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Managing Western Hemlock Forests in the Oregon Coast Range

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Contents

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Western hemlock forests in the coastal areas of Oregon are some of the most productive and diverse forests in the world. This rich diversity represents both a challenge and an opportunity for woodland owners interested in managing western hemlock on their property.

This publication deals with the management of western hemlock in the coastal forests of Oregon. It also provides background on the ecology, growth, and development of western hemlock stands, as well as management options for situations typically encountered by coastal woodland owners. Although the publication discusses management options primarily for western hemlock, management of other coastal species (such as Sitka spruce and Douglas-fir) in mixed stands with western hemlock also is mentioned.

There are several reasons for growing and managing western hemlock:

- Although western hemlock historically has been less valuable than Douglas-fir, the value of hemlock logs has increased in recent years. It now is a financially worthwhile species to grow and manage.
- Western hemlock forests are very productive. The species grows well at high densities and can grow more wood volume per acre in the coastal fog belt than pure stands of Douglas-fir.
- Western hemlock is regenerated easily by either natural seeding or hand planting.
- Western hemlock is immune to Swiss needle cast, which affects Douglas-fir, and is not affected by the Sitka spruce weevil. Adding western hemlock back into coastal stands after harvest, and maintaining and managing existing stands that contain a mixture of western hemlock, Sitka spruce, western redcedar, and Douglas-fir, increases within-stand diversity. Therefore, it's possible that the impact of Swiss needle cast and Sitka spruce weevil may be reduced in the long run.

Although western hemlock traditionally has been managed using even-age silvicultural systems such as clearcutting, its ability to tolerate shade makes it an ideal species for uneven-age management on some sites. This system requires periodic thinning and regeneration, and creates an uneven-aged forest that provides periodic income and has a highly aesthetic continuous forest canopy. Therefore, the opportunity to manage western hemlock in this fashion may appeal to many woodland owners.

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***Table 1.*—Various species' tolerance of brush competition, shade, flooding, and browsing and clipping.**

Species	Relative tolerance of brush competition	Relative tolerance of shade	Relative tolerance of flooding	Relative tolerance of browsing and clipping
Grand fir	4	3	2	2
Western hemlock	2	1	3	5
Western redcedar	2	2	1	4
Sitka spruce	1	2	1	1
Douglas-fir	5	4	5	4

1 = More tolerant 5 = Less tolerant

Coastal climate and ecological setting

Western hemlock *(Tsuga heterophylla* (Raf.) Sarg.) thrives in the wet, mild climate of the Pacific slopes of the Coast Range and also is found at the moist, medium elevations of the Cascades. The focus of this publication is on management options for hemlock forests on the coastal side of the Oregon Coast Range.

Annual rainfall in the western Coast Range ranges from 60 to 200 inches. The coastal climate has relatively mild winter temperatures and cool summers with no pronounced summer drought. Ample water, a long growing season, and rich soils are the primary factors that make western hemlock forests some of the most productive in the world.

Western hemlock grows in nearly pure stands near the coast in northwest Oregon. More commonly, it is found in mixed stands with Douglas-fir, Sitka spruce, western redcedar, grand fir, or red alder.

Along the Oregon coast, there is a 5- to 30-mile-wide fog belt (widening to the north) where Douglas-fir and western hemlock both grow well. Within this zone, western hemlock does best toward the west. To the east and beyond the fog belt, where it tends to be drier, Douglas-fir grows better. However, both species do well in mixtures where crowding is not severe and soil drainage is adequate.

Western hemlock and most associated tree species, other than Douglas-fir, are very shade-tolerant (Table 1). Western hemlock is slightly more tolerant of shade than Sitka spruce and western redcedar. Douglas-fir and grand fir are the least shade-tolerant conifers in the coastal fog belt.

When developing a management strategy for western hemlock, landowners can capitalize on western hemlock's ability to grow and reproduce in shade and to respond to release (thinning) after long periods of suppression and competition. Like most tree species, however, western hemlock grows much better in full sunlight than in partial or full shade. Even though western hemlock is shade-tolerant, it does not grow well in riparian zones or other bushy places without some weeding or vegetation control.

Table 1 also shows how western hemlock and other coastal tree species tolerate flooding, brush competition, and browsing and clipping by wildlife. Knowledge of these traits can be useful in managing your coastal woodland.

Young stand growth and development

After a major disturbance, western hemlock readily seeds into openings, thus creating dense young stands with several thousand trees per acre. Pure stands of western hemlock and mixtures with Sitka spruce and Douglas-fir are common. These stands originated from past fires and timber harvesting.

Young stands with 10,000–20,000 trees per acre are not uncommon. Left on their own with no density control, most trees in these stands become suppressed. As they slowly grow and mature, many trees die from intense competition. The end result is smaller tree size, reduced merchantable wood volume per acre (measured in board feet), and trees of low value. Controlling density in young stands can improve tree size and value greatly.

Total wood volume production of hemlock or mixed hemlock-spruce stands can be 10–15 percent greater than Douglas-fir on sites of comparable productivity for a given age. This is because western hemlock stands can support more stems per acre due to its greater shade tolerance. Western hemlock's ability to produce more volume may, in many cases, offset the fact that hemlock and spruce historically have had lower log values.

In dense western hemlock forests, little understory vegetation develops because of low light levels. The lack of a significant understory can represent an advantage when harvesting and regenerating coastal sites using the clearcut harvest system. A new stand can be reforested and established before competing vegetation becomes a problem.

However, be aware that most shrubs and other hardwood species have a tremendous ability to invade openings created by timber harvesting. In particular, invading red alder is a widespread problem because it quickly establishes and overtops conifer seedlings.

Where light is allowed to penetrate western hemlock forests, ferns and shrubs become abundant. They may include salmonberry *(Rubus spectabilis)*, red huckleberry *(Vaccinium parvifolium)*, salal *(Galtheria shallon)*, rhododendron *(Rhododendron macrophyllum)*, vine maple *(Acer circinatum)*, sword fern *(Polystichum munitum)*, and many herbaceous species. These species often create problems when reforesting harvested sites because they compete intensely with newly established tree seedlings.

