until trees reach about 3 feet high, individual tree fertilizer applications are more precise than broadcast applications—the root mass of these trees isn't yet large enough to take advantage of broadcast-applied fertilizer.

In fertilizing second-year plantations (2-foot-tall trees), use about ½ to 1 ounce per tree of actual nitrogen scattered beneath the drip line of the tree. On more established (3-foot-tall trees), apply 3 ounces of nitrogen.

Once trees are taller than 3 feet, you can use either broadcast or individual tree applications of fertilizer. With 3- to 5-foot trees, 75 pounds per acre of nitrogen is a medium rate of application. With 5- to 7-foot trees, 150 pounds per acre of nitrogen is a moderate rate. With individual tree applications, apply about 1 ounce of nitrogen per foot of tree height.

Note that these rates are based on pounds of actual nitrogen; they'll vary on a product basis with the concentration of nitrogen used. Table 5 gives some conversions between actual N and product for many common fertilizers.

Be cautious with broadcast applications if your field has been interplanted or if the trees aren't of uniform size.

Table 5.—Fertilizer conversion between actual nitrogen and selected products

Actual nitrogen	Urea (45%N)	Ureasul (33.5%N)	Ammonium sulfate (21%N)	Ammonium nitrate (34%N)
		Per tree		
1 oz	2 oz	3 oz	5 oz	3 oz
3 oz	7 oz	9 oz	14 oz	9 oz
7 oz	15 oz	21 oz	33 oz	20 oz
		Per acre		
75 lb	166 lb	224 lb	357 lb	220 lb
150 lb	333 lb	448 lb	714 lb	441 lb

In rare instances, limitations on other nutrients may cause problems. Soil and foliar samples may help sort these out. You might also consider establishing a small test plot on your farm where some trees will receive the fertilizer and others won't. You can then judge the effectiveness of a treatment before applying it over the entire field.

Soil-applied nitrogen fertilizer requires rain to move it into the rooting zone of the tree. Temperatures must also be cool. March then becomes an excellent time for fertilizer application, if needed, along the western Cascades and into Idaho.

Shaping the trees

Tree quality has increased markedly over the past 10 years. Today, trees are denser and more intensively cultured. Buyers are also becoming more discriminating in the quality of trees they purchase.

We'll outline the cultural practices common to noble and grand fir and then discuss each species individually. In describing the shearing process it is important to have a good grasp of the terms, illustrated in figure 6.

Shearing can create any of a wide variety of tree forms—skinny trees, fat ones, dense trees, or open trees. While it may sound premature, it's wise to think about selling your trees before you shear.

Talk to buyers for ideas about the demand for the trees. Set a goal for the general "type" of tree you're trying to produce: Will it be a dense 7-foot tree, an open 6-footer, or something else?

We won't discuss all the methods of culturing or shaping trees. Rather, we'll outline production with an overall objective of producing a high percentage of #1 trees in as short a time period as possible. We'll discuss these cultural activities in a chronological sequence, even though some of these activities may occur several times.

