Planting and Care of Fine Hardwood Seedlings

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Fertilizing, Pruning, and Thinning Hardwood Plantations

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This publication outlines the cultural operations of pruning, fertilizing, and thinning that can greatly enhance the timber value of a plantation. This summary is based on the findings of many individuals. While there are alternatives to many of the recommended practices and differences of opinion existing among professionals, our purpose is to give the landowner a set of general guidelines that have provided good results under a broad range of circumstances.

Fertilizing

Plantations will often benefit from fertilization, especially if the fertilizer is accompanied by chemical weed control (Pope et al. 1982). Additional fertility will not help if other factors such as water or light are limiting growth. Soil nutrient and soil pH analysis during the planning stage can help to identify which species and soil amendments should be considered. A soil pH between 6.5 and 7.2 is optimal for most fine hardwood species. By raising the pH of an acid soil (pH of 5.0 to 6.0), additional nutrients will be made available for trees and may make fertilization unnecessary. Correct a low pH soil with lime during site preparation in the fall before planting. Lime should be incorporated into the top 6 or 7 inches of soil by disking.

Hardwood seedlings should not be fertilized the year of planting unless the fertilizer is a slow-release formulation, the fertilizer is thoroughly mixed into the surrounding soil prior to planting, or it is uniformly broadcast on top of the soil just prior to or after planting. The roots of young trees are damaged by contact with concentrated nitrogen fertilizers, and bare-root trees planted with fertilizer near the stem are susceptible to frost heave in the spring and drought in the summer. Drought or weed competition will override any growth benefit a fertilizer application may produce in the first year. Fertilizers increase the growth of weeds that retard the growth of first-year trees. Thus, do not fertilize first year seedlings unless a good weed control program is planned.

On very good sites, soil nutrient levels are usually adequate for good growth, at least while the trees are young. Nitrogen (N) is the basis for most fertilizer recommendations. Recommended nitrogen fertilization rates are based on actual amounts of N rather than amounts of fertilizer. For example, application of 100 pounds per acre of 12-12-12 (12 percent N-12 percent P-12 percent K) fertilizer only provides 12 pounds of actual N per acre. One general guideline is to apply 0.13 pounds of N per inch of stem diameter per tree (Garrett et al. 1996). Nitrogen is best applied in small amounts at regular intervals throughout the growing season, but it is usually more practical to make a single application in mid- to late spring, or a split application: half in mid- to late spring and half in early to late summer. Granular fertilizers are broadcast onto the surface of the soil. Fertilizer is most effective when applied just prior to a good rainfall.

Pruning

The purpose of pruning is to train trees to a single straight stem and develop more valuable, knot-free trunks. Pruning and thinning should be considered together. It is unwise to waste time pruning a weak, poorly formed tree that will be removed at the next thinning. High-density plantations or hardwoods planted with alternating rows of conifers will have lower pruning costs than low-density plantations. The larger the initial tree spacing, the more artificial pruning will be required to produce a clear bole. The close spacing of trees in high-density plantations forces an upright growth habit and causes natural pruning of the lowest branches as a result of lack of light.

How does pruning help?

Pruning some branches increases the growth rate of the remaining branches (Ramos et al. 1998). This invigorating effect lasts for one year. By directing the tree's growth through pruning, one can improve the growth and form of the tree. In contrast, careless pruning can significantly reduce growth, introduce disease, and reduce timber value.

