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# TIMBER STAND IMPROVEMENT

## In Ohio Woodlands

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**Acknowledgements**

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Table 2. 1970. *Managing Woodlands for Wildlife.* U.S.D.A. Forest Service, State and Private Forestry, Northeastern Area. 16 p.

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Table 4. Prepared by Robert L. Brisbin, Research Forest Products Technologist, U.S.D.A. Forest Service, Northeastern Forest Experiment Station, Delaware, Ohio, and William F. Cowen, Jr., Extension Forester, The Ohio State University.

Table 5. Beers, T. W. 1964. *Composite Hardwood Volume Tables.* Purdue University Agriculture Experiment Station Research Bulletin 787. 12 p.

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# Timber Stand Improvement in Ohio Woodlands

## Objectives

Timber stand improvement (TSI) and thinning are forest cultural treatments that require the selective removal of undesirable trees, vines or large shrubby species from forest stands to concentrate the growth energy of the site on the more desirable trees. If the material to be removed is salable or usable, it is harvested; otherwise it is killed with an herbicide.

Thinning is especially applicable in plantations or natural stands where the trees were all planted or started to grow at the same time. In this type of situation, the trees are even-aged and relatively uniform in height and diameter. TSI is most often applied to stands that are more variable in age, height, diameter and species composition. A landowner who uses TSI or thinning can control the kind of trees and increase the growth rate and quality of the trees remaining in the woodland.

TSI is the basic forest practice necessary to initiate forest management on hardwood forest areas. Ohio timberlands have been producing commercial wood products since the early 1800s. The average cutting cycle has been about 20 years. This means that most established woodlands could have had as many as nine harvest cuttings. During most of the harvest cuttings, only the highest value timber was removed. From a timber buyer's standpoint, this method of operation is economic common sense. For a forest landowner, it may mean that less desirable trees are left after each harvest. After eight or nine harvests in a woodland not under forest management, it is possible to build up a high proportion of undesirable trees that may not be salable for any purpose.

A landowner who uses TSI or thinning can manipulate forest vegetation and produce the kind of forest that matches ownership objectives. Three general situations will be described.

### Veneer and Sawlogs

Tree value differs greatly depending on species, size, quality and end use. Based on recent Ohio timber prices for sawtimber stumpage, black walnut, black cherry, white ash, white oak, red oak, hard maple, soft maple, yellow poplar (tuliptree) and basswood were more valuable than hickory, pine, elm, beech, cottonwood, blackgum and sycamore.

For example, white oak can be used for pulpwood, pallets or blocking, firewood, sawtimber, cooperage and face veneer in increasing order of value. As you go up the scale, larger and higher quality stems are required. If timber production for sale as stumpage is your goal, it is important to work with the kind of tree capable of producing a high value product. From the commercial viewpoint, there is a tremendous difference between 20 acres of decadent beech and 20 acres of white oak or walnut that has face veneer potential. To keep track of the values of different kinds of trees for differing products, you may want to have your name placed on the mailing list for the Ohio Timber Price Report. Issued twice a year, the report is available from the Ohio Crop Reporting Service, Room 608 Federal Building, 200 N. High Street, Columbus, Ohio 43215 (Appendix A).

Table 1 will help landowners who want to know how many board feet are contained in standing trees if the trees are cut, hauled to a sawmill and sawed into 1-inch thick boards. To use this table, you must know the diameter in inches of the tree measured at a point 4¼ feet above the ground (dbh). In addition, you need to calculate the usable height of the tree measured in 16 foot and 8 foot increments to an 11-inch diameter at the end of the top log, or until heavy branching or defects are encountered. For example, a tree that is 18 inches in diameter and has 40 feet of usable length (2½ 16-foot logs) would contain 200 board feet if estimated by the Doyle tree scale in the standing tree.

### Wildlife

Almost all of the trees and shrub species found in hardwood forests have some value for wildlife as sources of food or cover. Some kinds of trees valuable to wildlife are not highly valued for timber production. For example, American beech is not a valuable timber spe-

**Table 1: Tree Scale (Doyle)**

| Dbh | Number of 16-Foot Logs | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ½ | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 |
| | Contents in Board Feet | | | | | | | |
| 12" | 20 | 30 | 40 | 50 | 60 | | | |
| 14" | 30 | 50 | 70 | 80 | 90 | 100 | | |
| 16" | 40 | 70 | 100 | 120 | 140 | 160 | 180 | 190 |
| 18" | 60 | 100 | 130 | 160 | 200 | 220 | 240 | 260 |
| 20" | 80 | 130 | 180 | 220 | 260 | 300 | 320 | 360 |
| 22" | 100 | 170 | 230 | 280 | 340 | 380 | 420 | 460 |
| 24" | 130 | 220 | 290 | 360 | 430 | 490 | 540 | 600 |
| 26" | 160 | 260 | 360 | 440 | 520 | 590 | 660 | 740 |
| 28" | 190 | 320 | 430 | 520 | 620 | 710 | 800 | 880 |
| 30" | 230 | 380 | 510 | 630 | 740 | 840 | 940 | 1040 |
| 32" | 270 | 440 | 590 | 730 | 860 | 990 | 1120 | 1220 |
| 34" | 300 | 510 | 680 | 850 | 1000 | 1140 | 1300 | 1440 |
| 36" | 350 | 580 | 780 | 970 | 1140 | 1310 | 1480 | 1640 |
| 38" | 390 | 660 | 880 | 1100 | 1290 | 1480 | 1680 | 1860 |
| 40" | 430 | 740 | 990 | 1230 | 1450 | 1660 | 1880 | 2080 |
| 42" | 470 | 830 | 1100 | 1370 | 1620 | 1860 | 2100 | 2320 |