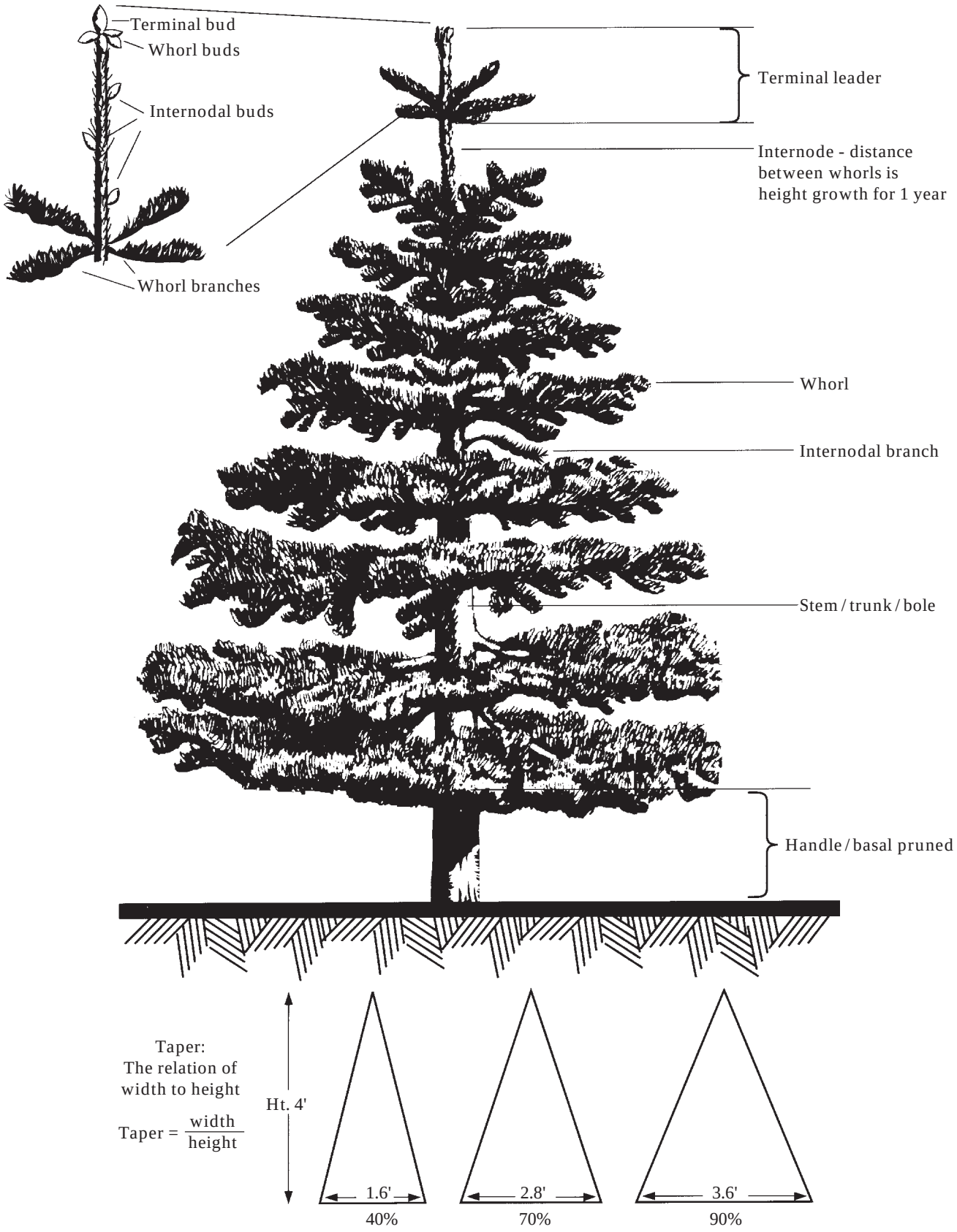

Figure 6.—Christmas tree terms.

Figure 7.—Remove multiple leaders to maintain tree conformity and leader dominance.

Cultural practices common to noble and grand fir

Correcting multiple leaders. An important objective of skillful Christmas tree culture is to maintain a single leader throughout the tree's development (figure 7).

When more than one leader forms, cut out all except the best, flush with the main stem, in the year they occur. Considerations for selecting the best leader are length, vigor, erectness, central position, and completeness of terminal bud set.

For example, if one multiple leader has five branch buds on the terminal and another has only four, save the five-budded leader to ensure a balanced, five-branched top whorl next year.

Removing multiple leaders is usually the only type of pruning required during the first 2 or 3 years after you establish a plantation. Postponing this job may cause crowding and suppression of lateral branches, and development of crooked stems, because multiple leaders tend to lean away from each other.

Suckers are similar in appearance to multiple leaders except that they rise vertically from an upturned lateral branch or sprout below the top whorl. (We might quote P.T. Barnum's advice: "Never give a sucker an even break!")

Completely removing a sucker is almost always the preferred solution. Removing only the top portion seldom stops its abnormally vigorous and haphazard growth characteristics, which detract from the appearance of a tree.