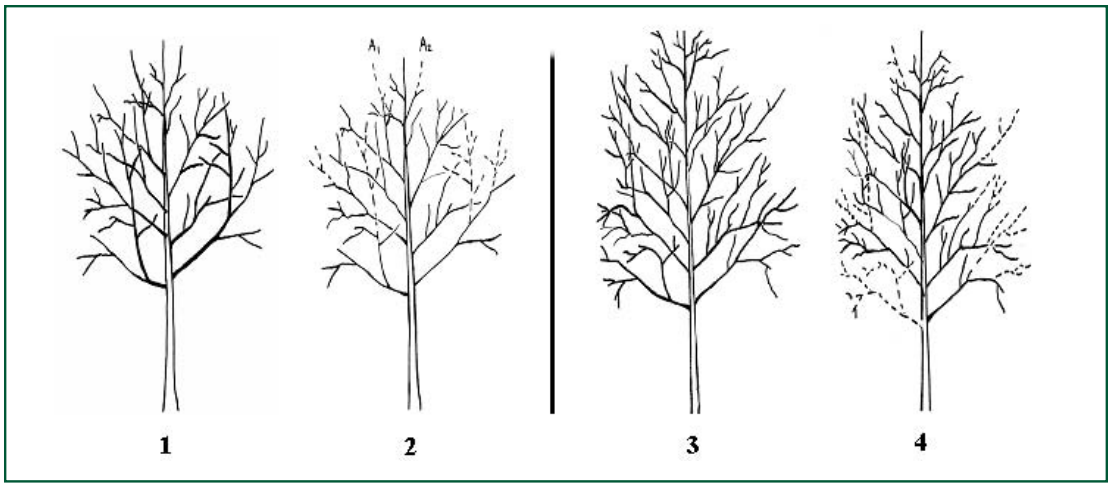

Figure 1. *Pruning a young tree. The tree at position (1) should be pruned as shown in (2). Removed branches (dotted lines) at A_1 and A_2 are competing leaders that could create forks. Subordinating the lower limbs prevents them from becoming too large. To subordinate a limb, remove the leader back to a point where it forks with a smaller limb that has a diameter 1/3 to ½ as large as the leader. After a year of growth, the tree is ready for more pruning (3). Again, starting at the top of the tree, remove any co-dominant leaders and any limbs growing from the bottom half of the tree into the top third. Subordinate the leaders of dominant side limbs to keep them from growing too large. The lowest limb at (4) has been thoroughly subordinated and now can be removed. The other lower limb has been suppressed and should not increase much in diameter.*

When to Prune

Pruning to develop a single stem can begin when trees are 2-years-old. Young trees 1- to 6-year-old are most commonly pruned in late winter, as close to bud break as practical, so that the pruning cuts will be overgrown rapidly with the onset of active growth in the spring. Older trees may be pruned in the summer or when they are dormant.

Figure 2. *The branch collar and bark ridge are very apparent on this northern red oak. The branch collar (left) is the swollen area at the base of the branch where it attaches to the trunk. It is formed by overlapping and deflected branch and trunk wood. Within the branch collar, a branch protection zone forms to prevent decay of the trunk. The bark ridge is a raised area of bark at the point where the branch attaches to the trunk. A properly pruned large branch one-year later (right). Note that the branch collar is intact and the healthy ring of callus surrounding the cut.*

What to Prune

Creating a healthy, structurally sound tree with good branch architecture should take precedence over the rapid production of a long, branchless trunk. The most common problems that require pruning are codominant stems (upright branches that compete with the main leader of the tree), low limbs growing upward into the canopy, forks (vigorous lateral branches arising from the central leader with a narrow, less than 45° branch angle), dead branches, epicormic sprouts, and branches that cross over each other. Pruning should start at the top of each tree and proceed down to the trunk. This top-to-bottom approach is valuable because at the top of the tree, where branches are small in diameter, future large problems can be corrected early (Fig. 1). Pruning to maintain a strong central leader results in a longer merchantable log, which increases the value of a tree.

Regardless of tree age, step one is to remove any dead, broken, diseased, or dying branches. Step two is to identify the main stem or leader, any branches that will compete with it, and decide how much of the competing stems should be removed. Step three is the suppression or removal of lower limbs, or vigorous branches that are growing upward into the canopy. Any branch that originates in the bottom half of the tree that has grown into the top third of the canopy should be either removed or subordinated. No more than 25

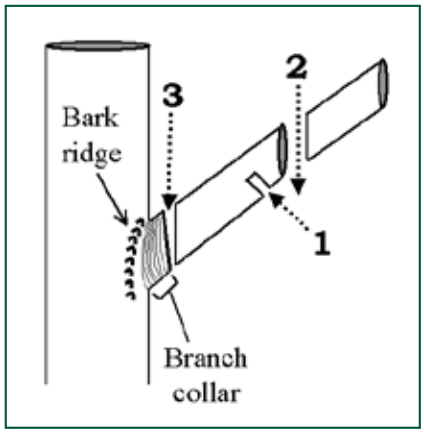

Figure 3. *Three-step pruning of larger limbs. The numbers and arrows show the order and direction to saw. The first cut is a notch about 1/3 the diameter of the stem, several inches above the branch collar to protect from tearing bark down the trunk. The second cut removes most of the branch. The final finish cut is perpendicular to the branch, following the outside edge of the branch collar. If the branch collar is not visible, cut perpendicular to the branch being removed with the top of the cut being no closer to the trunk than the bark ridge.*

to 30 percent of the foliage should be removed in any year, especially if a tree is mature. Side limbs should be pruned before they reach 1 inch in diameter (Gilman and Lilly 2002). One and a half to 2 inch limbs may also be pruned safely if proper technique is used. Lower limbs larger than 2 inches may be cut back to a short stub and gradually removed over a 2 to 3 year period.