Insect and disease concerns

Few insects attack and kill western hemlock. Occasionally, the western hemlock looper can severely defoliate western hemlock trees and stands. The first observed outbreak occurred in 1889. Although the hemlock looper is most damaging to old-growth stands, even vigorous 80- to 100-year-old stands can be defoliated severely.

Figure 1.—Feeding by the Sitka spruce weevil larvae kills the terminal leader, causing it to look like a shepherd's crook. Western hemlock is not affected by the Sitka spruce weevil.

Perhaps the most destructive insect in coastal hemlock-spruce forests is the Sitka spruce weevil. The weevil larvae feed on the terminal leader and upper lateral branches of young Sitka spruce seedlings and saplings up to 25–30 feet tall. The feeding activity kills the terminal leader, which then looks like a shepherd's crook (Figure 1). The loss of the tree's leader creates a deformity in the main stem, and as a result the tree is overtopped by surrounding trees.

The Sitka spruce weevil has hit many Sitka spruce plantations, with up to 40 percent of the spruce being infested. Originally, Sitka spruce stands just outside the fog belt were hardest hit, but now even Sitka spruce trees within the coastal fog belt are experiencing heavy damage.

There are no direct control measures for the Sitka spruce weevil in forestry situations. Recent research has indicated that managing Sitka spruce stands under the shade of deciduous trees such as red alder reduces weevil damage. Since Sitka spruce is tolerant of shade, it eventually grows through the red alder overstory. However, maintaining a mixed stand of western hemlock, Douglas-fir, western redcedar, and some Sitka spruce increases within-stand diversity and may offer the best opportunity to limit damage by the Sitka spruce weevil in the long run.

Swiss needle cast is an important foliar disease of Douglas-fir in the coastal fog belt of Oregon. Swiss needle cast affects older Douglas-fir needles and causes premature needle drop. Needle drop can be so severe that tree growth and vigor are severely affected. Pure Douglas-fir plantations and even plantations with a mix of species have been heavily affected along the northwest Oregon coast. Plantations along the central and southern Oregon coast also have been affected.

At this time, there are no known direct control measures for Swiss needle cast. Reforesting clearcut areas with a mixture of western hemlock, Sitka spruce, western redcedar, and Douglas-fir, and maintaining and promoting older mixed-species stands, increases within-stand and landscape diversity. These strategies may offer the best long-term solution for limiting the extent of this disease. Moreover, having a mixture of several species provides a "backup" in case one species becomes affected by an insect or disease. The likelihood of the other species being affected is much less; thus you have more management options.

One major pest of western hemlock is dwarf mistletoe. Millions of board feet of lumber are lost each year due to mistletoe infections. Dwarf mistletoe is a small parasitic plant that often infects hemlock and other conifers. It causes distorted branches, lowers wood quality, and slows growth. It reproduces by seeds that use an explosive projection mechanism to spread. The fruits build up water pressure and burst, shooting out the sticky seeds to fall on the regeneration below or on adjacent trees.

It is a good idea to inspect your western hemlock stand for mistletoe, both in overstory trees and in understory regeneration. If mistletoe is present in overstory trees, remove those trees in a thinning operation. This will help sanitize the stand and reduce future infections. If the mistletoe has spread to advanced regeneration below, remove infected saplings in a precommercial thinning. For more information, see *Forest Disease Ecology and Management in Oregon*, Manual 9; and *Diseases of Pacific Coast Conifers*, USDA Handbook 521.

A number of root diseases, commonly referred to as root rots, infect western hemlock, Sitka spruce, and Douglas-fir. These diseases include Armillaria and Annosus root diseases, and laminated root rot caused by *Phellinus weirii*. Infection of healthy trees by Armillaria and *Phellinus* occurs primarily through root grafting—contact of healthy roots with infected ones.

Annosus root disease is spread by air currents, which distribute spores to new infection sites such as freshly cut stumps and logging wounds. Once a tree is infected with Annosus, the disease can spread to healthy neighboring trees via direct root contact. Western hemlock is particularly susceptible to annosus root disease, and this disease is an important consideration when thinning and managing western hemlock stands.

Management strategies

Managing your hemlock forest depends, in large part, on current stand conditions and your management objectives. For example, has your site been harvested recently? Was it harvested several years ago with no reforestation? Is the area brushy? These common situations directly affect your management options and how much money and effort you'll expend to meet your objectives. Other factors that affect the management strategy you choose include market value of western hemlock and associated species, reforestation costs, timber harvesting costs, terrain, and access.

Three situations commonly encountered by landowners on the Oregon coast are presented in this section. They include:

- Reforestation strategies following harvest
- Thinning young, dense stands of western hemlock or mixed stands of western hemlock, Douglas-fir, and Sitka spruce
- Managing advanced regeneration in multi-aged stands

Reforestation options

If your site was logged recently, you'll need to reforest the site. In fact, you're required to do so by Oregon's Forest Practices Act. Reforestation can occur by allowing natural seeding or by hand planting nursery-grown seedlings.

Forest Practice regulations require prompt establishment of a minimum number of seedlings with assurance that the seedlings are "free-to-grow" above competing vegetation. Talk to your Oregon Department of Forestry (ODF) forest practices forester about the number of seedlings and time for establishment required for your harvest area.

Because competing vegetation can take over coastal sites quickly, you should reforest as soon as possible. Delays in getting seedlings established will require greater effort and expense to control vegetation that competes with hemlock seedlings. In addition, it makes good business sense to reforest promptly so no time is lost in establishing the next forest.

The following are some reforestation options you may want to consider, depending on your situation, along with general recommendations for controlling competing vegetation.

Natural regeneration

Both western hemlock and Sitka spruce are prolific seed producers. Although some seed is produced every year, heavy cone crops occur every 3 to 4 years. The seed is very small, averaging 210,000 seeds per pound for Sitka spruce and 300,000 seeds per pound for western hemlock. Strong fall winds can carry seeds thousands of feet from western hemlock stands into adjacent openings.