There's one exception: If removing the branch will create an unsightly hole, retain a single outpointing branch.

Basal pruning is removing branches between the bottom whorl of the Christmas tree and the ground. The pruned stem or "handle" provides a straight, branchless area of at least 1.25 inches per foot of tree height. Most buyers require this amount of clear stem so consumers can insert the trees into their water stands.

When's the best time to start basal pruning? One good rule of thumb is to wait until a leader develops at least 12 inches in length above two good whorls. This stage of development frequently occurs after three or four growing seasons in the plantation.

If you do this when the tree is too small, basal pruning may overshock the tree and appreciably stunt the leader growth for another year or two. When you postpone it too long, excessively long leaders may result, as well as increased costs—because of difficulty in cutting the heavy bottom branches.

You can basal prune at any time of year, but be extra careful to avoid breaking tender shoots during the early stages of growth (April-June). Some growers basal prune in October-November to take advantage of bough markets.

Prune the stem high enough to avoid serious defects, such as incomplete bottom whorls and crooked stems. Most growers try to keep about 10 inches between the bottom whorl and the ground. This allows enough leeway in handle length to help prevent cutting into the ground and dulling the chain saw when you fell the trees.

Cut the branches flush with the stem to avoid both stubs and heavy scars. Avoid cutting into the main stem—this may attract boring insects. Hand pruners, or short saws are used for basal pruning.

The selected bottom whorl should contain five or more uniform, well-distributed branches (figures 8a and 8b). Sometimes, however, the only available prospects for forming a bottom whorl contain only three of four branches.

In such cases, the deficient whorl may be "backed up" by several strong internodal branches just below or above the main whorl to complete the whorl pattern and help fill in the gaps.

Basal pruning provides several benefits besides forming a handle. It defines the usable portion of the crown and exposes the bottom whorl to sunlight. It promotes mowing, cultivating, spraying, fertilizing, and harvesting; and it slows leader growth.

Noble fir culture

Each of the true fir species has unique growth features. Here we'll outline activities necessary to produce top quality noble fir.

Replacing lost leaders. Abortion of the center bud on the tip of the leader is a frequent and very troublesome problem on noble fir.

During the succulent growth stage (May-July), existing leaders may also be broken off by birds, animals, or equipment. Whenever a leader is broken off near its base or fails to develop, serious deformity problems result unless you take prompt remedial action.

There are several solutions, depending on tree age and other situations.

Figure 8a.—The year to begin basal pruning occurs when leader length exceeds 12 inches and when two complete whorls remain above the basal-pruned portion.

Figure 8b.—Cut pruned branches flush with the main stem. Be careful to avoid cutting into the stem.

Nonharvest year. There are two methods used in replacing lost leaders on younger trees: bud forcing and tying a branch.

Determining which method to use involves tradeoffs. Bud forcing develops the most natural top, but it's the slowest method of reforming a top—and sometimes new tops don't develop. Tying up a nodal or internodal branch often produces an asymmetrical top.

No solution is perfect, but timely remedial action can mark the difference between a salable tree and a cull.

Bud forcing usually preserves the shape of the tree quite well, but it may slow development. It works well if small buds or sprouts are beginning to show where the top leader bud aborted or broke off. To force a new leader, cut back each branch on the top whorl about 50% of its length (figures 9a and 9b).

In cutting, make sure at least one or two buds remain on each branch stub to keep it alive and balanced. This cutting will stimulate the growth of the leader buds (often multiple leaders will sprout). Retain the best leader; cut out all others at the base.

Tying up a branch is a second, and often less preferred, method of reforming a top. If one branch has moved into a more vertical position, you can select it as the new top and secure it with a splint to force the branch into the new upright position.

When none of the branches in the top whorl seem to "want" to form a new leader, you can force a branch into the leader position. One method is to select two branches that are directly opposite each other (figure 10).

Draw them together into the vertical position. Bind them tightly together near their bases and near their tops with a couple of wraps of plastic flagging. After several months, when they've set in a vertical position, remove the flagging, select the best leader, and remove the other.