**Table 2: Expected Yields of Fresh Acorns in Pounds Per Tree for Some Oak Species Common to the Northeastern United States**

| Dbh | Black | Chestnut | Northern Red | Scarlet | White |
|---|---|---|---|---|---|
| 10 | 1.1 | 0.9 | 0.4 | 2.5 | 1.9 |
| 12 | 1.7 | 3.0 | 2.2 | 3.9 | 3.6 |
| 14 | 2.3 | 5.0 | 5.7 | 5.6 | 5.2 |
| 16 | 2.8 | 6.0 | 10.0 | 8.0 | 6.9 |
| 18 | 3.4 | 8.1 | 14.5 | 12.1 | 8.6 |
| 20 | 4.0 | 8.9 | 15.8 | 14.8 | 10.2 |
| 22 | 4.6 | 9.8 | 17.1 | 17.5 | 12.0 |
| 24 | 5.2 | 10.1 | 15.4 | 17.9 | 13.6 |
| 26 | 5.8 | 10.5 | 13.8 | 18.3 | 15.2 |

Note: This table can be used to estimate pounds of acorns per acre. A circular acre has a radius of 117.8 feet, and a square acre is 208.5 feet on a side. In good oak country, wildlife will use as much as 85 pounds of acorns per acre. This is why it is important to have at least half the woodland acreage in sawtimber stands containing large-diameter trees.

cies, but beechnuts are excellent food for gray and fox squirrels, white-tailed deer, ruffed grouse, wild turkey and many songbirds. Beech has a decided tendency to develop heartwood rots at an early age. Hollow beeches make excellent den trees, but such trees are not usable for sawlogs. Black gum and maples also make good den trees when infected with heartwood rot.

Sawtimber stands produce the walnuts, hickory nuts, acorns, beechnuts and other fruit (mast) vital to maintaining wildlife populations. Oaks are common and important mast producers in Ohio forests. An estimated 85 to 90 pounds of acorns per year will satisfy the acorn requirements for wildlife in the area. Table 2 shows that eight or nine 20-inch diameter white oaks per acre will produce the necessary acorns in a normal production year. For sustained wildlife production the landowner should maintain a variety of mast producers. Large, dominant trees with big crowns produce the most mast. Table 3 is a guide in rating tree species for value to wildlife.

Recent information shows that dead, upright trees in all stages of decay are vital for nesting and feeding of many forest birds. These birds eat numerous potentially harmful insects. In a "cleaned" forest, these beneficial birds simply are not present or are rare. The landowner must weigh the hazards against the values of leaving dead trees, but we suggest that at least a few dead trees be left in separate parts of the forest.

## Firewood

Interest in firewood production has increased rapidly in recent years. The average Ohio oak-hickory or maple-beech woodland that is reasonably stocked with trees and 40 to 60 years old will produce about 40 cubic feet of wood fiber per acre per year or more in standing trees. One standard cord of wood is 128 cubic feet in volume when cut and stacked. It takes about 80 cubic feet in standing trees to equal 128 cubic feet of stacked wood due to the large amounts of air space in a stacked cord. Therefore, the growth rate of this forest is about one-half cord in standing trees each year. If you require eight cords of wood per year for your home heating requirements, 16 acres of this type of woodland might sustain your needs if firewood is the only wood product harvested.

**Table 3: Ratings of Tree Species for Value to Wildlife**

| Tree | Value to Wildlife: All Wildlife | Songbirds | Upland Game Birds | Fur & Game Mammals |
|---|---|---|---|---|
| Oak *Quercus spp.* | Excellent | Excellent | Excellent | Excellent |
| Black cherry *Prunus serotina* | Excellent | Excellent | Excellent | Excellent |
| Apple *Malus spp.* | Excellent | Excellent | Excellent | Excellent |
| Pine *Pinus spp.* | Excellent | Excellent | Fair | Good |
| Flowering dogwood *Cornus florida* | Excellent | Excellent | Good | Fair |
| Maples *Acer spp.* | Good | Good | Fair | Excellent |
| American beech *Fagus grandifolia* | Good | Fair | Fair | Excellent |
| Alder *Alnus spp.* | Good | Good | Good | Fair |
| Aspen *Populus spp.* | Good | Fair | Good | Excellent |
| Birch *Betula spp.* | Good | Fair | Good | Good |
| Spruce *Picea spp.* | Good | Good | Fair | Good |
| Hackberry *Celtis occidentalis* | Fair | Good | Fair | Fair |
| Hickory *Carya spp.* | Fair | Fair | Fair | Good |
| Ash *Fraxinus spp.* | Fair | Fair | Fair | Fair |
| American basswood *Tilia americana* | Fair | Fair | Fair | Fair |
| Black walnut *Juglans nigra* | Fair | Fair | Fair | Fair |
| Blackgum *Nyssa sylvatica* | Fair | Fair | Fair | Fair |
| Eastern cottonwood *Populus deltoides* | Fair | Fair | Fair | Fair |
| Elm *Ulmus spp.* | Fair | Fair | Fair | Good |
| Eastern hemlock *Tsuga canadensis* | Fair | Fair | Fair | Fair |
| Black locust *Robinia pseudoacacia* | Fair | Fair | Fair | Fair |
| Magnolia *Magnolia spp.* | Fair | Fair | Fair | Fair |
| Eastern redcedar *Juniperus virginiana* | Fair | Good | Fair | Fair |
| Sassafras *Sassafras albidum* | Fair | Fair | Fair | Fair |
| Sweetgum *Liquidambar styraciflua* | Fair | Fair | Fair | Fair |
| Sycamore *Platanus occidentalis* | Fair | Fair | Fair | Fair |
| Yellow poplar *Liriodendron tulipifera* | Fair | Fair | Fair | Fair |
| Willow *Salix spp.* | Fair | Fair | Fair | Fair |

One pound of oven-dry wood of any species will produce the same amount of heat. The problem is one of volume, not weight, and involves weight densities of different woods. From Table 4, note that shagbark hickory weighs about 50.9 pounds per cubic foot at 20 percent moisture content (MC), whereas eastern cottonwood weighs 29.2 pounds per cubic foot at 20 percent MC. An 80 cubic foot cord of shagbark hickory weighs about 4,072 pounds, but the same volume of eastern cottonwood is 2,336 pounds. Because 1 pound of wood at 20 percent MC produces about 7,000 BTU before the stove efficiency factor is applied, the cord of hickory will yield about 28 million BTU compared to about 16.3 million BTU for the cottonwood.

