PNW 184

Thinning

An Important Timber Management Tool

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Contents

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Thinning is the practice of removing some trees in an immature stand to increase growth of the remaining trees and the total yield or value of usable wood. You thin stands in which the trees are approximately the same age.

There are two methods of thinning: commercial and precommercial. In commercial thinnings, the immediate value of the removed trees pays the thinning costs. If the value of the trees does not return enough to pay thinning costs, the practice is a precommercial thinning.

A good thinning program meets one or more of these six objectives.

1. Use or sell trees that otherwise would die and decay.
2. Redistribute the total fiber growth of the stand to fewer trees of higher quality, thereby increasing the value of *usable* fiber.
3. Increase the profitability of growing trees by reducing the investment in standing volume.
4. Provide money to pay off investments, such as reforestation, precommercial thinning, and other stand improvement activities.
5. Enhance nontimber uses of the forest such as grazing, wildlife, and recreation.
6. Provide more frequent *periodic* incomes.

In order to understand thinning, it is necessary to have some knowledge of how seedlings grow into mature trees and how groups or stands of trees develop.

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Basic tree growth

Trees, like all living things, grow by forming cells. New cells form in the cambium (Figure 1), which is just inside the bark along the entire length and circumference of the tree stem, branches, and roots. Adjacent to this growth area is the transportation network for the tree.

Water and nutrients move upward in the xylem (sapwood), and food manufactured in the leaves moves downward in the phloem, a region between the cambium and the bark. If a tree is "girdled" (by cutting a notch all the way around the stem), the phloem is severed and the tree will die unless the notch is bridged by new growth.

Except in the extreme tips of growing shoots, new cells formed in the cambium remain in place. The cambium layer moves outward as the tree grows in diameter, ever surrounding the tree and forming new cells outside the old ones.

Thus, a nail driven in 5 feet above the ground in a tree with a 10-inch diameter will always remain 5 feet above the ground and will always be in the center 10 inches of the bole (trunk), no matter how large the tree grows. New wood eventually will bury the nail by growing around and over it.

Cells formed in the spring, when growth is rapid, have thin walls and produce wood that is light in color. Later in the summer, when growth slows, cells have thicker walls, which appear to be darker. These alternate light and dark layers make up annual rings, which you see on a stump or log end.

A paired light and dark layer form an annual ring—the amount of wood a tree produces in one growing season. Annual rings enable you to trace the growth history of the tree.

Basic growth processes

Knowledge of three basic growth processes—photosynthesis, respiration, and translocation–assimilation—is important to understand thinning. You might also call these processes energy storage, energy release, and food transport–cell formation.

Energy storage (photosynthesis)

This process converts carbon dioxide and water into carbohydrates, the basic food of the tree. Sunlight supplies the energy necessary for photosynthesis, which takes place in the leaves. The tree stores this energy in a form of reusable plant food. When water and nutrients are plentiful, light and temperature determine and limit the rate of photosynthesis.

