Commercial thinning is the removal of some trees from a hardwood or conifer stand with a profitable sale of the removed trees. It can often be a useful tool for managing stands if done at the proper time and in the proper way. Done incorrectly, however, it can take the Tree Farmer further from their objectives than had no thinning been done.

Commercial thinning may not be needed for some stands and for some objectives, but thinning serves such functions as extending the rotation, extending the wood supply and income flow, creating future trees of targeted species or quality, reducing insect and fire danger, and increasing wildlife values.

A general thinning rule is to focus on the trees left after thinning, not on the trees to be removed. Of course, one should account for the value of the trees removed; however, if the remaining stand has too little value after the thinning, the owner would probably be better off harvesting the stand completely rather than thinning it.

Operationally, thinning needs to be done with several factors in mind:

- It should not be done in the spring or early summer because the bark of the remaining trees is easily knocked off by the machinery and logs being removed during this season. Once this bark is removed, the trees are susceptible to rot, and the remaining stand can be ruined.
- Stumps of the removed trees should be low to the ground to avoid future accidents and other difficulties.
- Appropriate markets are needed for the material being thinned. If markets are only available for species and sizes of the trees that really should be retained following the thinning, then thinning should not be done.
- Appropriate equipment needs to be available for thinning. If bulky equipment that usually handles large logs is used to thin a stand of small trees, the trees that should be retained are commonly so damaged that the future value of the stand is lost. Similarly, if the only available equipment will ruin the soil, the thinning probably should be avoided.
- Stands to be thinned are commonly not perfectly uniform in topography, tree size, and species. Consequently, the thinning methods will need to vary somewhat over the area.
- Thinning is best done under the guidance of a professional forester (such as one certified by the Society of American Foresters and legally permitted to practice forestry in the state). This professional will be knowledgeable about local markets, good loggers with appropriate equipment, needed permits, and appropriate thinning techniques.
- State forestry and Extension agencies can be helpful in putting Tree Farmers in touch with knowledgeable foresters.
Several thinning guidelines are also available online, such as <http://oak.snir.moissouri.edu/silviculture/tools> (see "Spreadsheets") and <www.umaine.edu/fas/wagner/publication%20files/randolph_etal-thinme_paper-njaf2005.pdf>.

In almost all cases, the operational cost of thinning is greater than the cost of a final harvest because the equipment needs to maneuver around the remaining trees in a thinning. The exception is when the thinning simply removes the large, valuable trees and does not spend effort on protecting or harvesting the smaller, less-valuable trees. In this case, the thinning probably severely reduces the value of the residual stand. Such a practice is known as "high grading" and is strongly discouraged by most foresters.

This article will describe commercial thinning opportunities in both single and mixed species, even-aged stands. I will first describe the development patterns and thinning opportunities in single-species stands, followed by a similar discussion of mixed-species stands. The single-species discussion can be thought of generally as conifer stands, with the mixed species being hardwood stands. This generality is not universal, since there are mixed-species conifer stands in western North America (e.g., Douglas-fir/western hemlock/western red cedar) that would follow the principles of mixed-species stands described here.

Development and Thinning of Single-Species, Even-Aged Stands

Figure 1 shows a schematic even-aged stand of a single species changing over time. Trees compete with each other for sunlight, moisture, nutrients, and other factors; however, for purposes of this article, we shall assume light is the important factor. The green leaves in the tree's crown (the living branches and foliage) absorb light, convert it to energy, and feed the rest of the tree.
This food keeps the tree alive, and the tree uses any excess food for growth. The growth is prioritized as height growth (highest priority) and then a combination of diameter growth and insect/disease resistance. Those trees that have small canopies because they are shaded by other trees can eventually die because they receive insufficient sunlight (energy). The most successful trees (referred to by foresters as "dominants") are generally the tallest, have the largest canopies, and the largest diameters. Others (codominants) can be more crowded and so are usually slightly shorter in height, have smaller canopies for future growth, and are noticeably smaller in diameter. Still others (intermediates) can have very small canopies and small diameters relative to their heights. Finally, others (overtopped or suppressed) may have extremely small canopies and such small diameters relative to their heights that they cannot hold themselves up; they are highly susceptible to insect infestations and even death.

Responses of Trees to Thinning: When the surrounding trees are removed by thinning, trees of different crown classes (e.g., dominant, codominant, intermediate, and overtopped) behave differently.

- The dominants continue to grow vigorously and get larger in size. They may grow even faster if the lower branches are kept in the sunlight by removal of the other trees.
- The codominants may slowly increase their growth and get larger, although less rapidly than the dominants since they need to rebuild their canopies in the increased sunlight before they can grow.
- The intermediate trees generally will not increase in growth very much, since they first must use the extra sunlight to increase their crown size and area of green leaves. They may fall over (buckle) if there are no trees around them to lean on.
- The overtopped trees will generally show little response to release, except perhaps fall over or die from the unaccustomed exposure to the sun.