American beech and hickory are excellent sources of food for wildlife and are valuable firewood trees. They are not now high value timber trees. White ash is of less value for wildlife but is a valuable timber and firewood species. Sometimes it is necessary to compromise between timber, wildlife and firewood. For example, girdling a hollow beech will remove the tree from competition with higher quality neighboring trees while retaining a valuable den tree for many years, but this means sacrificing the use of the tree for firewood. Flowering dogwood is rated as an excellent species for all wildlife and has attractive flowers. It is also very dense, making excellent firewood. The choice of species to favor and species to remove in a TSI/thinning operation must relate to landowner objectives for that woodland.

Table 5 will help firewood cutters who want to know how many trees of a given size would be needed to make up 80 cubic feet of wood in standing trees. To use this table, you need to know the diameter in inches of the tree measured at a point 4¼ feet above the ground and the usable height of the tree up to a 4-inch diameter top. A tree that is 13 inches DBH and has 36 feet of usable height to a 4-inch diameter top would contain 20.8 cubic feet. Four trees of this size would yield about one cord when the trees are cut, split and stacked as firewood.

## Which Trees to Cut

Many unmanaged woodlots in Ohio are too dense and have a high proportion of defective trees. Grapevines in the crowns of desirable trees can also be a serious problem, especially on the better timber-growing sites. Occasionally, a woodlot will have large unsalable beech or other species scattered throughout a younger, even-aged stand. All of these situations offer opportunities for applying TSI to achieve various forest management objectives.

The decision on whether a particular tree should be cut depends mainly on the answers to the following questions: 1) Is the tree defective or an undesirable species according to management objectives in regard to wildlife, timber or other purposes? 2) Is the tree crowding a more desirable (crop) tree?

If the answer to either or both of these questions is "yes", the tree is a likely candidate for removal. However, care must be taken to avoid overcutting to the extent that the stand becomes poorly stocked. Consideration must be given to proper spacing between potential crop trees. A crop tree is one that is to be grown to maturity and not removed before the final harvest. It is usually selected on the basis of its size, quality and location with respect to other trees. Crop trees are straight and tall; they are valuable species

**Table 4: Ohio Hardwoods—Listed in Decreasing Order of Weight Densities at 20% Moisture Content (MC)**

| Tree | Lb/Cu. Ft. (20% MC) | Tree | Lb/Cu. Ft. (20% MC) |
|---|---|---|---|
| Osage-orange | 56.9 | White (paper) birch, black walnut, sourwood, Kentucky coffeetree | 39.7 |
| Pignut hickory | 53.2 | Red maple, gray birch | 38.9 |
| Persimmon | 52.4 | Slippery (red) elm, hackberry | 38.2 |
| Flowering dogwood | 51.7 | Sweetgum (redgum) | 37.4 |
| Mockernut hickory, shagbark hickory, swamp white oak | 50.9 | American (white) elm, southern magnolia, black tupelo (sourgum, blackgum), black cherry | 35.9 |
| Eastern hophornbeam (ironwood), American hornbeam (musclewood, blue beech) | 50.2 | Black ash, American sycamore | 35.2 |
| Black (yellow) locust, shellbark hickory, apple | 49.4 | Cucumber magnolia (cucumbertree) | 34.4 |
| White oak | 48.7 | Silver maple, sassafras | 33.7 |
| Honeylocust, scarlet oak, post oak | 47.9 | American chestnut | 31.4 |
| Bitternut hickory, chestnut oak, pecan | 47.2 | Yellow poplar (tuliptree, tulip poplar) | 30.7 |
| Red mulberry, black (sweet) birch | 46.4 | Red alder, northern catalpa | 30.0 |
| American beech, bur oak | 45.7 | Eastern cottonwood | 29.2 |
| Rock (cork) elm, sugar maple, northern red oak, pin oak | 44.9 | Bigtooth (largetooth) aspen, black willow | 28.5 |
| Yellow birch | 44.2 | Butternut (white walnut), quaking (trembling) aspen | 27.7 |
| Black oak, white ash | 43.4 | American basswood | 27.0 |
| Blue ash | 41.9 | Yellow buckeye | 26.2 |
| American holly, black maple | 41.2 | Balsam poplar | 24.7 |
| Green ash | 40.4 | | |

Note: Wood to be air-dried to 20% MC. One pound of wood at 20% MC produces about 7,000 BTU. Apply stove efficiency factor to 7,000 BTU/lb.