Figure 9a.—Forcing a new central leader bud requires cutting back top whorl branches about 50%.

Figure 9b.—Each cut branch should retain a minimum of one or two buds. The new forming leader may take time to develop.

Figure 10.—If plentiful top whorl branches exist, you can tie opposing branches together (this saves the use of a splint). When branches can remain vertical without the tie, retain the best leader.

The leader formed by an upturned branch tends to produce a two-sided, branchlike whorl the following year. One way to minimize this appearance is to cut the upturned branch at a lone bud above a bud cluster.

In cases when bud forcing and whorl branches fail, you can form a top by removing the entire top whorl above a strong internodal branch. It's best to do this as early as possible after you know you have a problem. You can either leave a stub on which to tie up the branch or use a splint.

Be sure to tie the branch at the base and top. Remove the flagging after several months when the new leader has "set" in position.

Harvest year. This year, most buyers will demand a single erect leader cut to a proper length. There's no time to force a new leader from a latent bud as you would with younger trees. In addition, it's not important that the new leader have good bud set since the tree is being harvested.

Therefore, in the harvest year, a branch from the top whorl can be turned up and forced to replace a missing leader.

Select the whorl branch that would cause the least disruption to the conformation of the tree. This will become the new top. Next, turn up and secure the branch. It's important to use a firm splint to force the new leader into place (figure 11).

Secure the new leader at three places along the splint: bottom, at the middle, and at the top. Unless you do this, the branch will continue to behave like a branch.

Occasionally, you may need to move up this top branch in two steps to avoid breaking it. The splint should remain in place for about 2 months.

Figure 11.—Using a splint is the most common method of "encouraging" a top to remain upright. Rigid wires are also used.

Figure 12a.—When you measure leader length, be careful to begin your measurement from the top whorl, as shown here.

Leader pruning is necessary to increase the density of the tree and to help tree conformity. It consists of cutting back excessively long leaders and removing unwanted multiple leaders. A 16-inch shearing knife provides an easy measuring stick in the field (figures 12a and 12b).

Growers have various opinions about the length to cut leaders—partly because of differences in the type of final *product* they want. For example, growers looking for a more open tree might be content to leave leaders in the 16- to 18-inch range when the trees are small.

Growers looking for a very dense tree may never allow a leader longer than 12 inches.

What's the take-home message? It's important to develop *your* technique for *your* site and market. Experiment with a few trees and record progress as you try different shearing techniques—this way, you can learn during this first rotation.

Time of year. Trials have shown that the ideal time for trimming leaders is in the early succulent period when the new growth is complete and you can clearly see the buds on the leaders. This is often mid-July through early August.

The reason for cutting during this time appears to be that you achieve a higher percentage of erect leader growth next year. The longer you delay pruning, the more leaders you'll have to tie up in the following growing season—and the more branchlike they'll appear.

It's still important to perform the leader pruning if you miss this succulent season, but expect to tie up more of these leaders.

How to cut leaders. First, you need to identify the types of buds that you might find on a leader. There are two, the bubble bud (figure 13) and the standing bud (figure 14).

The bubble bud is smaller and usually doesn't have needles surrounding it as the standing or petioled bud does. This distinction is important: Bubble buds tend to form more upright and complete terminal buds the next year than standing buds do.

Let's first look at the ideal way to cut a noble fir top; then we'll consider options that might be less perfect.

Figure 12b.—Frequently, the lower leader is selected as the retained leader. This helps control excessively long leaders and removes an unsightly leader stub.

Figure 13.—Small bubble buds, though hard to find, tend to form near vertical tops.

Figure 14.—Frequently, standing buds are the only type you'll find on a leader.

The ideal situation for leader pruning is to locate a uniformly spaced internodal bud cluster (these buds, remember, will be next year's "false whorl" branches) just below a single bubble bud at 12 to 16 inches above last year's top. Figures 15a and 15b illustrate this situation.

Naturally, this "textbook" solution won't always be available, so you'll often need to find the next best solution. It's important to keep in your mind's eye what it is you're trying to do in top cutting. Essentially, you're attempting to force the tree into producing as natural a top as possible.