The size, shape, and proximity of the harvest area can be designed to take advantage of adjacent seed sources. Often, clearcut areas reseed readily and abundantly with western hemlock and Sitka spruce, with a much smaller proportion of Douglas-fir. However, natural regeneration of western hemlock, Sitka spruce, and western redcedar can be nearly impossible to obtain in areas where surrounding stands have been converted to Douglas-fir, since there no longer is a nearby seed source. Natural regeneration of Sitka spruce generally is favored by burning after harvest to expose mineral soil for seed germination.

In contrast, natural regeneration of Douglas-fir often is poor in coastal areas. Douglas-fir produces heavy seed crops infrequently, and its heavier seed does not carry far. Even when Douglas-fir is able to regenerate from windblown seed, it often is overtopped by western hemlock and Sitka spruce.

It is important to remember that all three tree species are sensitive to competition from other vegetation. None of them survives well if seeds fall into heavily vegetated clearings. See "Controlling competing vegetation" below.

Artificial regeneration

Because coastal sites quickly become brushy after logging, and natural seeding can be less predictable, hand planting of seedlings often is the best option to assure prompt reforestation. This is particularly important for Douglas-fir. Planting clearcuts and openings with at least 400 seedlings per acre assures prompt reforestation and early capture of the site by trees. This provides the seedlings a head start over competing vegetation. Be aware that additional seedlings may establish from windblown seed between the planted seedlings.

Because Sitka spruce and western hemlock can seed in and establish quickly on many coastal sites, natural Douglas-fir may be excluded. Therefore, in order to ensure the presence of some Douglas-fir in your stand, you may need to hand plant this species.

However, before ordering seedlings, you should conduct a reforestation survey of your clearcut or harvest area. There may be adequate numbers of natural hemlock, spruce, and cedar seedlings already growing on portions of the site.

When planting coastal sites, a good guideline is to use the largest and most

References to other publications

When you're referred to another OSU Extension Service publication, you'll find additional information in "For further reading," page 13.

vigorous seedlings available. Use 1-1 or plug-1 seedlings that are at least 18 inches tall with 0.5 cm caliper and a good root system. See *Selecting and Buying Quality Seedlings,* EC 1196, for more information.

Large seedlings offer several advantages. They resist bending by soil movement and falling debris; they can withstand damage from rodents, rabbits, and big game; and they are more resistant to heat.

To minimize stress during planting, keep seedlings cool and moist. For detailed information on handling seedlings and minimizing planting stress, see *Seedling Care and Handling*, EC 1095.

Also, be sure your seedlings are genetically matched to your site or seed zone. Seedlings you purchase from a nursery should be grown from seed collected from the zone and elevation band that encompass your property. Tree seedlings grown from seed outside your seed zone may grow more slowly or develop insect and disease problems later in life.

Seedlings established from seed and growing wild are called "wildings." Western hemlock wildings can be used to reforest small areas of your woodland. Planting large wildings into areas where brush competition is expected to be severe can provide a height advantage over typical nursery seedlings in these competitive situations.

To transplant wildings, select seedlings 15 to 30 inches tall with a well-developed, fibrous root system. The best time to dig and transplant wildings is January and February. Remember, the larger the wilding you transplant, the more root mass you need to include to ensure a proper balance between the top and roots.

Use herbicides safely!

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

Controlling competing vegetation

Controlling competing vegetation often is an integral part of the regeneration process in coastal areas. Vegetation control before or after planting using fire, herbicides, or manual methods is almost certain to be needed on most coastal sites.

Controlled fire can be used after harvest to consume slash and create mineral soil for natural regeneration, or to prepare the site for hand planting. See *Site Preparation: An Introduction for the Woodland Owner,* EC 1188, for more information. Herbicides also are used to control vegetation—either immediately after harvest to prepare the site, or after planting to release seedlings from invading weeds.

Releasing western hemlock from competing vegetation with herbicides is a challenge because hemlock can be more sensitive to some herbicides than Douglas-fir. However, herbicides can be used effectively and safely if applied with care. Consult your Extension forestry agent of the OSU Extension Service for current herbicide recommendations.

Wildlife damage to seedlings

Wildlife can damage or kill newly planted seedlings. For example, deer and elk browse on the terminal leader of seedlings, retarding growth. Although browsing rarely kills seedlings outright, competing vegetation quickly can overtop the damaged seedlings.

The mountain beaver, a rodent, is a serious pest in conifer plantations in the Oregon Coast Range. Mountain beavers clip seedlings at ground level and pull them into their burrows to eat later. In some areas, clipping by mountain beaver can be so severe that entire areas are left without young trees and must be replanted.

If deer, elk, or mountain beaver are present on your property, you may need to protect young seedlings. Rigid vexar tubing can protect young seedlings from deer and elk browsing, and can reduce the amount of clipping by mountain beaver. However, mountain beaver can climb up the vexar tubing and clip seedlings as they grow out of the tube. Thus, trapping mountain beaver may be required where their populations are high. For additional information, see

Controlling Mountain Beaver Damage in Forest Plantations, EC 1144, and *Understanding and Controlling Deer Damage in Young Plantations,* EC 1201.

Management options for young hemlock stands

Young, dense stands of western hemlock can benefit greatly from thinning. How you thin and how often you thin depend on existing stand conditions and your objectives. Thinning allows you to manage and mold the stand to meet these long-term objectives. Thinning also shortens the time to achieve large-diameter trees that bring a higher price at the mill. For more information, see *Thinning: An Important Timber Management Tool,* PNW 184.

Precommercial thinning

Typically, precommercial thinning is required in young stands that are overdense. Areas planted with too many trees, and areas where too many trees have naturally established from seed, are prime candidates for precommercial thinning (Figure 2). See *Using Precommercial Thinning to Enhance Woodland Productivity,* EC 1189, for more information.

Precommercial thinning involves removing trees in young, dense stands that are 10–15 years old. The young trees are cut, and the slash is left to decay on the forest floor. Because of their small size, these trees have no economic value, hence the term “precommercial.” Thinning these young, dense stands to about 300–400 trees per acre is about right (10–12 feet between leave trees) (Figure 3). This allows the stand to grow to an average stand diameter of 8–10 inches, when a commercial thinning may be conducted (Table 2).