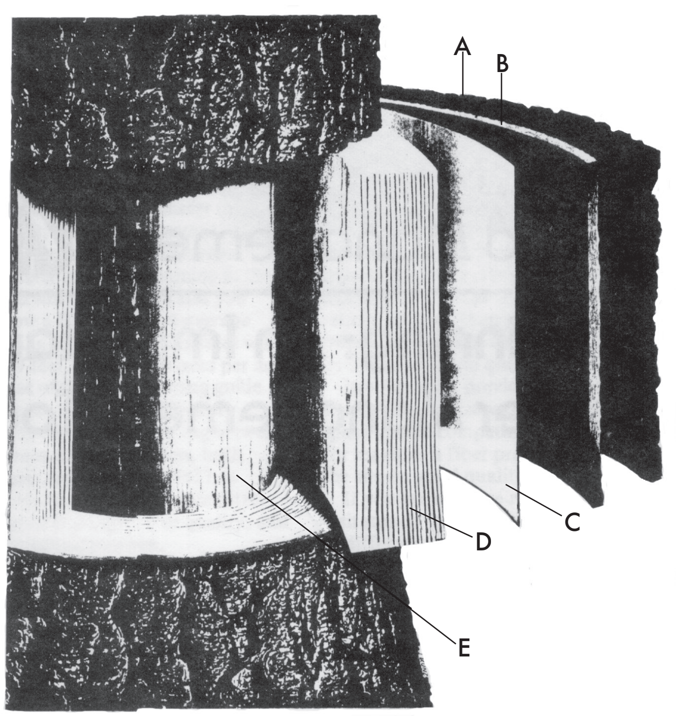

*Figure 1.—*Types of tree cells and their functions. The outer bark (A) insulates the tree from extreme heat and cold, helps keep out rain, and protects the plant against insect enemies. The phloem (B) conducts food from leaves to the rest of the tree. Eventually, it becomes part of the tree's bark. Immediately inside the phloem is the cambium layer (C). The cambium produces new bark and new wood annually in response to hormones, called auxins, that stimulate the growth of cells. Sapwood, or xylem, (D) is the pipeline for water and nutrients moving from roots to the leaves. When its inner cells lose their vitality, they turn into heartwood (E). Heartwood is the central, supporting column of the mature tree. Although it is dead, it will not decay or lose strength as long as the tree's outer layers remain intact. *(Illustration courtesy of The St. Regis Paper Company, New York, NY.)*

Energy release (respiration)

This process occurs in all living cells of the tree. It releases energy by breaking down the carbohydrate manufactured in photosynthesis. Although this breakdown and energy release are necessary, breakdown may be excessive, i.e., use more carbohydrate than necessary. Temperature is very important in regulating the rate of respiration.

Food transport–cell formulation (translocation–assimilation)

Carbohydrates manufactured in the leaves must move out to all parts of the cambium so new cells can form and the tree can grow. The carbohydrates must be assimilated into new cells. Transporting food and converting it to new cells requires energy. This energy is liberated from the food during respiration.

Summary

Photosynthesis, the energy-storing process, is controlled by temperature and the amount of sunlight, water, and nutrients available to the tree. Temperature controls respiration, which uses food to maintain the life processes of the tree and to release the energy necessary for growth. The amount of growth depends on how much energy or food is left over after the tree uses what it needs for respiration.

How thinning affects individual tree growth

Effects on the tree's environment

Removing some of the trees that compete for limited water and soil nutrients makes more water and nutrients available for the remaining trees. Thinning also opens the stand's crown canopy, making more light available for the remaining trees.

Effects on tree growth

The increased water, nutrients, and light that result from thinning increase photosynthesis in the remaining trees. More food is produced, making more carbohydrate available for new cell formation and growth.

The increased volume growth of individual trees normally occurs as diameter rather than height growth. With a wide range of tree density per acre, height growth is relatively constant for a given species and site.

The primary effect of thinning, therefore, is to increase diameter growth of the remaining trees. Effective thinnings will stimulate this growth within a few years.

Effect on species and age

The growth response to thinning varies with the age of the tree (more so for some species than others). Foresters have long observed that old and large trees do not respond to thinning as readily nor as dramatically as small, young trees. This is particularly true for species that are intolerant of shade.

Intolerant species require nearly full sunlight to thrive and grow. Tolerant tree species can survive and grow in low light levels, such as those that develop beneath a full canopy of intolerant species. Shade- tolerant species are more likely to respond to thinning at older ages.

The tolerance of common Pacific Northwest species varies (Table 1).

Thinning shock

There are exceptions to the generalization that thinning increases the growth rate of remaining trees. In dense stands of young trees, the trees may continue to grow at the same rate—or they might display up to 40 percent slower growth. This undesirable reaction to thinning is called *thinning shock*.

Table 1.—Tree species' tolerance to shade.

Tolerant
grand fir, mountain hemlock, Pacific silver fir, spruce, western hemlock, western red cedar
Intermediate
Douglas-fir, sugar pine, western white pine
Intolerant
alder, cottonwood, lodgepole pine, noble fir, ponderosa pine, western larch