Trees suddenly stripped of side branches become spindly and susceptible to damage during wind or ice storms. Pruning too many limbs can lead to bole sprouts (epicormic sprouts). Hardwood species differ widely in their tendency to grow epicormic sprouts. For example, white oak is very prone to epicormic sprouting. Epicormic sprouts should be removed as soon as possible because they will lead to the formation of knots.

Timber trees must have a harvestable butt log with a clear stem a minimum of 8 ½ feet in length. Side limbs should be pruned to a height of 9 or 10 feet to allow for stump height and trimming. To produce two logs, a tree must have a clear stem 17 feet in length requiring pruning to a height of 18 to 20 feet.

How to Prune

Pruning tools are chosen based on the diameter of the branch to be pruned. Small branches, ¼ to 1 inch in diameter, may be pruned with a pair of hand shears or loppers. Avoid using anvil type pruning shears because their crushing action will damage the branch collar and slow the recovery of pruned stubs. Use bypass type shears that cut with the same action as scissors (Figure 4E and F). Pole pruners are used to reach branches up to 24 feet from the ground, and can also be used to eliminate small-diameter side limbs that may grow into forks (Fig. 4D). Larger limbs, 1¼ inch or greater, typically require the use of a saw. Power saws and handsaws can be attached to poles for working high in the canopy (Figure 4 A and C). In agroforestry plantations (widely spaced tree rows) and other types of low-density plantations, a pruning tower or motorized lift can be used for pruning. Pruning is always easier, and cuts will recover more quickly and completely, when shears and saw blades are sharp.

Limbs should always be pruned so that the branch collar is intact, never flush to the trunk (Fig. 2). The branch collar slows the entry of decay causing organisms (Gilman and Lilly 2002). Cut at the upper, outer edge of the branch collar, starting just outside the bark ridge, perpendicular to the branch being removed. Some tree species do not have visible branch collars like the one shown in Figure 2. Limbs of these trees have a branch protection zone in the same place, and one should prune as if it was visible. The three-step method of pruning should be used for larger branches that require the use of a saw (Fig. 3).

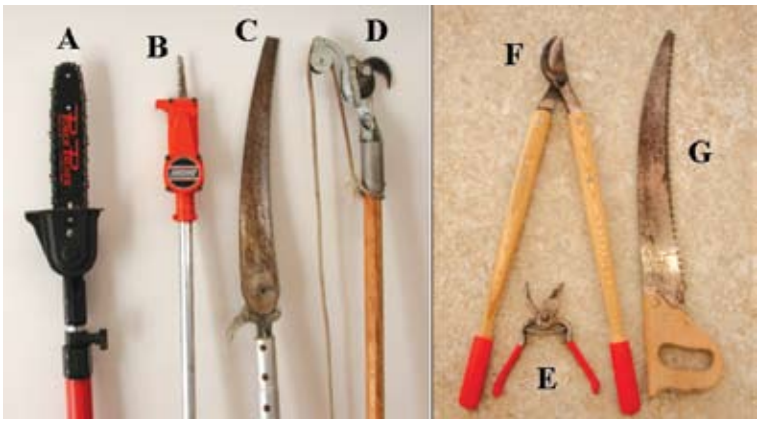

Figure 4. *Pruning tools. The saws (A and B) are powered by 2-stroke gasoline motors. Both have telescoping poles that reach as high as 12 to 16 feet. The hand pole saw (C) has 6-foot aluminum pole sections that can be added to reach high limbs. The pole pruner (D) can cut limbs up to 1- to 1 1/4-inch diameter with extra 6-foot sections to extend the reach. Bypass style hand shears (E), lopping shears with 2-foot handles (F), and a handsaw (G).*

Coppicing

Badly malformed trees may be cut back close to the ground, a pruning technique known as coppicing. This low coppice should take place while trees are dormant. If there is plenty of light, the stump will typically produce several shoots. The larger the diameter of the coppiced stump, the more shoots will grow. A single shoot should be selected from the many stump sprouts after 1 or 2 years of growth, and the other competing branches and stems removed.

A high coppice can be used to rescue young trees with form defects. Trees may be pruned back to a bud or a point just below where the crookedness or damage is found (Fig. 5). Side branches below this point should be removed or subordinated to encourage the growth of a new, dominant leader. Multiple stems will often form as the result of a high coppice and follow-up pruning is essential if another fork is to be avoided.