## Table 5: Gross Volume in Cubic Feet

| Dbh (inches) | Merchantable Height in Feet (to a 4″ Diameter Top) | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | 48 | 52 | 56 | 60 | 64 | 68 | 72 | 76 | 80 |
| 5 | 1.2 | 1.4 | 1.7 | 2.0 | 2.3 | 2.6 | 2.9 | 3.1 | 3.3 | 3.6 | 3.8 | 3.9 | 4.1 | 4.2 | 4.4 | 4.5 | 4.6 | 4.6 | 4.7 | 4.7 |
| 6 | 1.5 | 1.8 | 2.2 | 2.7 | 3.1 | 3.5 | 3.9 | 4.3 | 4.6 | 5.0 | 5.2 | 5.5 | 5.7 | 5.9 | 6.1 | 6.3 | 6.4 | 6.5 | 6.6 | 6.6 |
| 7 | 1.8 | 2.3 | 2.9 | 3.5 | 4.1 | 4.7 | 5.2 | 5.7 | 6.2 | 6.6 | 7.0 | 7.4 | 7.7 | 8.0 | 8.2 | 8.4 | 8.6 | 8.7 | 8.8 | 8.9 |
| 8 | 2.3 | 2.9 | 3.6 | 4.5 | 5.2 | 6.0 | 6.7 | 7.4 | 8.0 | 8.5 | 9.1 | 9.5 | 9.9 | 10.3 | 10.6 | 10.9 | 11.1 | 11.3 | 11.4 | 11.5 |
| 9 | 2.8 | 3.5 | 4.5 | 5.5 | 6.5 | 7.5 | 8.4 | 9.2 | 10.0 | 10.7 | 11.4 | 12.0 | 12.5 | 13.0 | 13.4 | 13.8 | 14.0 | 14.3 | 14.4 | 14.5 |
| 10 | 3.3 | 4.2 | 5.5 | 6.8 | 8.0 | 9.2 | 10.3 | 11.4 | 12.3 | 13.2 | 14.0 | 14.8 | 15.4 | 16.0 | 16.5 | 17.0 | 17.3 | 17.6 | 17.8 | 17.9 |
| 11 | 4.0 | 5.1 | 6.6 | 8.1 | 9.6 | 11.1 | 12.4 | 13.7 | 14.9 | 16.0 | 17.0 | 17.9 | 18.7 | 19.4 | 20.0 | 20.5 | 21.0 | 21.3 | 21.5 | 21.7 |
| 12 | 4.6 | 6.0 | 7.8 | 9.6 | 11.4 | 13.2 | 14.8 | 16.3 | 17.7 | 19.0 | 20.2 | 21.3 | 22.2 | 23.1 | 23.8 | 24.5 | 25.0 | 25.4 | 25.7 | 25.8 |
| 13 | 5.4 | 7.0 | 9.1 | 11.3 | 13.4 | 15.4 | 17.4 | 19.2 | 20.8 | 22.3 | 23.8 | 25.0 | 26.2 | 27.2 | 28.0 | 28.8 | 29.4 | 29.8 | 30.2 | 30.4 |
| 14 | 6.2 | 8.0 | 10.5 | 13.1 | 15.6 | 17.9 | 20.2 | 22.2 | 24.2 | 26.0 | 27.6 | 29.1 | 30.4 | 31.6 | 32.6 | 33.5 | 34.2 | 34.7 | 35.1 | 35.3 |
| 15 | 7.1 | 9.2 | 12.1 | 15.0 | 17.9 | 20.6 | 23.2 | 25.6 | 27.8 | 29.9 | 31.8 | 33.5 | 35.0 | 36.4 | 37.5 | 38.5 | 39.3 | 40.0 | 40.4 | 40.7 |
| 16 | 8.1 | 10.4 | 13.7 | 17.1 | 20.4 | 23.5 | 26.4 | 29.2 | 31.8 | 34.1 | 36.3 | 38.2 | 40.0 | 41.5 | 42.9 | 44.0 | 44.9 | 45.6 | 46.1 | 46.4 |
| 17 | 9.1 | 11.8 | 15.5 | 19.4 | 23.1 | 26.6 | 29.9 | 33.1 | 36.0 | 38.6 | 41.1 | 43.3 | 45.3 | 47.0 | 48.6 | 49.8 | 50.9 | 51.7 | 52.3 | 52.6 |
| 18 | 10.2 | 13.2 | 17.4 | 21.7 | 25.9 | 29.9 | 33.7 | 37.2 | 40.5 | 43.5 | 46.2 | 48.7 | 51.0 | 52.9 | 54.6 | 56.1 | 57.3 | 58.2 | 58.8 | 59.2 |
| 19 | 11.3 | 14.8 | 19.5 | 24.3 | 29.0 | 33.4 | 37.6 | 41.6 | 45.2 | 48.6 | 51.7 | 54.5 | 57.0 | 59.2 | 61.1 | 62.7 | 64.1 | 65.1 | 65.8 | 66.3 |
| 20 | 12.6 | 16.4 | 21.6 | 27.0 | 32.2 | 37.2 | 41.9 | 46.2 | 50.3 | 54.1 | 57.5 | 60.6 | 63.4 | 65.9 | 68.0 | 69.8 | 71.3 | 72.4 | 73.2 | 73.7 |
| 21 | 13.9 | 18.1 | 23.9 | 29.9 | 35.6 | 41.1 | 46.3 | 51.2 | 55.7 | 59.8 | 63.7 | 67.1 | 70.2 | 72.9 | 75.3 | 77.3 | 78.9 | 80.2 | 81.1 | 81.6 |
| 22 | 15.2 | 19.9 | 26.3 | 32.9 | 39.2 | 45.3 | 51.0 | 56.4 | 61.4 | 65.9 | 70.1 | 73.9 | 77.3 | 80.4 | 83.0 | 85.2 | 87.0 | 88.4 | 89.3 | 89.9 |