Unpublished results from more than 30 years of research on Oregon’s north coast have shown that western hemlock stands precommercially thinned to 300 trees per acre can produce 40,000 board feet

Figure 2.—This overdense young stand would benefit from thinning.

Figure 3.—Precommercially thinned and pruned young stand of western hemlock and Douglas-fir.

Table 2.—Suggested density and tree spacing for fully stocked western hemlock stands on the Oregon Coast.

Average tree diameter in inches	Low density		High density	
	Trees per acre	Distance in feet between trees	Trees per acre	Distance in feet between trees
6	491	9.4	770	7.5
8	319	11.7	500	9.3
10	228	13.8	358	11.0
12	173	15.9	272	12.7
14	138	17.8	216	14.2
16	113	19.6	177	15.7
18	94	21.5	148	17.2
20	81	23.2	127	18.5
22	70	24.9	110	19.9
24	61	26.7	96	21.3
26	54	28.4	85	22.6
28	49	29.8	76	23.9

(40 MBF) per acre or more at age 40 (site 165 - 100 year index). In contrast, a similar unmanaged stand may yield only 30 MBF per acre. Precommercial thinning also may improve the stand's windfirmness, which is important if commercial thinning is anticipated.

Be aware that precommercial thinning before a stand reaches age 10 allows more hemlock to seed between the residual saplings, resulting in a dense thicket of trees requiring additional thinning.

Precommercial thinning also allows you to alter species composition. For example, if a young stand is dominated by western hemlock with some Sitka spruce and Douglas-fir, you may want to concentrate on removing more of the western hemlock. This will ensure the presence of Sitka spruce and Douglas-fir in order to maintain a good balance between all three species in the stand. Similarly, if Sitka spruce saplings are heavily infected and deformed by Sitka spruce weevils, you may want to remove them and favor other species with good form and growth potential.

Because the cut trees have no economic value, precommercial thinning is a cost to the landowner and a long-term investment in the stand. Landowners may be reluctant to invest in precommercial thinning, but failure to thin early in overdense stands results in reduced tree growth, excessive tree mortality, lost revenue, delays in commercial thinning and income opportunities, and trees more susceptible to windthrow. In addition, attaining stand conditions necessary for other non-timber objectives (wildlife, aesthetics, etc.) may be delayed.

Forestry cost-share assistance may be available to help defray some of the costs of precommercial thinning. Contact your local Oregon Department of Forestry service forester to see whether financial incentives are available to you.

Commercial thinning

Western hemlock stands that have attained an average diameter of 8 or more inches generally are merchantable and can be thinned commercially. However, log and pulpwood markets and logging costs undoubtedly will influence the diameter at which stands can be thinned profitably.

Western hemlock stands of merchantable size offer many thinning options. Stands can be thinned either lightly and frequently (i.e., every 5–10 years), or more intensively but less often (i.e., 10 years or longer).

The choice depends on your income needs and whether the terrain is gentle enough to allow ground-based harvesting equipment, which generally is less expensive and can pay for itself even when thinning removals are light. Steeper terrain, which requires more expensive cable logging systems, often requires removing more trees to pay for the operation and still provide profit to the landowner.

To what spacing should you thin your stand? Proper tree spacing depends primarily on tree size, as measured by average tree diameter at breast height (d.b.h.). The larger the average stand diameter, the wider the spacing should be between leave trees. Larger trees need and consume more resources such as sunlight, water, nutrients, and space. Therefore, as the stand grows and develops, residual trees need to be spaced progressively more widely to ensure continued good growth and health.

If stands are not thinned, excessive competition among trees reduces tree vigor and increases mortality. Allowing stands to become so dense that tree mortality occurs represents a financial loss to the landowner because the trees that die are of merchantable size.

Table 2 provides density and spacing guidelines for western hemlock stands with an average diameter between 6 and 28 inches. This density table applies only to even-aged stands comprised of 70 percent or more western hemlock. For each diameter class, "low density" and "high density" columns show the recommended number of trees per acre. The number of recommended trees for each diameter class decreases as the average stand diameter increases.

If you leave fewer trees than is recommended in the low density column, the stand is too open, site resources are wasted, and growth per acre is reduced. On the other hand, if you maintain more trees per acre than is recommended in the high density column, competition among trees becomes intense, diameter growth slows, and mortality occurs. Keeping your stand between the low- and high-density range for each diameter class maintains full site occupancy and optimum stand growth, and avoids tree mortality. A strategy for doing so is discussed in the example on pages 10–11.

If you manage your stand close to the high-density level, residual trees grow more slowly and take longer to reach a predetermined size because there is more competition. If you manage your stand at the lower density or minimum-density level, there are fewer trees and less competition, and the trees grow faster in diameter.

It's important to select the best trees to leave for future growth. For maximum volume and value growth, leave dominant and codominant trees with at least 40 percent live crown ratio (see Figure 4).

If your stand has been overdense for a long time and has stagnated, even the dominant and codominant trees may have a crown ratio less than 40 percent. In this case, it still is a good idea to leave the dominant and codominant trees, but their response to thinning will be delayed by a few years until they have had time to add additional crown volume as they grow in height.

Leave trees also should have the following characteristics:

- Dominant or codominant trees
- Good crowns (40 percent crown ratio or greater)
- Free of sweep, crooks, double-tops, and logging damage
- Free of insects, disease, and mistletoe

Mark cut trees with paint so the logging operator knows which trees to cut. Details should be specified in a logging contract.

When thinning a stand for the first time, be aware that wind is a problem along the Oregon coast. Opening up a dense stand too much all at once can lead to extensive blowdown. The first thinning in a dense stand usually should be light to allow residual trees to develop some windfirmness. After a few years, subsequent thinnings can open up the stand progressively with fewer problems.