This natural top is one with a single erect leader surrounded below by a symmetrical whorl of four to six branches. In leader pruning, you're also trying to increase tree density by slowing the tree's upward growth.

Leader scarring is a method used by a few growers to reduce height growth of the terminal bud. Use a sharp knife to remove the bark and cambium on two sides of base of the terminal leader (figure 16). A narrow strip remains uncut on opposite sides of the leader. Make the cut before flushing of the buds, in March or April.

Growers who don't like this practice claim that on many trees the growth doesn't appear to be reduced. Some also believe the leader scar produces a weak area in the tree that may break at harvest or hauling time.

Growers who promote the practice argue that anything that can help them avoid cutting a top is worth the effort.

Figure 15a.—The finger points out a cluster of standing buds that potentially will form a simulated or false whorl once the leader is shortened.

Figure 15b.—This bubble bud just below the clippers will become next year's top once the leader is cut. The standing buds 1 to 2 inches below this bud will become next year's top whorl.

The correct cut-leader length is often site- and tree-specific. The proper length will depend on your answers to these questions:

- How important is increased density to buyers?
- What's the bud arrangement on the leader?
- How "full" is the existing tree?
- What's the tree height?

Table 6 outlines some generalized leader-cutting regimes.

Side shearing consists of cutting back the tips of lateral branches to correct overwide trees and increase density. Although some consumers still prefer the completely natural look of the unsheared tree, increasing numbers want the denser sheared tree.

In response to this changing market demand, most growers now shear all true firs. Several types of shearing tools are used, including hand pruners, shearing knives, hedge shears, and electric and gasoline motor-operated power shearing machines. Hand picking of buds is also common.

Choice of tool depends upon your preference or your buyer's request; currently, knives are the most commonly used shearing tool.

Leader pruning should precede side shearing to establish the top of the cone and provide a guide for shearing the lower portion of the tree. Some growers prune the tops of their trees as a separate operation before starting to shear the sides. Others combine both jobs as part of the same operation. In either case, the techniques are the same.

Figure 16.—Leader scarring seeks to reduce excessive top growth. Results are often unpredictable, however.

Figure 17.—Leader and top whorl buds all show regrowth and have become lamas. Where growth is uniform, as is it here, little (if any) correction is warranted.

Shearing technique and timing. As trees reach about 3 feet in height, strive for 50 to 55% taper. Shear off the overly wide branches. Maintain this taper (or gradually increase it) until harvest year. In harvest years, taper should run 60 to 70%.

There are a number of techniques growers use to shear noble. Here are some advantages and disadvantages of each:

1. Hand shearing/bud picking. When growth is succulent (late June/early July), new growth is broken off by hand or with a small carving knife to achieve desired taper.
   - *Advantage:* It produces the most natural look without the shearing lines produced by knife cutting.
   - *Disadvantages:* It's time-consuming, and the succulent season when it works best is quite short, 2 to 3 weeks. Because of the time involved, some growers will use this technique only in harvest years.
2. Hand pruners. After new growth has elongated (July), prune with hand clippers to desired taper.
   - *Advantages:* A more natural tree and a longer shearing window.
   - *Disadvantage*: As with bud picking, it's time-consuming, and worker may be too close to tree to visualize overall cone shape.
3. Knife shearing. The knife is the most common shearing tool and is used after the new growth has elongated. The side shearing is best done before the new growth becomes "woody" and hard to shear in the fall.
   - *Advantages:* The knife-sheared tree can appear uniformly cut like a Douglas-fir or more random, where individual branches that project outside the desired taper are cut off (this more random look is generally preferred).
   - *Disadvantage:* Some buyers dislike the cut lines on needles produced by the knife.

Lamas growth is a late summer regrowth that occurs in most years. In essence, the buds rebreak and grow a somewhat shortened version of next year's growth (figure 17). It's sometimes accentuated on lower-elevation plantings.

The problem is that lamas growth might produce a nonsymmetrical tree if allowed to grow unchecked. It's most common on the top buds. Solutions depend on the circumstances.