| 23 | 16.7 | 21.8 | 28.9 | 36.1 | 43.0 | 49.7 | 56.0 | 61.9 | 67.3 | 72.4 | 77.0 | 81.2 | 84.9 | 88.2 | 91.1 | 93.5 | 95.4 | 97.0 | 98.1 | 98.7 |
| 24 | 18.2 | 23.8 | 31.5 | 39.4 | 47.0 | 54.3 | 61.2 | 67.6 | 73.6 | 79.1 | 84.2 | 88.7 | 92.8 | 96.4 | 99.6 | 102.2 | 104.4 | 106.1 | 107.2 | 108.0 |
| 25 | 19.8 | 25.9 | 34.3 | 42.9 | 51.2 | 59.2 | 66.7 | 73.7 | 80.2 | 86.2 | 91.7 | 96.7 | 101.2 | 105.1 | 108.5 | 111.4 | 113.7 | 115.6 | 116.9 | 117.6 |
| 26 | 21.5 | 28.1 | 37.3 | 46.6 | 55.6 | 64.3 | 72.4 | 80.0 | 87.1 | 93.7 | 99.6 | 105.0 | 109.9 | 114.2 | 117.9 | 121.0 | 123.6 | 125.5 | 127.0 | 127.8 |
| 27 | 23.3 | 30.4 | 40.3 | 50.4 | 60.2 | 69.6 | 78.4 | 86.7 | 94.4 | 101.4 | 107.9 | 113.8 | 119.0 | 123.6 | 127.7 | 131.0 | 133.8 | 136.0 | 137.5 | 138.4 |
| 28 | 25.1 | 32.9 | 43.5 | 54.5 | 65.1 | 75.2 | 84.7 | 93.6 | 101.9 | 109.5 | 116.5 | 122.9 | 128.5 | 133.5 | 137.9 | 141.5 | 144.5 | 146.9 | 148.5 | 149.5 |
| 29 | 27.0 | 35.4 | 46.9 | 58.7 | 70.1 | 81.0 | 91.2 | 100.8 | 109.8 | 118.0 | 125.5 | 132.4 | 138.5 | 143.9 | 148.5 | 152.5 | 155.7 | 158.2 | 160.0 | 161.1 |
| 30 | 29.0 | 38.0 | 50.4 | 63.0 | 75.3 | 87.0 | 98.0 | 108.4 | 118.0 | 126.8 | 134.9 | 142.3 | 148.8 | 154.6 | 159.7 | 163.9 | 167.4 | 170.1 | 172.0 | 173.1 |
| 31 | 31.1 | 40.7 | 54.0 | 67.6 | 80.7 | 93.3 | 105.1 | 116.2 | 126.5 | 136.0 | 144.7 | 152.6 | 159.6 | 165.8 | 171.2 | 175.8 | 179.5 | 182.4 | 184.5 | 185.7 |
| 32 | 33.2 | 43.6 | 57.8 | 72.3 | 86.4 | 99.8 | 112.5 | 124.4 | 135.4 | 145.6 | 154.9 | 163.3 | 170.8 | 177.5 | 183.2 | 188.1 | 192.1 | 195.2 | 197.4 | 198.7 |
| 33 | 35.5 | 46.5 | 61.7 | 77.2 | 92.2 | 106.6 | 120.2 | 132.8 | 144.6 | 155.5 | 165.4 | 174.4 | 182.4 | 189.6 | 195.7 | 200.9 | 205.2 | 208.5 | 210.9 | 212.3 |
| 34 | 37.8 | 49.5 | 65.7 | 82.3 | 98.3 | 113.6 | 128.1 | 141.6 | 154.2 | 165.7 | 176.3 | 185.9 | 194.5 | 202.1 | 208.7 | 214.2 | 218.8 | 222.3 | 224.8 | 226.3 |
| 35 | 40.2 | 52.7 | 69.9 | 87.5 | 104.6 | 120.9 | 136.3 | 150.7 | 164.1 | 176.4 | 187.7 | 197.9 | 207.0 | 215.1 | 222.1 | 228.0 | 232.8 | 236.6 | 239.3 | 240.8 |
| 36 | 42.7 | 56.0 | 74.3 | 93.0 | 111.2 | 128.5 | 144.8 | 160.1 | 174.3 | 187.4 | 199.4 | 210.2 | 220.0 | 228.5 | 236.0 | 242.3 | 247.4 | 251.4 | 254.2 | 255.9 |
| 37 | 45.3 | 59.4 | 78.8 | 98.7 | 117.9 | 136.3 | 153.6 | 169.8 | 184.9 | 198.8 | 211.5 | 223.0 | 233.3 | 242.4 | 250.3 | 257.0 | 262.5 | 266.7 | 269.7 | 271.5 |
| 38 | 47.9 | 62.9 | 83.5 | 104.5 | 124.9 | 144.4 | 162.7 | 179.9 | 195.9 | 210.6 | 224.1 | 236.3 | 247.2 | 256.8 | 265.2 | 272.2 | 278.0 | 282.5 | 285.7 | 287.6 |
| 39 | 50.7 | 66.5 | 88.3 | 110.5 | 132.1 | 152.7 | 172.1 | 190.3 | 207.2 | 222.8 | 237.0 | 249.9 | 261.5 | 271.7 | 280.5 | 288.0 | 294.1 | 298.9 | 302.2 | 304.2 |