Figure 5. *This seedling suffered deer browse during its first year in the plantation. Rather than selecting a single central leader prior to the second growing season from among the many side limbs, it was coppiced below the multiple stems. The remnant of last year's trunk (painted white) shows the vigor and straightness of the new leader that has more than doubled the tree's diameter.*

Thinning the Stand

As a plantation matures, trees become crowded and competition among trees causes growth rates to decline. Thinning is the selective process of removing or killing some trees to allow the remaining trees to maintain a steady growth rate. Thinning also provides the opportunity to selectively remove poorly formed trees and species of lower value. The need for thinning will arise faster and be more important for high-density plantation on good sites with high survival. If there is a lot of variation in growth and survival, thinning may be necessary only in areas where the trees are very dense. In some cases, thinning will be directed at trees that grow above and shade out smaller higher quality trees. Some species may drop out of a mixed species planting if competition becomes too great and thinning is not practiced. Contact your local district forester for advice, or consider hiring a private consulting forester to help you with thinning.

Because the goal of thinning is to maintain a steady growth rate, monitoring the growth rate of the trees is important. The standard forester's measure of growth rate is the annual increase in diameter at breast height (DBH) of the trunk. To measure DBH, measure the circumference of the trunk 4 ½ feet above the ground, and divide the circumference by π, 3.14. The annual growth rate is determined by subtracting the previous DBH from the current DBH, and then dividing the difference by the number of years between measurements. Because it is not practical to measure every tree in a plantation, measure ten representative trees per acre of each species. Mark each tree with a number and map them so that the same trees are re-measured. Waiting until the trees show obvious signs of suffering from crowding can result in trees that are slow to respond to thinning if they respond at all. If DBH has been averaging 0.40 inches per year and drops to 0.25 inches over a 2- or 3-year period, thinning is necessary.

Trees planted at high density usually require two pre-commercial thinnings before harvest. In pure hardwood plantations, a first thinning will typically be necessary when the trees are 8 to 15 years old, just before the crowns start to touch each other (crown closure). The second thinning occurs when trees are between 20 and 25 years of age (Fig. 6). Thinning pre-commercial trees is expensive, but the costs of the second thinning can be offset if a pulp, pole, firewood, or chip

***Table 1**. Tentative stocking guidelines for growing high quality black walnut on good sites[1].*

				Recommended stocking and spacing after thinning or releasing for different product objectives[4]			
	Stocking and spacing when crowns begin to touch[2]			Veneer logs		Veneer logs and nuts	
Avg. stand DBH (inches)	No. trees per acre	Tree spacing (feet)[3]		No. trees per acre	Tree spacing (feet)	No. trees per acre	Tree spacing (feet)
2	889	7		258	13	222	14
4	360	11		170	16	151	17
6	222	14		121	19	109	20
8	151	17		90	22	82	23
10	109	20		70	25	60	27
12	76	24		56	28	48	30
14	60	27		45	31	40	33
16	48	30		40	33	36	35
18	40	33		36	35	30	38
20	32	37		32	38	25	42
22	27	40		--	--	--	--
24	24	43		--	--	--	--

[1] Source: Adapted from Phares (1973).
[2] Based on the equation: crown width (feet) = 1.993 × diameter at breast height (DBH) in inches + 4.87 (Krajicek and Bey 1969).
[3] Square row and tree spacing.
[4] These values are based on the assumption that crop trees will grow 4 inches in diameter before they need to be thinned or released

market can be found for the removed stems. Thinning costs are lower where hardwoods are mixed with pine in alternating rows. In mixed hardwood-conifer stands, the first pre-commercial thinning is usually unnecessary, as the pines will be overtopped and start dying around age 15 to 20. Only the hardwood rows need to be thinned at a time corresponding to the second thinning, when trees are 18 to 25 years old. At the completion of the second thinning of pure hardwoods, or the first for the pine-hardwoods in alternating rows, about 100 crop trees per acre remain.

The first commercial thinning can begin when trees are 30 to 40 years old, depending on site conditions; or when the trees are about 14 inches in diameter. At this stage, 40 to 50 of the 100 crop trees are removed. A second commercial thinning occurs 10 to 15 years later when the trees are about 18 inches in diameter. The second commercial thinning should leave approximately 40 crop trees per acre. These trees can be removed gradually over the next 20 years, depending on site and market conditions, as the trees reach the 22 to 24 inch diameter class. Stands managed in this manner should have plenty of natural regeneration and can be managed for the long term as forests.