In the case when all buds break and form lamas growth, little needs to be done, assuming they're symmetrical.

Frequently, only a few of the buds will break while others will remain unbroken. In this case, try to maintain the symmetry of the tree and prevent competing

Figure 18a.—Out of five top whorl buds, three have become lamas. Without correction, this situation could produce multiple tops and unsymmetrical sides.

Figure 18b.—To correct lamas growth, cut the regrowth back, retaining one bud on each lamas branch.

tops. To do this, you must cut back the lamas branches so that only one outpointing bud, or two opposed buds, remain on the branch.

In figure 18a, three out of five branch buds have become lamas branches. The solution will be to cut the lamas branches back so only one or two buds remain (figure 18b). It's best to do this in late fall after the lamas growth has stopped.

The harvest year. This year, shearing and leader pruning can and should be conducted differently. For example, in leader pruning, only straightness and length are important. So if the existing leader is straight but too long, cut the leader to provide proportion for the desired taper.

Here's a rough rule of thumb: Cut the top at or slightly above the apex of the cone formed by the crown of the tree.

It's best to ask your buyers—before you cut—what leader length they might prefer.

Forming a replacement top can also be handled differently in the harvest year (see "Replacing lost leaders, Harvest year," page 13).

Shearing or bud picking is also best done early (July-August) to allow branch ends time to heal and darken.

Summary. Table 6 summarizes some of the major cultural activities as they occur yearly. These guides will cover average situations. Some fields may develop at different rates, just as individual trees will differ in development. A videotape is also available to help you see these operations on a tree (see "For further reading," inside back cover).

Grand fir culture

Grand fir develops quite differently from noble. Most of the differences are a result of the fact that grand fir tends to have more internodal buds than noble, and grand isn't as apt to develop lamas branches west of the Cascades. In Idaho, lamas growth is more common.

Likewise, the shearing techniques developed for grand fir are intermediate between those used on Douglas-fir and those used on noble.

Let's focus now on some of the practices that are different for grand fir.

Table 6.—Noble fir cultural events (a 9-year summary)[a]

Yr	Major activity	Weed and grass control	Pest monitor and control	Side shearing	Tree ht after culture	Taper	Leader pruning	Average cut leader length[b]
1	Order seedlings Prepare site for planting Correct drainage problems Soil test for nutrients	√						
2	Lay out field for planting Plant trees	√	√		10″			
3	Replant where trees died	√	√		1′6″			
4	Side shear excessively wide trees	√	√	√	2′5″	50%		
5	Basal prune Top cutting	√	√	√	3′7″	50%	√	14″
6	Top straightening/cutting and shearing	√	√	√	4′9″	55%	√	14″
7	Top straightening/cutting and shearing	√	√	√	5′9″	55%	√	12″
8	Fertilize to improve color Minor harvest Top straightening/cutting and shearing	√	√	√	6′7″	60%	√	10″
9	Fertilize to improve color Major harvest Top straightening/shearing	√	√	√	7′6″	65%	√	Cut to proportion

[a]List is not all-inclusive, nor will all trees develop at the same rate. A √ indicates a practice beginning in that year.

[b]Leader length will depend on the individual tree bud characteristics and the density desired by buyers. The proposed schedule should produce a medium-density noble fir.

Leader pruning. Grand fir is usually endowed with a plentiful supply of buds on the leader. Leader cutting then is more like Douglas-fir than noble fir. Typical leader lengths are 12 to 16 inches, depending on your tree's density and tree height.

Growers begin leader pruning as trees exceed 4 to 5 feet. Once a tree exceeds this height, cut the leader to around 14 inches. Consider this a *maximum* length. If the tree is sparse of buds and branches, a shorter leader is preferred. In successive years, trim the leader to 11-14 inches.

As with noble fir, make the top cut so that a specific bud is isolated to become a new top. With grand fir, it usually isn't necessary to pick a bud cluster to form a top whorl; ample buds are usually present.

There are additional techniques to help improve tree quality. One is to reduce the leader length to 7-10 inches in the year before harvest. This reduces the amount of open area near the top of the tree.