However, you should be aware that some sites along the coast are more prone to

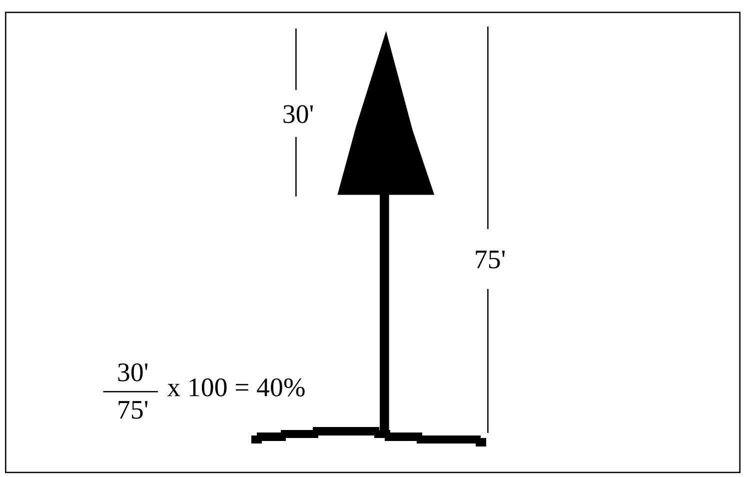

Figure 4.—How to determine crown ratio. Crown ratio is not actually measured; it is estimated visually.

blowdown than others. These sites include areas with either shallow soils or a high water table, both of which restrict root development, and areas where the terrain tends to funnel the wind. Special attention is needed in these areas, and thinning may not be desirable.

Management of two- or three-aged stands

What if you live on your forest and don't want to clearcut? Western hemlock seedlings can become established on the forest floor when small openings are created in the forest canopy. Openings created by blowdown, root disease, and thinning activities can encourage establishment of seedlings in the understory (Figure 5). The result is a "two-storied" stand. This "advanced regeneration" is low-cost and can be left to grow for several years before additional thinning or complete overstory removal is conducted.

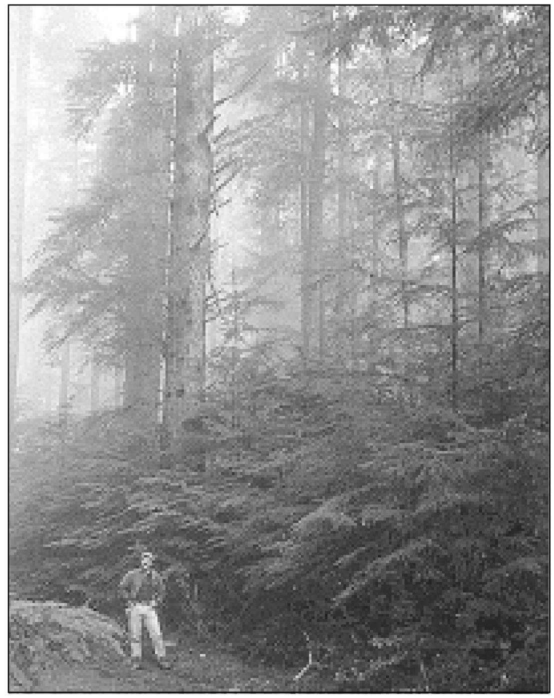

Figure 5.—As seedlings establish in small openings in the forest canopy, a two-storied stand develops.

Advanced regeneration and overstory trees can be managed with two approaches, depending on the amount, distribution, and height of advanced regeneration and your long-term objectives. A key to managing multi-aged stands is finding a logging operator who is skilled at thinning and protecting understory regeneration. Remember, understory regeneration represents your future crop trees. See "Minimizing logging damage" below.

Assuming the understory is well-stocked, one approach is to remove the entire overstory eventually and "release" the regeneration from overstory competition. This essentially converts the stand to a young, even-aged stand with no overstory (Figure 6—Scenario 1).

Special care is required in removing the overstory in order not to damage the regeneration excessively. Studies have shown that when overstory stands containing 30 MBF or more per acre are removed in one step, it is likely that most of the advanced regeneration will be either destroyed or severely damaged. A recent study at the Oregon State University Research Forest resulted in acceptable damage to understory regeneration when more than 14 MBF per acre were removed in one harvest entry with a cable-yarding system.

However, depending on overstory density, it is possible to remove the overstory in a series of staged thinnings separated by a few years to avoid excessive damage to the regeneration.

The other approach to managing stands with advanced regeneration is to selectively thin portions of the stand to encourage additional understory regeneration. Managing a stand in this fashion creates an uneven-aged stand comprised of three or more age classes (Figure 6—Scenario 2). A stand managed this way has a diverse forest canopy and a high aesthetic appeal to most people. Also, because the stand is entered periodically for commercial removals, income is generated periodically.

When a stand is managed in this fashion, the goal is to thin the overstory lightly to create growing space for existing understory regeneration and to create additional space in other areas of the stand for establishment of other age classes of seedlings. If the overstory is left too dense, it can retard the growth and recruitment of understory trees into the mid- and overstory canopy levels. Because western hemlock produces abundant regeneration, the understory also may require precommercial thinning to reduce competition and improve the ability of saplings to grow into the