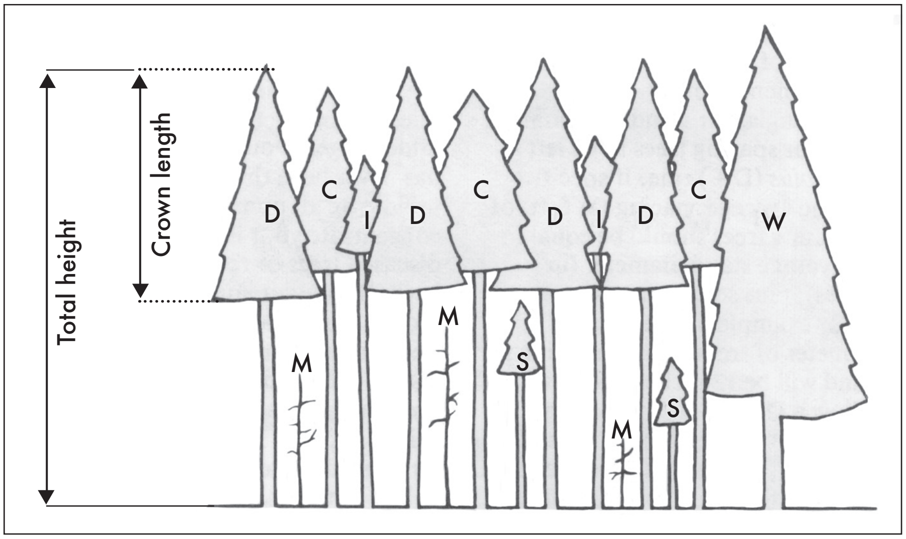

Figure 2.—Crown type classifications of trees in even-age stands. D = Dominant, C = Codominant, I = Intermediate, W = Wolf, S = Suppressed, M = Mortality. The “crown ratio” is the proportion of total tree height that is occupied by live crown. In this illustration, the dominants have a 50 percent crown ratio; the wolf tree has an 80 percent crown ratio.

How thinning affects stand growth

Thinning applies to stands of trees rather than to individual trees. The fact that thinning ordinarily increases the growth of individual remaining trees does not mean total stand growth is increased—there are fewer trees in a thinned stand. The effects of thinning on stand growth are best understood after a discussion of stand development under natural, unthinned conditions.

Shock occurs in trees with small crowns where the vertical crown length is less than one-third the total tree height (see Figure 2 for an illustration of crown ratio).

Repeated thinning stimulates vigorous growth and produces crowns greater than 40 percent of the total tree height. Shock is unlikely in such stands.

What causes thinning shock?

There is no universally accepted reason. One explanation is that the limited crown size prevents an increase in photosynthesis large enough to offset the increased respiration that may result from direct sunlight on the stems of remaining trees.

Another explanation is sunscald—the death of the bark and cambium of young trees on the newly exposed south side of the tree. A possible reason for this type of shock is that trees in dense stands tend to have thinner bark, which may contribute to scald.

A third explanation is tree leaves that develop in shade cannot control their water loss when they are exposed suddenly to full sun. They sometimes wilt and die and leave the tree with less leaf area, which reduces photosynthesis.

Crown classification

A tree crown classification system is useful in discussing stand development. Figure 2 illustrates a commonly used system, which has the following six classes.

1. *Dominant*. Trees with the crown extending above the general level of the crown canopy receive full sunlight from above and some from the sides. The sides of the crowns are well developed but (possibly) somewhat crowded.
2. *Codominant*. Trees with crowns forming the general level of the crown cover receive full light from above but little from the sides. The tree crowns are medium size and more crowded on the sides than are dominants’ crowns.
3. *Intermediate*. These trees usually are shorter than those in the two preceding classes. They have small, crowded sides. The crowns extend into the canopy formed by dominant and codominant trees; they receive a little direct light from above but none from the sides.
4. *Suppressed (overtopped)*. The crowns on these trees are below the level of the crown canopy. They receive no direct light from above or from the sides.
5. *Wolf*. These trees develop and grow in the open. They have full crowns on all sides, with branches well below the canopy

level. The crowns are uncrowded on two or more sides and receive full light from above and well down on two or more sides.

6. *Mortality*. These are dead trees within the stand. Suppressed trees usually die, and trees of any crown class may die from disease or insect attack.

Stand development under natural conditions

As illustrated in Figure 3, a very young, even-age stand is composed entirely of dominant trees because the seedlings do not shade one another. As the trees grow, height becomes critical to their survival. Tall trees shade shorter trees. At some point the increased shading reduces photosynthesis, which further reduces growth.

The tallest trees remain in the dominant crown class, while shorter ones drop down to the codominant, intermediate, and suppressed classes. Once a height advantage is lost, normally it is not regained. As this process continues year after year, the stand develops into one with varied crown classes. The process continues as long as the even-age stand exists.

All trees compete for light, water, and nutrients. Some trees in the dominant class remain there; others fall behind gradually until they are in the codominant class. Some trees in the codominant class remain there, but others fall behind and become members of the intermediate class. Trees in the intermediate class often become overtopped and eventually die.

With increased stand age, crown class differentiation becomes more pronounced, and the number of trees in the stand is reduced constantly. In an unmanaged stand, the remains of dead trees rot in place.

Stagnation of tree stands occurs when normal stand development does not take place. It is usually found on poor sites and results in very slow stand growth and many suppressed trees.