Following thinning, most hardwood species and some conifer species develop small branches along their stem below their main crown. These branches (a.k.a., "water sprouts," "adventitious sprouts," or "epicormic sprouts") generally reduce the timber value of the stem if they persist. A thinning that removes few trees and leaves vigorous dominant trees allows shade to return to the tree stems rapidly and kills the sprouts before they can grow large and affect timber value.

Thinning Techniques and Objectives: Thinning reduces tree crowding, with several objectives:

1. By removing the intermediate and overtopped trees, thinning captures the timber value of these trees before they die and become worthless.
2. By removing some dominant and codominant trees but leaving others, thinning puts the growth on fewer dominant and codominant trees to make them larger.
3. By removing trees of poor quality, the remaining trees of better quality have more sunlight for more rapid growth.
4. By removing only some trees, thinning obtains some wood and/or revenue, while having more wood and/or revenue available in the near future.
5. By removing the crowded, weakened, and dying trees and avoiding crowding of other trees as they grow, thinning reduces the insect or fire danger.
6. Thinning also provides more light to the forest floor, so more plants can grow for wildlife, aesthetic, and other purposes.

Terminology of Thinning: To achieve these various objectives, different techniques are used that remove trees of different classes. These techniques are referred to below (from Silviculture Terminology of Society of American Foresters, prepared by the silviculture instructors subgroup of the Silviculture Working Group of the Society of American Foresters in 1994):

- Low thinning (thinning from below): Removal of trees from lower crown classes to favor trees in upper crown classes.
- Crown thinning (thinning from above, high thinning): Removal of dominant and codominant trees to favor the best trees in those same crown classes.
- Selection thinning (dominant thinning): Removal of dominant and codominant trees to favor trees in lower crown classes.
- Mechanical thinning (geometric thinning): Removal of trees in rows or strips using fixed spacing intervals.
- Free thinning: Removal of trees to control stand spacing and favor desired trees using a combination of thinning criteria without regard to crown position.

Timing of Thinning: Commercial thinning cannot begin until the trees are large enough to be commercially sold. The smallest size that a log can be sold (the "minimum merchantable size") depends largely on local markets and species. The minimum merchantable size fluctuates with the economy as well.

Sometimes, stands contain so many stems that none of them can grow to commercial size and a precommercial thinning is done.

If commercial thinning is done too late, the residual trees may have crowns too small to respond and grow — and may even fall over without neighbors to lean on. Specific tables and diagrams to aid thinning timing and spacing have been developed and can be found on various websites, described above. Very general rules are:

- Do not let the tree spacing become less than 20 percent of the dominant tree height before thinning, although...
I personally prefer a slightly wider spacing.
- Ensure the residual trees have at least a 40-percent live crown ratio (vertical length of green foliage divided by total tree height).

If the stand is more crowded than these standards and one insists on thinning, it is prudent to remove few trees during the first thinning — and perhaps a few more five or 10 years later — to allow the residual trees to stabilize.

The spacing to leave after thinning depends largely on the site (tree growth potential based on the soil, climate, and other physical factors) and how long one plans before returning for another thinning or final harvest. A common tendency is not to wait long enough following the thinning for the residual trees to grow enough to capture the benefits of thinning. Generally, 10 or 15 years is needed.

Development and Thinning of Mixed-Species, Even-Aged Stands

Figure 2 shows a schematic even-aged stand of mixed species changing over time. Once again for purposes of this article, we shall assume light is the important factor. The stand generally behaves similarly to the single-species stand described above, with certain notable differences:

- Some species fall behind others in height growth.
- Those falling behind either live in the shade of the taller species — or die if they cannot survive in this shade.
- Those surviving in the shade generally quit growing straight and slow in height and diameter growth. They begin producing a crooked stem from the height at which they first become shaded. (As exceptions, spruces, firs, and sugar maples seem to maintain a straight stem somewhat better than other species when thus shaded).
- The resulting stand appears in canopy layers, or “strata,” of different species. (These strata have been

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Figure 2. Schematic development of a mixed-species, even-aged stand, typical of hardwood stands when juvenile (A), young (B), and ready for a commercial thinning or harvest (C). Brackets to right show canopy strata. (No trees are shown in the “Emergent,” or A-stratum.) Black crowns show shade-intolerant species that becomes overtopped and dies (dead stems shown in “C”). Striped crowns show shade-intolerant species that dominates the upper continuous stratum (B-stratum). Gray crowns show species of intermediate shade tolerance that survive in shade. White crowns show extremely shade-tolerant species.
labeled as shown in Figure 2C).

- Individuals still compete and form "dominant," "codominant," "intermediate," and "overtopped" trees within each stratum.
- The taller trees in full sunlight grow much faster than the shaded, lower-strata trees and soon appear older than the other trees and give the stand an all-aged appearance.