In the harvest year, cut the leader to a length conforming with the general taper of the tree.

Side shearing. Grand fir can look like Douglas-fir or noble depending on how it's cultured. The important difference will be determined by how much branch "definition" is allowed and how long the leader remains.

Typically, growers try for some sort of intermediate appearance—with a density between those of noble and Douglas-fir (figure 19).

Time of year. West of the Cascades, grand fir can be (and often is) sheared ahead of noble and Douglas-fir. Shearing can begin when the new growth is fully elongated in the first part of July. Shearing is also quite easy when the branches aren't woody.

In eastern Washington and in Idaho, shearing typically begins in late July and the first part of August.

Late summer or dormant shearing is also quite acceptable with grand fir, but the job is slightly more difficult after the new wood begins to harden.

How to shear. Most grand fir are side-sheared, using shearing knives or machines to develop a uniformly tapering cone. Bud picking is seldom warranted.

Side shearing with grands often begins in the third year, and it may precede leader pruning by a year or two.

Many growers begin side shearing after the trees are well established and as tree width exceeds a 50% taper. Once you begin side shearing, continue it every year.

Maintain a taper of around 50% until a year or two before harvest. At that point, you can allow the tree to fill out toward the final 60 to 70% taper that most consumers prefer.

Figure 19.—Grand fir is often cultured to produce a density somewhere between Douglas-fir and noble. Leader length control and side shearing will largely determine how dense the final product will become.

Conclusion

There's much more to growing true firs than planting the trees and coming back in 8 to 10 years to collect your profits.

- Successful growers are selective about site and planting stock.
- Successful growers have also developed skills to help trees attain a desirable shape and density.
- Successful growers accomplish yearly tasks (weed control, pest monitoring, and other chores) in a timely and professional manner.

Christmas tree growing is becoming increasingly competitive. Poor quality trees that were acceptable years ago are now difficult to sell at any price.

New growers not only must be capable of producing quality trees—they must also be proficient business managers.

For further reading

OSU publications and videotape

These publications and videotape are available from:

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Antonelli, A.L., *Recognition and Management of Christmas Tree Pests,* Western Washington Research and Extension Center publication WAEB 735 (1986). 75¢

Landgren, Chal G., *Calibrating and Using a Backpack Sprayer,* Pacific Northwest Extension publication PNW 320 (Oregon State University, Corvallis, 1987). $1.00

Landgren, Chal G., *Shearing and Culturing Christmas Trees,* Oregon State University Extension Service videotape VTP 005, 65 minutes, VHS (Corvallis, 1991). $30.00 plus $3.00 shipping and handling.

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

PNW Weed Control, Insect Control, and Plant Disease Control Handbooks. Revised annually, each handbook lists currently registered treatment options to control pests on Christmas trees. $15.00 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., *Christmas Trees in the Small Woodland,* Oregon State University Extension Service Circular 1099 (Corvallis, revised 1985). 50¢

Proebsting, William M., and Chal G. Landgren, *Developing Sheared Douglas-fir Christmas Trees,* Pacific Northwest Extension publication PNW 227 (Oregon State University, Corvallis, revised; in press 1992).

William, Ray D., and Ken N. Brown, *Managing Weeds and Vegetation in Christmas Trees,* Pacific Northwest Extension publication PNW 219 (Oregon State University, Corvallis, revised 1987). 50¢

Other publications

Carkner, Richard, *Christmas Tree Establishment, Production Costs, Returns in Western Washington,* Washington State University Cooperative Extension publication EB 1151. 50¢

Christmas Tree Lookout, published 4 times a year by the Northwest Christmas Tree Assn., PO Box 3366, Salem, OR 97302. An excellent source reporting on research results, management ideas, and affairs of a growers' association.

Computer program

Financial Analysis Spreadsheet, available to accompany Lotus 123, Quattro, or SuperCalc3. Useful in evaluating expected returns from Christmas tree operations. Available for $10.00 from Columbia County Office, OSU Extension Service, Courthouse, St. Helens, OR 97051.

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