Trees that develop in the open often become undesirable "wolf" trees with large branches.

Effect of thinning on stand development

Thinning can alter the way a stand develops by influencing the proportion of trees that grow into each crown class. The extent of the alteration depends on the particular way you thin. If you remove trees early in a stand's development, you reduce the competition the remaining trees face.

With reduced competition, fewer remaining trees will develop into intermediate and suppressed trees. They will grow faster and will be larger than trees in an unthinned stand on a similar site.

After competition begins and the stand develops all crown classes, removing only intermediate and suppressed trees may not significantly reduce the competition faced by the larger dominant and codominant trees. Suppressed trees, in particular, do not compete significantly with larger trees.

A successful *low* thinning removes all suppressed, most intermediates, many co-dominants, and even some dominant trees. The remaining stand consists of uniformly spaced dominant and codominant trees.

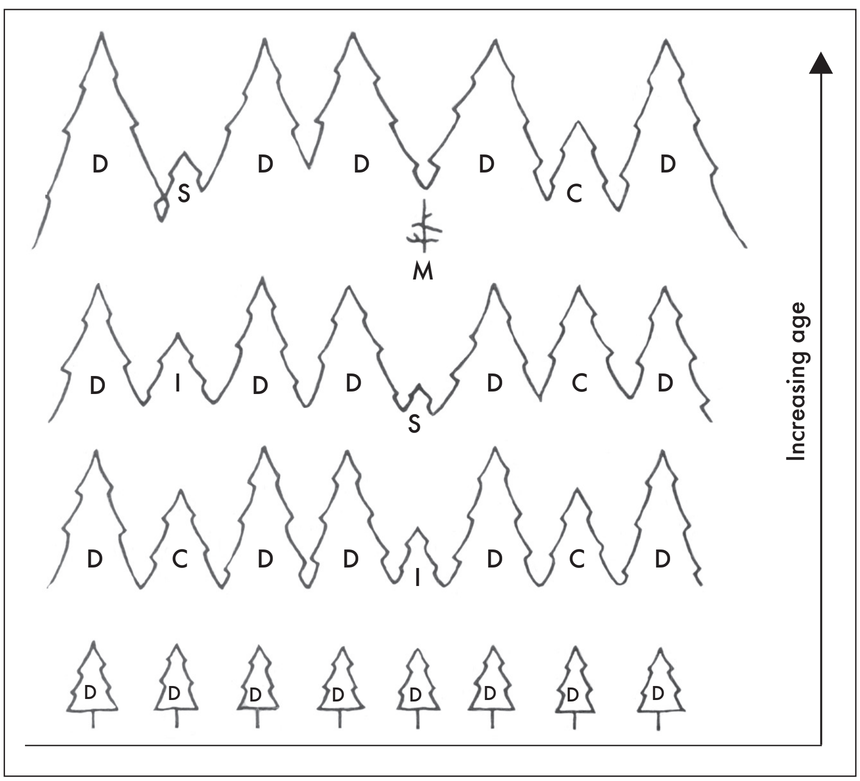

Figure 3.— Trees differentiate into crown classes as stands become older.

In a *high* thinning, removing relatively few dominant and codominant trees will release a large number of remaining trees. High thinning is not likely to stimulate a good release response if competition has produced a stand where few trees have crowns extending 30 to 40 percent of the tree's height.

Effects of thinning on total stand yield

On a forested site, the total amounts of water, nutrients, and light are fixed, which limits the total volume of wood fiber a stand will produce within a given time. This implies that total fiber growth is also fixed and you cannot increase it by thinning. However, thinning can increase the *usable* fiber a stand produces.

Thinning channels the limited light, water, and nutrients into fewer trees, enabling each of them to grow faster. Unless thinning is so severe that too few trees are left to fully occupy the site, the total fiber growth that the site is capable of producing is concentrated on fewer stems. This results in a few large logs rather than many small logs.

Large logs usually have a higher value per unit of volume than small logs, for two basic reasons. The logging cost is lower because a few big logs cost less to handle than many small logs; and the products that can be made from large logs (veneer, large timbers) are worth more than those made from small logs.

In a natural stand, part of the gross growth is lost when trees die from competition or other factors, go unsalvaged, and eventually decay. Thinning "captures" this mortality—it increases the amount of usable (and salable) fiber that a stand produces.

Thinning does *not* produce increased growth, but because thinning concentrates growth onto a few large stems, *individual tree and stand value increase*.