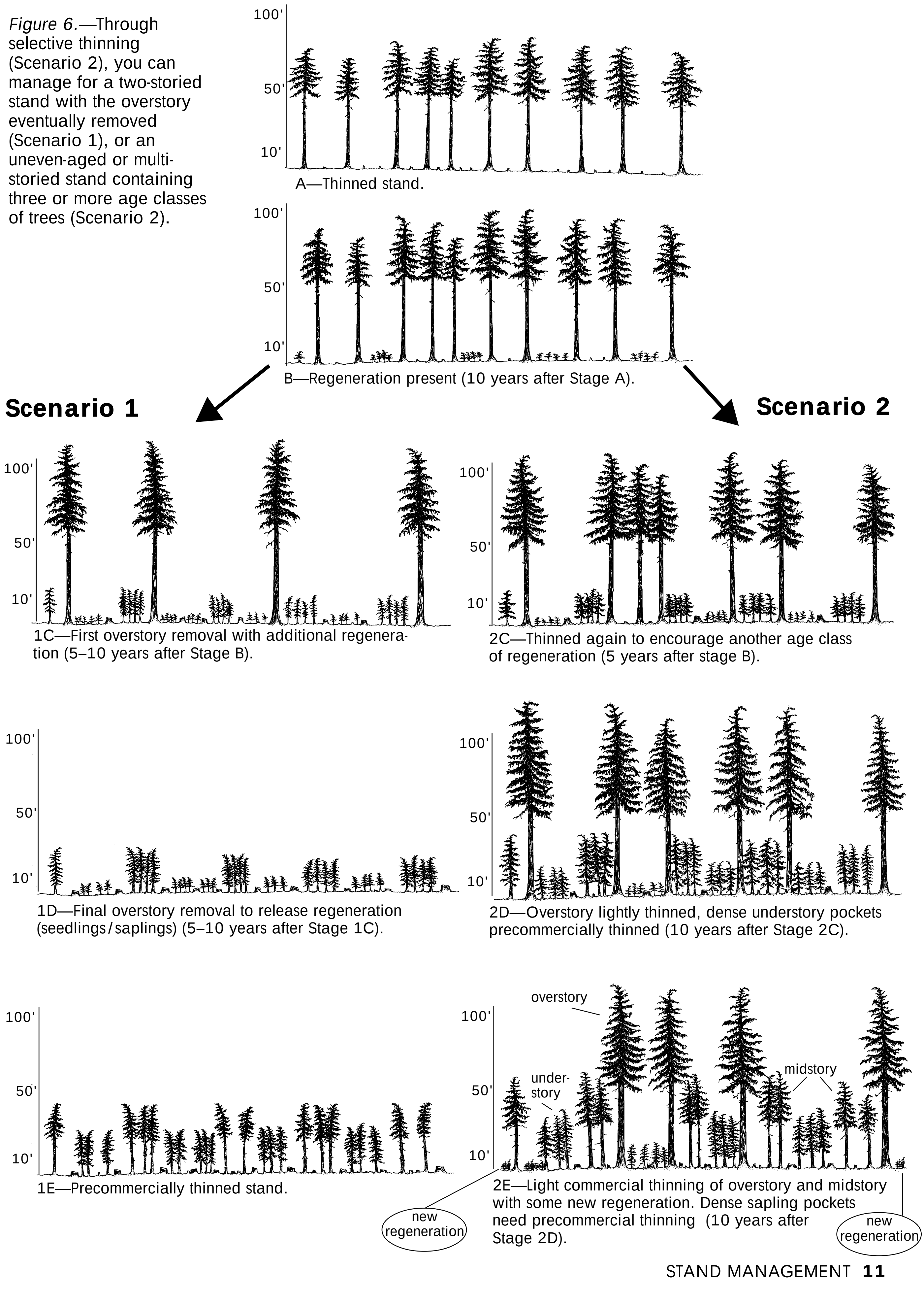

Figure 6.—Through selective thinning (Scenario 2), you can manage for a two-storied stand with the overstory eventually removed (Scenario 1), or an uneven-aged or multi-storied stand containing three or more age classes of trees (Scenario 2).

A—Thinned stand.

B—Regeneration present (10 years after Stage A).

1C—First overstory removal with additional regeneration (5–10 years after Stage B).

2C—Thinned again to encourage another age class of regeneration (5 years after stage B).

1D—Final overstory removal to release regeneration (seedlings/saplings) (5–10 years after Stage 1C).

2D—Overstory lightly thinned, dense understory pockets precommercially thinned (10 years after Stage 2C).

1E—Precommercially thinned stand.

2E—Light commercial thinning of overstory and midstory with some new regeneration. Dense sapling pockets need precommercial thinning (10 years after Stage 2D).

overstory, eventually replacing trees harvested in previous thinning entries.

If some overstory trees are infected with dwarf mistletoe, remove them in the next thinning. Otherwise, the overstory will continue to infect healthy understory trees.

Uneven-age management of western hemlock has not been practiced widely. Steep slopes, typical of coastal sites, limit the applicability of uneven-age management because thinning operations currently are done with ground-based harvesting equipment that cannot operate effectively on slopes greater than about 30 percent. The risk of blowdown also limits the use of uneven-age management in areas prone to high winds. However, if uneven-age management is limited to flatter terrain, and if harvest entries are conducted carefully, risk from blowdown is reduced.

Minimizing logging damage

Working with logging equipment in hemlock-spruce stands always incurs some risk. Both species have thin bark and therefore are susceptible to stem scarring from logging activity (also known as basal or butt scarring).

The potential for stem scarring is even greater from spring through midsummer. During this active growth period, more sap flows through the cambium layer just under the bark. At this time of year, trees are damaged much more easily when bumped by equipment or logs. If thinning is done during spring or midsummer, widespread damage to residual trees is likely to occur, possibly resulting in future loss from decay, sap stain, and disease.

Both hemlock and spruce are shallow- to medium-rooted species. This makes them susceptible to soil compaction and root damage during harvest entries. Root damage can be minimized by limiting logging activity to late summer and early fall and by staying on designated skid trails. The likelihood of stem scarring also is less during this period because the bark is not actively growing and "tight."

Use of a well-designed, permanently placed skid trail system helps minimize damage to residual trees, improves operator efficiency, and reduces soil compaction. Each time the stand is thinned, the skid trails are reused. Since designated skid trails help minimize damage to residual trees, there is less chance for disease and decay to enter the stand. See *Designated Skid Trails Minimize Soil Compaction,* EC 1110, for more information.

Summary

Hemlock-spruce forests of the coastal fog belt are among the most productive forests in the world. Their shade tolerance and ability to reseed prolifically make them especially resilient and productive. They do, however, provide some unique management challenges.

Competition from brush and other vegetation is a common problem during reforestation and establishment stages. Spacing control is important in young, overstocked stands to maximize volume growth, improve windfirmness, and increase future value and income opportunities.

Commercial thinning of western hemlock must be done carefully to avoid blowdown, root damage, and stem scarring. Both western hemlock and Sitka spruce are shallow rooted and are susceptible to blowdown during winter storms, particularly when soils are very wet. You can expect to experience some blowdown in thinned areas, riparian zones, and exposed timber edges adjacent to clearcuts and roads.