Fig. 1

Fig. 2

free from serious defects (Fig. 1). Guidelines for spacing are given in the next section.

Following are descriptions of trees that would ordinarily be cut in a TSI operation:

**Damaged**—Trees with stems damaged or scarred by fire, log skidding or other mechanical injury, or those with severe breakage of the main branches or top due to ice or wind (Fig. 2).

**Poor Form**—Main stems forked or badly crooked within the first 16 feet (Figs. 3-5); trees badly crooked above 16 feet to the extent that wind breakage or poor future growth is likely (Fig. 6).

Fig. 3

Fig. 4

Fig. 5

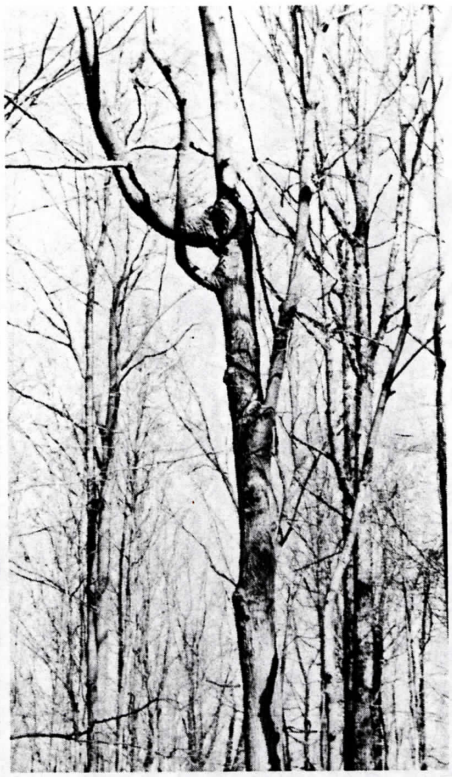


Fig. 6

Fig. 7

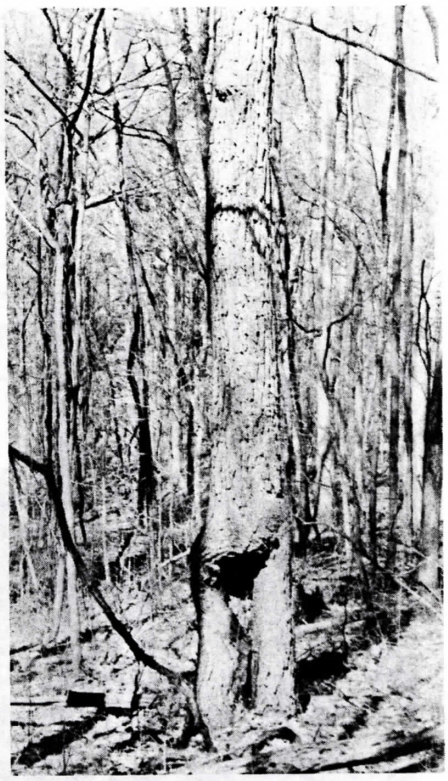


Fig. 8

Fig. 9

**Diseased**—Trees with evidence of serious decay, such as hollow or partly overgrown branch stubs (Figs. 3, 4 and 7) or hollow areas in the bole (Fig. 8). Large wounds that have healed over are usually indicative of heart rot, but the extent of decay is uncertain (Fig. 9).

**Multiple Stems**—Stumps often producing two or more competing tree stems (Fig. 10). Multiple stems often develop decay and should be discriminated against whenever possible. Sometimes, however, these trees are the most desirable because of species or quality

Fig. 10

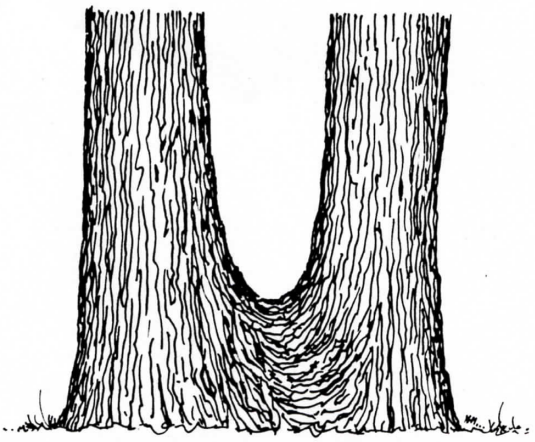


Fig. 11-a

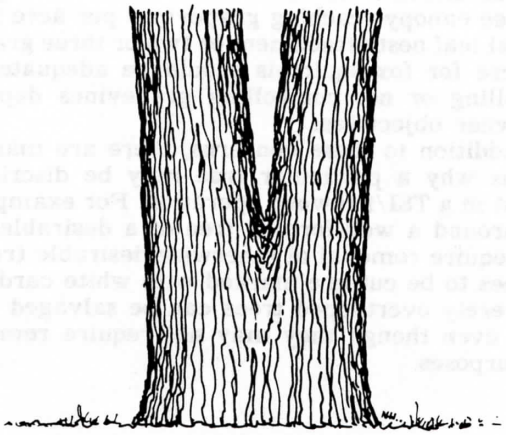


Fig. 11-b

and should be retained. Multiple stems should be treated as follows:

a) The straightest good quality stem with the fullest crown should be saved and the others may be cut if the union is U-shaped (Fig. 11-a).

b) Both stems should be cut or both should be saved in the case of V-shaped unions (Fig. 11-b). Removing one stem of such a union eventually transfers decay from the stump to the remaining stem.

c) Where several young stems are growing from a stump, save one desirable sprout that originates near the ground and cut all others.

**Wolf Tree**—Tree occupying more space in the forest than its timber value justifies (Fig. 12). Wolf trees are usually larger than other trees in the stand and have short, usable stems and large, spreading crowns. When these are a mast-producing species or hollow, they are highly beneficial to wildlife. Wolf trees may be used for firewood in a TSI cut to allow more valuable tree reproduction to occupy the growing space.

**Cull Tree**—Trees that are of merchantable size but are unmarketable because of excessive defect (usually more than 50 percent of total volume unusable, Fig. 13). Because culls have no potential for increased value, they are normally cut during TSI.

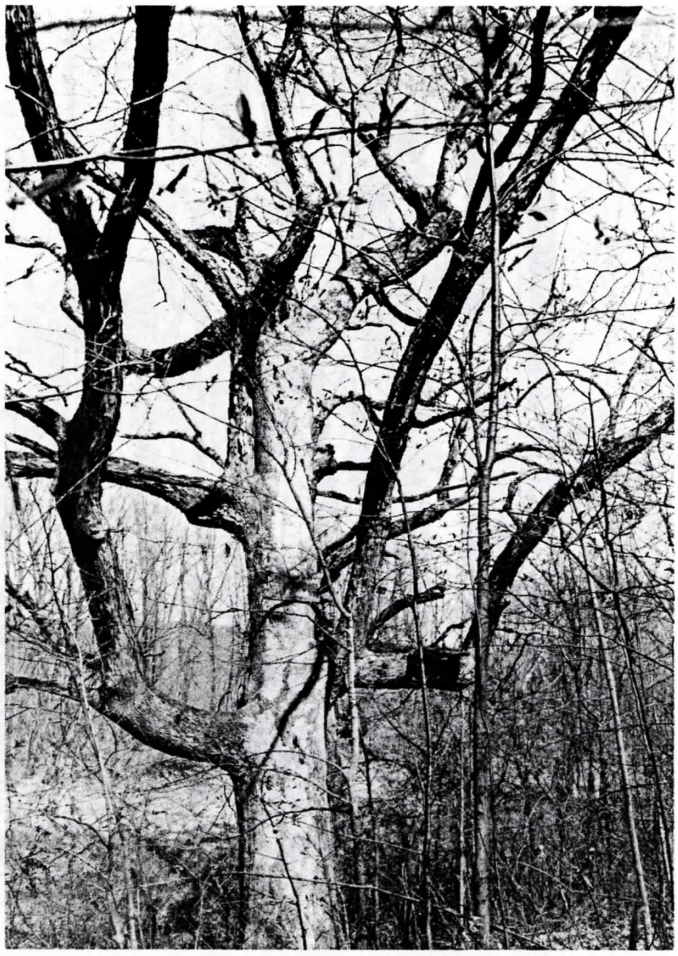


Fig. 12

Fig. 13

Fig. 14

**Weed Tree**—A tree that has little or no sale value as sawtimber by virtue of species. Examples of these are American hornbeam (blue beech, musclewood), ironwood (hophornbeam) and blackgum (sourgum).