The way to increase stand production is to supplement elements that stimulate growth, such as increasing nitrogen by fertilizing or water by irrigating. Genetic improvement programs, which can create trees that grow more efficiently, also can increase production. You obtain best results with fertilization, irrigation, and genetic improvement when they are combined with a careful thinning program.

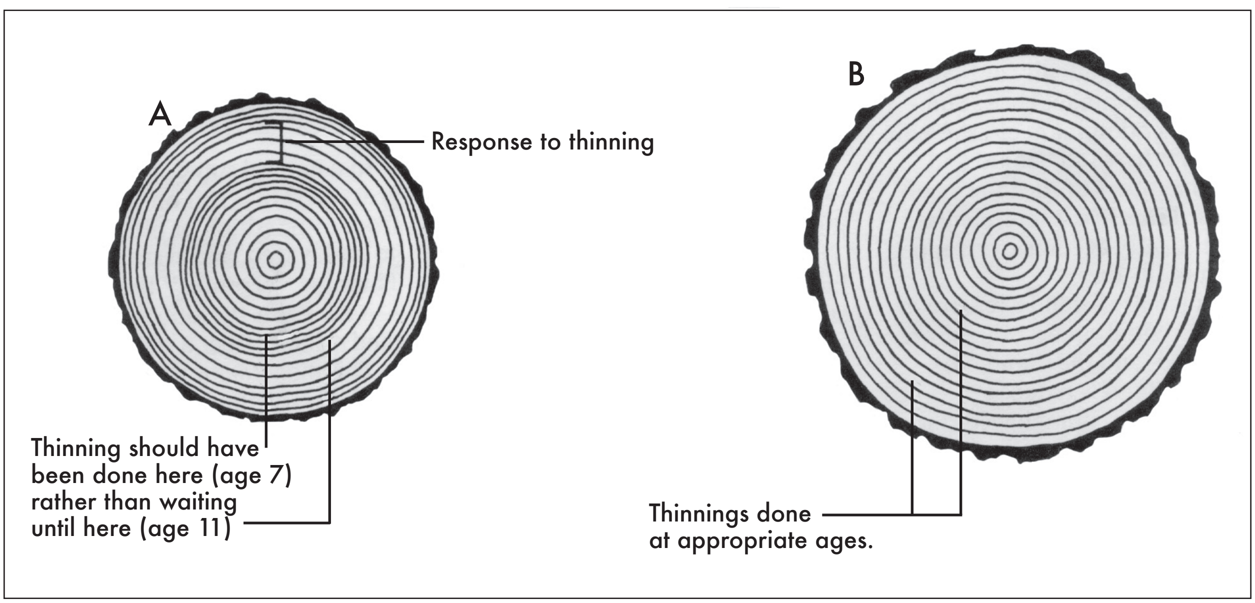

Figure 4.—Some effects of thinning frequency. Thin often so that the width of growth rings remains relatively constant. Cross sections A and B are of 21-year-old trees. Thinning for tree A was postponed too long, causing the diameter growth restriction shown. Upon thinning, diameter growth increased but then slowed again as the tree crowns closed. Tree B was properly thinned, allowing its diameter growth to remain fairly uniform.

How to thin

In deciding how to thin, you must answer several questions: When should I thin? How many trees should I remove? Which trees should I remove? What logging methods should I use?

When to thin

To get the biggest increase in usable fiber, begin thinning early, when trees are 10 to 20 years old. Actually, the density of the stand and size of trees—rather than stand age—dictate when thinning is effective. Thinning before competition begins accomplishes little, but thinning when the crowns of adjacent trees begin to touch will reduce competition.

In stands with 4- to 12-inch diameters (diameter at breast height, or dbh), thin before the crown ratios drop below 40 per-cent. If crowns have receded beyond this point, thin lightly to prevent thinning shock. Use early thinnings (which are likely to be precommercial thinnings) to shorten the time until you can harvest merchantable logs and to keep stands vigorous and healthy.

Make subsequent thinnings as competition recurs but before diameter growth is severely reduced. As stand competition increases, annual rings of individual trees become thinner. Rapid increases in the width of the trees' growth rings after thinning often are dramatic examples of the benefits of thinning. Ideally, however, you should thin before diameter growth drops off severely (see Figure 4).

The interval between thinnings depends on the *intensity* of thinning and the productivity of the site. Intensity of thinning refers to the number of trees (and competition) you remove with respect to full, natural, or "normal" stocking. A *heavy* thinning removes many trees and reduces competition for a longer period than does a *light* thinning, which removes fewer trees.