You can manage western hemlock with traditional even-age systems such as clearcutting, and with uneven-age management using selection thinning. Uneven-age management creates a multi-aged stand that is thinned periodically to promote continuous regeneration of understory hemlock. Forests managed in this fashion maintain a continuous forest canopy, are aesthetically appealing, and produce periodic income for woodland owners. It is, however, more costly to manage your forest this way. Also, strong coastal winds, steep slopes, and shallow soils limit the application of uneven-age management in many coastal areas.

For further reading

OSU Extension publications

deCalesta, D.S., R.E. Duddles, and M.C. Bondi, *Controlling Mountain Beaver Damage in Forest Plantations,* EC 1144 (reprinted 1993). $1.00

DeYoe, D.R., D.S. deCalesta, and W. Schaa, *Understanding and Controlling Deer Damage in Young Plantations,* EC 1201 (reprinted 1993). $2.50

Duddles, R.E., and C.G. Landgren, *Selecting and Buying Quality Seedlings,* EC 1196 (revised 1993). $1.25

Emmingham, W.H., and M. Bondi, *Managing Woodlands in the Coastal Fog Belt,* EC 1131 (reprinted 1993). $1.00

Emmingham, W.H., B.D. Cleary, and D.R. DeYoe, *Seedling Care and Handling,* EC 1095 (revised 1996). 75¢

Emmingham, W.H., and N. Elwood, *Thinning: An Important Timber Management Tool,* PNW 184 (1983). 50¢

Filip, Gregory M., Alan Kanaskie, and Allan Campbell III, *Forest Disease Ecology and Management in Oregon,* Manual 9 (1995). $14.50

Fitzgerald, S.A., *Site Preparation: An Introduction for the Woodland Owner,* EC 1188 (revised 1996). $1.50

Garland, J., *Designated Skid Trails Minimize Soil Compaction*, EC 1110 (reprinted 1993). $1.00

Oester, P.T., and W.H. Emmingham, *Using Precommercial Thinning to Enhance Woodland Productivity,* EC 1189 (reprinted 1997). $2.00

To order copies of the above publications, or additional copies of this publication, send the complete title and series number, along with a check or money order for the amount listed, to:

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Other publications

Bega, Robert V., *Diseases of Pacific Coast Conifers*, USDA Handbook 521 (revised 1979).

Burns, Russell M., and Barbara H. Honkala, *Silvics of North America, Vol. 1, Conifers,* USDA Handbook 654 (1990).

An example

You recently purchased some coastal forest land that includes a 10-acre stand of 27-year-old western hemlock. The prior owner precommercially thinned the stand at age 12 to about a 10-foot spacing, or 430 trees per acre.

Today, the stand averages about 10 inches d.b.h., and you've noticed some trees have died recently. The stand is too dense.

In the density table below (Table 2), you find the recommended maximum number of trees for a stand with an average diameter of 10 inches is 358 trees per acre. (In the first column under "Average tree diameter," find the 10-inch diameter row. Now look to the right under the high density column for the recommended trees per acre.)

You have 72 trees per acre more than recommended under the high density column (430 – 358 = 72). Your stand definitely is very dense, which explains why trees have died recently.

Thinning will benefit the stand, and there currently is a market for small logs. However, how many trees should you remove? You could thin the stand to 228 trees per acre (low density column), and the stand still would be fully occupied. That would mean removing approximately 200 trees per acre (430 – 228 = 202).

Because the stand is so dense, you are worried about possible blowdown if you open up the stand that much. To avoid blowdown problems, a forest service forester suggests thinning the stand to about 275 trees per acre—a removal of 155 trees per acre—leaving the larger, more windfirm trees: a good compromise.

When will the stand require a second commercial thinning? If 275 trees per acre are left after the first commercial thinning, you'll need to thin the stand again when average diameter reaches 12 inches. (In the high density column, find 272 trees per acre. Then look to the left under the average tree diameter column for the maximum diameter for that density.) Allowing the stand to grow larger with that many trees would result in mortality caused by excessive competition.

Because the first commercial thinning several years earlier improved the windfirmness of the stand, you now can thin the stand from its current 275 trees per acre down to 173 trees per acre—a removal of 102 trees per acre—and maintain full site occupancy at the recommended low-density level.

At 173 trees per acre, you could allow the stand to grow to an average diameter of 16 inches before another thinning would be required. How many trees should be removed this time? The answer depends on the diameter at which you plan to harvest the entire stand, in this case with clearcut.

You decide that when the stand reaches an average diameter of 18 inches the entire stand will be harvested. Thus, when the stand reaches 16 inches in diameter with 173 trees per acre, you need to thin to 148 trees per acre—a removal of 25 trees per acre. At this density, your stand can grow to a harvest size of 18 inches without experiencing any mortality.

Summary of activity for thinning example.

	Trees/acre	Average stand diameter	Notes
Current Stand	430 trees/a	10" diameter	Some tree mortality. Remove 155 trees per acre.
	275 trees/a	Grow to 12" diameter	Remove 102 trees per acre.
	173 trees/a	Grow to 16" diameter	Remove 25 trees per acre.
	148 trees/a	Grow to 18" diameter	Clearcut the stand.

Notes

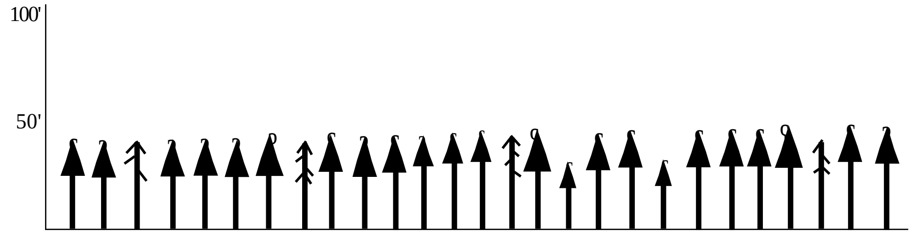
1. The average stand diameter increases when smaller trees in the stand are removed. This needs to be taken into account when calculating average stand diameter and choosing the correct spacing.
2. This example assumes 2" of diameter growth per decade.