**Grapevines**—Vines extending into the crowns of desirable trees, reducing growth through shading and greatly increasing the risk of top breakage (Fig. 14).

If grapevines are to be controlled in older stands with a complete forest canopy and heavy shade, cutting the vines near ground level usually kills them. The trees should be over 25 feet tall if the vines are cut at thinning/TSI time and about 18 feet if no thinning/TSI is done. By cutting but not using herbicides, one takes advantage of the fact that grapevines are intolerant of shade. Grapevines do not grow well or sprout effectively under heavily shaded conditions.

Grapevine seeds can remain dormant in the forest floor for as long as eight years before germinating. If an old stand is scheduled for a clear-cutting type of harvest, grapevines should probably be cut five to six years before the harvest.

Some authorities recommend that all grapevines growing into all treetops be eliminated. In young stands, the grapevines grow from one tree crown to another and are intermingled. In old stands scheduled for clear-cutting, all vines are eliminated well before the harvest to minimize the damage that would occur to the new trees as a result of grapevine sprouts and seed germination.

However, grapevines are important food sources for many wildlife species. Gray and fox squirrels use the vines as anchors for their leaf nests. Leaving one or two tree canopy-reaching grapevines per acre for gray squirrel leaf nest attachment or two or three grapevines per acre for fox squirrels should be adequate. Again, controlling or not controlling grapevines depends on landowner objectives.

In addition to these concerns, there are many other reasons why a particular tree may be discriminated against in a TSI/firewood operation. For example, thinning around a well-formed tree of a desirable species may require removal of otherwise desirable trees (Fig. 15; trees to be cut are marked with white cards). Dead or severely overtopped trees can be salvaged for firewood, even though they may not require removal for TSI purposes.

Fig. 15

All of the factors discussed, along with the spacing considerations presented later, must be taken into account when conducting a TSI/firewood cutting. Figure 16 portrays selectively marked trees (white cards) for removal in a TSI/firewood cut. From left to right, trees were marked for the following reasons: 1) decay in the upper stem of red maple; 2) white ash with crooked stem and small crown; 3) suppressed sugar maple—salvage for firewood; 4) crooked, decayed white ash with partly dead crown; and 5) crooked white ash. The plot area is about one-fifth acre and contains 2.2 cords of firewood in marked trees. At this rate, about one-half acre of TSI in this woodlot should provide the four to six cords of firewood needed by many homeowners for one season.

Figure 17 is another example of a woodland marked for cutting. Many of the marked trees are to be removed for spacing purposes around crop trees.


Fig. 16


Fig. 17

Fig. 18

## Other Considerations

Keep in mind that cutting and removing trees from the woodland risks damage to the residual stand and soil compaction or other disturbance, depending on the type of equipment used to transport harvested material. Soil compaction from vehicle traffic causes reduced tree growth, and scraping of tree stems by heavy equipment creates wounds that allow decay to enter. Felling should be done with care to avoid breaking tops or main branches of crop trees.

If wildlife habitat is a management objective, two to four hollow den trees, including one or two dead snags, should be left on each acre. Live den trees can be killed by girdling or with an herbicide for TSI purposes, but wildlife can continue to benefit from those left standing (Fig. 18).

In a TSI cut, consideration should also be given to selling trees 12 inches dbh and over as sawtimber. Their stumpage value will depend on the total net volume, the number of trees available, species and accessibility, as well as current market value and other factors.

## Spacing Density Guidelines

Trees to be cut or retained in a forest are selected on the basis of tree density or spacing, species and quality. Tree density or spacing generally determines whether any trees need to be removed from the stand. All these factors are considered in determining which trees should be removed.

An acre of land can produce a certain amount of tree growth. One of the goals of timber stand improvement and thinning is to obtain the correct number of trees per acre to most effectively utilize the forest's growth capacity. When there are too few trees in a forest to do this, the area is understocked and forest growth is less than the maximum possible. When there are too many trees in a forest, the area is overstocked. In an overstocked forest the trees crowd and stunt each other and tree growth is distributed among many more trees, reducing the growth of each tree. It takes much longer to produce desired products or values.

The desired number of trees per acre in a forest depends on the size of the trees, species, and products desired. The larger the trees, the fewer per acre there should be. For example, while one acre of land might adequately grow 435 yellow-poplar trees 6 inches dbh, the same acre would be overstocked if there were 435 trees 9 inches dbh. Tables 6 and 7 give the recommended spacing between trees of specific sizes to obtain the desired stocking. Table 6 should be used in forest stands with high proportions of sugar maple, red maple, American beech, yellow-poplar; Table 7 in stands with high proportions of oak.

**Table 6: Spacing Guide for Stands Containing Predominantly Sugar Maple, Northern Red Oak, American Beech, Yellow Poplar or Red Maple**

| Diameter of Larger Tree in Inches | Diameter of Smaller Trees in Inches | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| | . . . approximate distance between trees in feet . . . | | | | | | | | | | |
| 4 | 6 | | | | | | | | | | |
| 6 | 8 | 10 | | | | | | | | | |
| 8 | 10 | 11 | 13 | | | | | | | | |
| 10 | 11 | 13 | 14 | 16 | | | | | | | |
| 12 | 13 | 14 | 16 | 17 | 19 | | | | | | |
| 14 | 14 | 16 | 17 | 19 | 21 | 22 | | | | | |
| 16 | 16 | 17 | 19 | 21 | 22 | 24 | 26 | | | | |
| 18 | 17 | 19 | 21 | 22 | 24 | 26 | 28 | 29 | | | |
| 20 | 19 | 21 | 22 | 24 | 26 | 28 | 29 | 31 | 32 | | |
| 22 | 21 | 22 | 24 | 26 | 28 | 29 | 31 | 32 | 34 | 36 | |
| 24 | 22 | 24 | 26 | 28 | 29 | 31 | 32 | 34 | 36 | 37 | 39 |