When you do precommercial thinning (usually a heavy thinning), space the trees you leave so they will reach merchantable size before the stand closes and competition becomes severe. Crown closure and competition resume soon after light thinnings; therefore, conduct them more frequently than heavy thinnings. In the Northwest, thinning intervals commonly range from 5 to 15 years.

Time of year

Late summer and fall are the best times to thin. Trees grow in spring and early summer, and it is easy to scrape the bark from residual trees during felling and yard-ing operations. Also, during this season, cut trees can attract insects that can kill the remaining trees.

For example, if you thin ponderosa pine or lodgepole pine in spring, large numbers of bark beetles may be attracted to the cut trees. *Thin pine stands after August 1 to minimize the danger associated with bark beetles*.

Winter is also an acceptable time for thinning, with one note of caution. Soils are more prone to compaction and erosion in the wet season, so regulate use of ground-based skidders carefully. In areas where snow accumulates or the ground freezes, winter thinning is perfectly acceptable.

Thinning intensity

If the intensity of thinning is too light, the growth is spread over too many trees to achieve maximum benefits. If the intensity is too heavy, considerable amounts of nutrients, water, and light are outside the reach of the remaining trees, and the total productive capacity of the site is underused. Also, wind throw after thinning may be a problem for some species or on highly exposed sites. For these reasons, the intensity of thinning is an important management choice.

In Douglas-fir stands, a common guide for spacing trees to be left is the "D-plus" (D+) rule. It specifies that the average spacing (in feet) of remaining trees should be equal to the average stand diameter (in inches), plus some constant.

For example, if the average diameter of trees left in the stand will be 12 inches and you follow a D+5 rule, the average spacing of the remaining trees will be 17 feet, leaving 150 trees per acre.

Using the D+5 spacing guide does not indicate an arbitrary 17-foot by 17-foot spacing between all trees. Some variation, both greater and less than 17 x 17, is necessary to accommodate differences in tree vigor and tree quality and for other considerations.

It is commonly advocated that you make D+4 or D+5 thinnings in early years (until trees are about 8 inches dbh) and follow with somewhat heavier thinnings (perhaps D+6) in later years. Consider this a rough guide only.

Experience in thinning over the years in the Northwest has resulted in a gradual increase in the intensity of thinning. Other techniques for determining the spacing of trees to leave, such as density management diagrams, are now available and can produce equally satisfactory results.

The main point is to use some thinning guide so you can determine the spacing of residual trees. Consult with a professional forester about the guides used in your area.

Tree selection

The type of thinning you select depends on your objectives, on the age, size, condition, and species composition of the stand, and on its management history. A cardinal rule when thinning is to improve the stand's condition for future growth.

Low thinning is most common if residual trees are in the dominant and codominant crown classes. Residual trees should be straight and vigorous, have relatively small limbs and considerable clear bole, and be spaced as uniformly as possible.

A young Douglas-fir stand that has been precommercially thinned presents an entirely different set of selection problems than does a middle-age Douglas-fir stand that has never been thinned. In the middle-age, unmanaged stand, concentrate your initial thinning on diseased trees or rough, limby trees in the dominant and codominant crown classes and on poor quality trees in the lower crown classes. Pay less attention to the spacing of the remaining trees than you would in a thinned stand. The thinning primarily upgrades stand quality.

In a younger, previously thinned stand, focus on crown classification, spacing, and competition. Aim for maximum fiber production from the site on good quality trees.

If you are a novice at thinning, visit stands that were thinned in different ways to get a better feel for tree-selection criteria.

Species selection

Thinning offers a means of controlling the species composition of a stand by leaving the more valuable or better growing species to mature. This is often done during precommercial thinning when you remove large shrubs along with undesirable hardwood or conifer species.

Logging methods

Selection of logging methods and equipment is important. Logging systems differ in their capacity to handle logs of different sizes, adaptability to steep slopes, road access requirements, site disturbance, soil compaction potential, potential damage to remaining trees, and cost.

You can reduce damage to residual trees by not logging during spring and early summer when the bark easily is broken loose from the trunk. Planning and marking skidtrails can reduce the amount of soil compaction.

Some final notes

Thinning is an important stand management tool available to woodland owners. State service foresters and industrial and consulting foresters can give you valuable assistance in planning and conducting thinning operations. Educational programs and other literature on thinning are available from most county Extension offices. It is important that you understand thinning and define management goals before contacting professional help.

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