Foresters have developed a number of ways to determine when and how many trees to thin. All thinning guides are based on growth and number of trees per unit area. One of the most common measurements for defining stand density and evaluating thinning is basal area. The basal area of a stand is calculated by converting the average DBH to cross sectional area in square feet, and multiplying the value by the number of standing trees per acre (see formula below and measure DBH in inches). A basal area in the range of 40 to

***Figure 6.** The second thinning of a 21 year-old pure walnut plantation on a moderately good site. The density of the plantation has been reduced to about 175 trees per acre from an original density of 302 per acre (planted at 12-foot × 12-foot spacing).*

175 square feet per acre should be maintained (Smith et al. 1997). For example, if there are 200 trees per acre and the average DBH is 12 inches, the basal area is 157 square feet. The higher the quality of the site, the higher the basal area that can be maintained. Except for young trees (less than 5 inches DBH), a basal area of 40 – 70 will result in maximum growth. The best basal area for any particular stand depends on tree size, site quality, and management objectives; for details

Basal area (ft^2) = Number of trees per acre × [0.00545 × (average DBH)^2]

see Central Hardwood Notes 5.07, available online at: http://NCRS.fs.fed.us/pubs/ch/ch_5_07.pdf. Landowners should determine a target basal area and schedule periodic thinnings to maintain target goals. District foresters can provide optimum basal area values for species and sites in particular regions.

If trees are irregularly spaced, or the space between rows is more than twice the distance of trees within rows, a decision about thinning can be made by looking to see if the crowns of crop trees are touching neighboring non-selected trees. The crown of each crop tree can be divided into four equal quadrants and the "freedom to grow" in each quadrant can be assessed (Perkey and Wilkins 2001). Crop trees at least 25 feet tall should be released in three to four quadrants, but keep the bole of crop trees shaded to promote the natural pruning of lower limbs and minimize the potential for epicormic sprouting. Avoid removing a tree growing on the south side of a crop tree, doing so will expose the bole of the crop tree to full sunlight.

It is easy to remove trees that are diseased, poorly formed, leaning, stunted, or damaged, but thinning requires the elimination of trees that have good timber potential in order to make room for trees with even better potential. One half of the trees in a plantation initially planted at 10-foot ×10-foot will need to be removed by about year seven. In a high-density plantation planted at 7-foot × 7-foot spacing 3/4 of the trees will need to be thinned out after 12 years, or once the average DBH reaches 6 inches (Table 1). Through mortality or thinning, a fully mature stand will contain only 35 trees per acre spaced at approximately 35-foot intervals. Site quality, stand management history, and natural regeneration within the plantation will affect thinning and future management decisions.

Thinning can be accomplished any time of the year, however, thinning during the dormant season offers many advantages. Mark trees to be removed with tree paint. If more trees will be removed than retained, mark those to keep instead. Small trees under 4- to 6-inch DBH are best removed by sawing them down. Always wear the appropriate safety gear when operating chainsaws. For larger jobs, tractor mounted shears are available that can cut trees faster than chain sawing. Some foresters will treat freshly cut stumps with special forestry herbicides to eliminate sprouting from stumps. Depending on the species and the amount of light received, stump sprouts may die over time from lack of sunlight and not compete with crop trees.

Trees greater than 6-inch DBH can be killed by girdling. Girdle a tree by cutting two continuous rings, at least 2 inches apart, through the bark and around the circumference of the trunk with a chainsaw or hatchet. Some girdled trees will grow new branches below the girdled cuts. To reduce the number of trees re-sprouting, some foresters apply herbicides into the fresh cuts. A girdled tree left standing will become a dried-out snag that will be easier to remove and to haul away than a green tree, and will also provide some shade and training for neighboring crop trees. Standing snags may provide benefits such as habitat for wildlife, but snags can also be a hazard to equipment operators and others moving around in the stand.

The use of herbicides to kill trees in a plantation can be risky because of flashback, and drift or runoff of herbicides can harm crop trees. Flashback is the injury of neighboring trees by the application of an herbicide as a result of root grafting or when the treated tree is releasing the herbicide from its roots. Flashback is more prevalent when trees are large and close together. Walnut is thought to root graft infrequently, while oaks are thought to root graft readily. When using herbicides to kill trees in a plantation, follow all label directions carefully and seek professional help when in doubt to avoid damaging valuable trees. It may be wise to conduct a test on a few trees in advance of treating an entire plantation.

The cheap and easy way to dispose of cut logs is to leave them where they fall to decompose, as logs do in natural forests. Logs may be chipped on-site by using a portable chipper, and the wood chips scattered throughout the plantation. If a chipper is not practical, logs can be trimmed and the main stem and large limbs can be hauled out of the plantation.

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Other Resources

Web sites for additional information

Pruning

http://www.na.fs.fed.us/spfo/pubs/howtos/ht_prune/prun001.htm

http://www.agcom.purdue.edu/AgCom/Pubs/FNR/FNR-76.html

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