**Table 7: Spacing Guide for Stands Where Oaks Are Predominant**

| Diameter of Larger Tree in Inches | Diameter of Smaller Tree in Inches | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| | . . . approximate distance between trees in feet . . . | | | | | | | |
| 4 | 8 | | | | | | | |
| 6 | 10 | 12 | | | | | | |
| 8 | 11 | 13 | 15 | | | | | |
| 10 | 13 | 15 | 16 | 18 | | | | |
| 12 | 14 | 16 | 18 | 19 | 21 | | | |
| 14 | 16 | 18 | 19 | 21 | 23 | 24 | | |
| 16 | 18 | 20 | 21 | 23 | 24 | 26 | 27 | |
| 18 | 19 | 21 | 22 | 24 | 26 | 27 | 29 | 30 |

To determine the desired spacing between two trees with the spacing guides:

1. Select the correct table for the species.
2. Locate the dbh of the smaller tree across the top of the table.
3. Locate the dbh of the larger tree along the left side of the table.
4. Follow the row in line with the dbh of the larger tree until you are in the column below the dbh of the smaller tree. The number in the table at that point is the desired distance in feet between the two trees.

For example, the desired spacing between a 12-inch dbh red maple and a 16-inch dbh yellow-poplar is determined as follows:

1. Select Table 6.
2. Locate "12" across the top of the table.
3. Locate "16" along the left side of the table.
4. Follow the row in line with "16" across until you are in the column below "12" and read 22 feet.

The 12-inch dbh red maple and the 16-inch dbh yellow-poplar should be about 22 feet apart.

Use of the spacing guides is not quite as clear and absolute as it appears. One usually does not look only at the spacing between two individual trees, but rather at the spacing between all of the trees in an immediate area. If the spacing between all of the trees is acceptable, no trees are eliminated. If several of the trees are too close together, the tree or trees to be removed are selected based on 1) removing the trees that most improve the spacing of the remaining trees, and 2) removing trees of poorer quality or lower species value and leaving the more valuable trees to grow. Deciding which trees to cut and which to leave is often a compromise between achieving the desired spacing and removing the less desirable trees.

One must use a little common sense in applying the spacing guide. Rarely will trees be spaced at exactly the table-specified distance. If the trees are only a couple of feet closer than the guide specified and the surrounding trees are near the desired spacing, one would normally leave the trees at the existing density. On the other hand, if the trees are quite a few feet closer to the crop tree than the guide specifies, it is desirable to remove one or more of the trees that are interfering with crop tree growth.

It is better to err on the conservative side and remove too few trees from a forest than too many. At worst, removing too few trees will result in some growth loss and slightly slower growing individual trees. Removing too many trees from a forest can lead to excessive branchiness developing on the trees that are left; development of an undesirable brush understory; and increased wind, snow and ice damage.

Other forestry publications available from your county Cooperative Extension office include the following:

— Bul. 362 Forest Plantation Management
— Bul. 619 Insect Pests of Christmas Trees
— Bul. 629 Decay Losses in Woodlots
— Bul. 670 Ohio Christmas Tree Producers Manual
— Bul. 673 Forestry Herbicide Labeling and Uses
— L-214 Ohio Forests Need Help
— L-217 Preventing Trunk Decay
— L-233 Mini-Production of Maple Syrup
— L-257 Insecticides for Control of Insect Pests on Christmas Trees

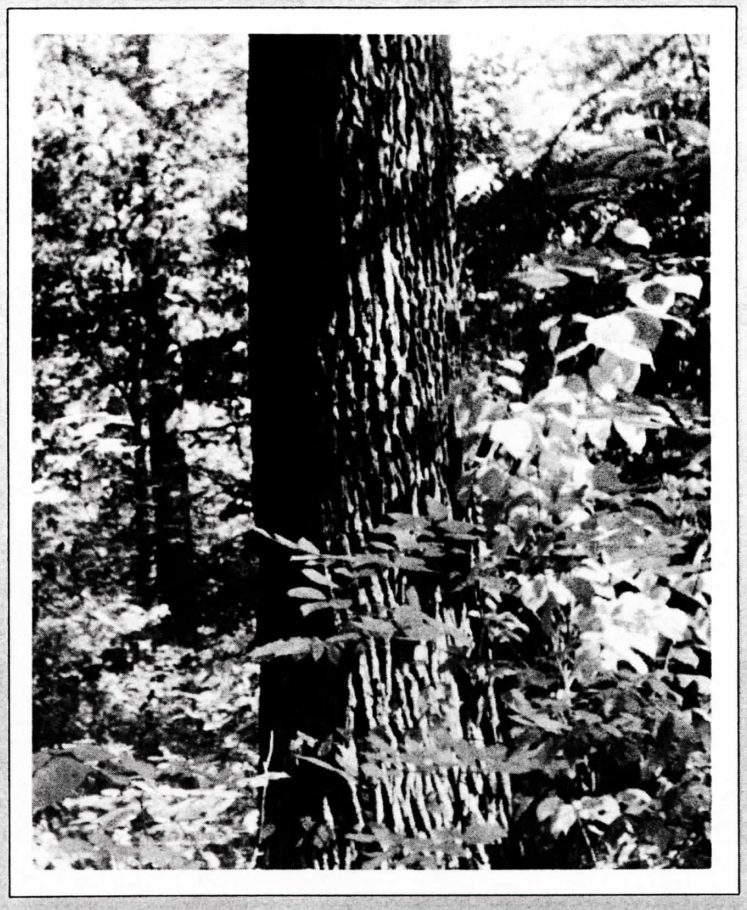
## Suggested Reading


Forbes, Reginald D. 1971. *Woodlands for Profit and Pleasure.* The American Forestry Association, Washington, D.C. 246 p.

Minckler, Leon A. 1975. *Woodland Ecology—Environmental Forestry for the Small Owner,* Syracuse University Press, Syracuse, N.Y.

Stoddard, Charles H. 1978. *Essentials of Forestry Practice.* John Wiley & Sons. New York. 387 p.

# Improve Your Timber Program



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