Responses of Trees to Thinning in Mixed-Species Stands: Within each stratum, the remaining trees of each crown class respond to thinning as did the single-species stands, except that even dominant trees in lower strata respond slowly if they are still in shade. Other factors also need to be considered when thinning mixed-species stands:

- Depending on the species, trees released by thinning may produce water sprouts that degrade their value. These sprouts can be minimized or avoided by releasing the most vigorous, dominant trees and by leaving surrounding smaller trees of lower strata — known as "trainer trees" — to keep the target trees' stems shaded.

- Dominant trees (trees with large canopies) in shaded strata (e.g., "C" or "D" strata) are extremely difficult to release by thinning. One problem is that they commonly break or become scarred as the taller trees are removed. Another problem is that, although they may rapidly increase in diameter, they will continue to produce a crooked but fatter tree wherever the stem had a crook from growing in the shade. Consequently, the log is often crooked and so its value for timber is commonly low.

- Another practice, timber extraction, can occur in mixed-species stands where currently only a few species have value, but markets are expected to develop for other species soon. In these cases, crown thinnings and free thinnings can remove the currently valuable trees while keeping the others alive until they, too, can be sold. Too much timber extraction can eventually lead to a high-graded stand of no current or potential value, at which time all merchantable and unmerchantable trees need to be removed and a new, even-aged stand begun if timber of much value is to be sustained.

A generally recommended practice is to space out the dominant trees in the B stratum, leaving smaller, trainer trees between them to keep limbs pruned and water sprouts from forming. Since the quality and value of hardwoods are generally based on their size and lack of knots, a wide spacing of dominant trees is recommended. Somewhere between about 40 and 100 such dominants (a spacing of between 20 and 35 feet between trees) can be left, with fewer trees left on more productive sites.

Except for trainer trees around the stems of crop trees, other trees can be removed in commercial thinnings if they have value.

As described above, an occasional, dominant C-stratum tree can also be released to fill a "gap" in dominant trees if it has a straight section of stem that is long enough to form a merchantable log as it grows in diameter.

Uneven-Age Management and Thinning
A common mistake in mixed-species stands is to assume that the smaller trees are younger, can be released by removing the overstory trees in a thinning, and that this process can continue indefinitely. This mistaken assumption is based on an outdated scientific theory that smaller trees of shade-tolerant species in mixed-species stands are most commonly younger trees that will naturally replace the larger ones in an all-age manner. Beginning in the 1970s forest scientists learned that stands do not commonly grow in the all-age manner, and the smaller trees in mixed stands are generally ones of the same age that lapsed behind — or ones that began from a later disturbance.

If the overstory trees are removed in such mixed stands (Figure 3), both the remaining trees in lower strata will grow and new trees will become established and begin growing. Both the lower-strata trees and the newly establishing ones will commonly grow with the crooks described earlier. In addition, the new trees will be of species that can live in the shade — generally not the more valuable species that is often originally in the B-stratum.

![Figure 3. Schematic uneven-aged treatment of stand in Figure 2C. Removal of dominant canopy released shade tolerant species with crooks formed while growing in shade, and also caused new, crooked stems of shade-tolerant species to regenerate.](image)
Thinning has been used to create and maintain an all-age stand that continues to produce a mixture of species, valuable timber, and other values; however, it is a difficult, costly, and time-consuming process. Other considerations are needed:

- Very few trees can be left after harvest (e.g., 12 trees per acre or fewer; a spacing of 60 feet; Figure 4) without dramatically slowing the growth or killing the new age class beneath.
- Even fewer residual trees — perhaps four per acre — can be left without their shade — favoring species that live in the shade and kill light-demanding species in the new cohort (age class). Consequently, leaving a few overstory trees can cause a formerly oak-dominated stand to regrow as a sweetgum or sugarberry stand; a Douglas fir stand to regrow as a hemlock stand; and a southern pine stand to regrow as a hardwood stand.
- The younger age class needs to be thinned — usually before the trees are merchantable — to avoid their becoming overly crowded and so unable to respond to a later thinning.

Commercial thinning is a science and an art that allows the Tree Farmer to put his or her personal stamp on the stand. Not all stands are suitable for thinning — depending on the landowner objectives, markets, skills of the loggers, and terrain. The nuances of thinning are such that a trained forester can generally identify years later who managed the thinning operation. Even with these variations, thinning can often be very rewarding for everyone and for many objectives if done properly. If done wrong, however, commercial thinning can destroy the present and future value of the stand.

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Figure 4 A. Schematic harvest of stand 2C, in which so many reserve trees were left that new cohort (age class) grows slowly and favors shade-tolerant species.

Figure 4 B. Schematic harvest of stand 2C, in which few reserve trees were left, so that faster growth and intolerant species are favored in the new cohort (age class).