***Table 2 (excerpt).*—Suggested density and tree spacing for fully stocked western hemlock stands on the Oregon Coast.**

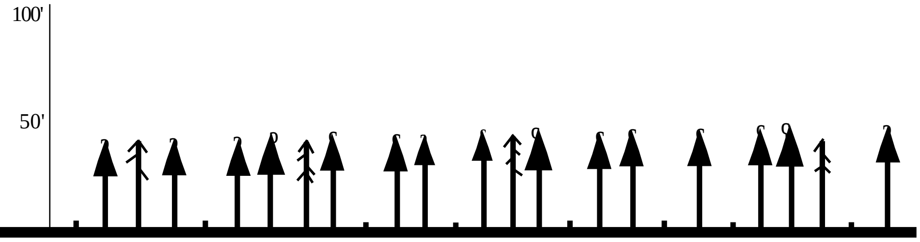
	Low density		High density		
Average tree diameter in inches	Trees per acre	Distance in feet between trees	Trees per acre	Distance in feet between trees	
6	491	9.4	770	7.5	
8	319	11.7	500	9.3	
***10**	**228**	**13.8**	**358 .... (430)**	**11.0**	**(current stand)**
12	173	15.9	272	12.7	
14	138	17.8	216	14.2	
16	113	19.6	177	15.7	
18	94	21.5	148	17.2	

The example illustrated

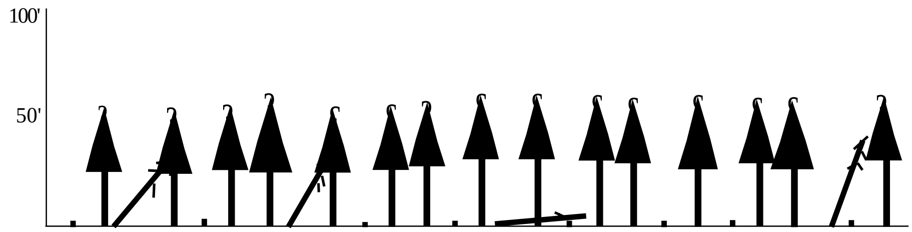
A 430 trees/a
10" diameter
Some tree mortality.



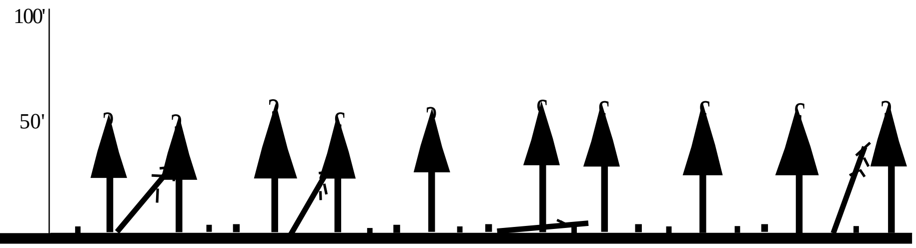
Remove 155 trees per acre.



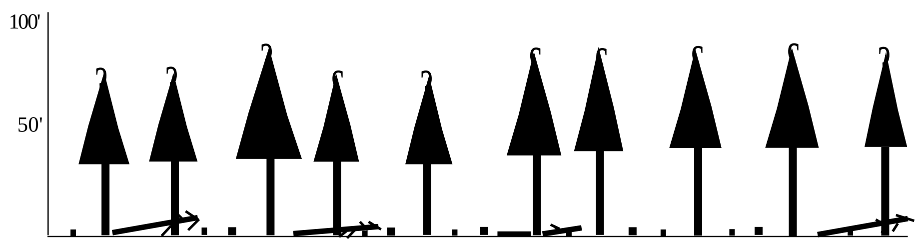
B 275 trees/a grow to 12" diameter.



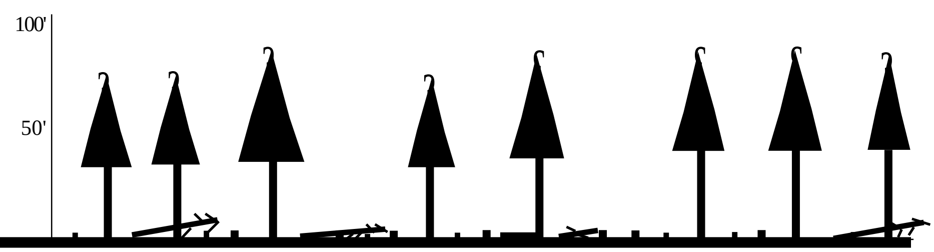
Remove 102 trees per acre.



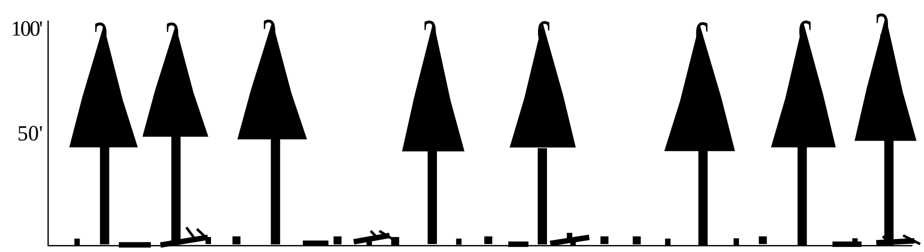
C 173 trees/a grow to 16" diameter.



Remove 25 trees per acre.



D 148 trees/a grow to 18" diameter.



Clearcut the stand and replant.

The Woodland Workbook is a collection of publications prepared by the Oregon State University Extension Service specifically for owners and managers of private, nonindustrial woodlands. The Workbook is organized into separate sections, containing information of long-range and day-to-day value for anyone interested in wise management, conservation, and use of woodland properties. It's available in a 3-ring binder with tabbed dividers for each section.

For information about how to order, and for a current list of titles and prices, inquire at the office of the OSU Extension Service that serves your county.

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