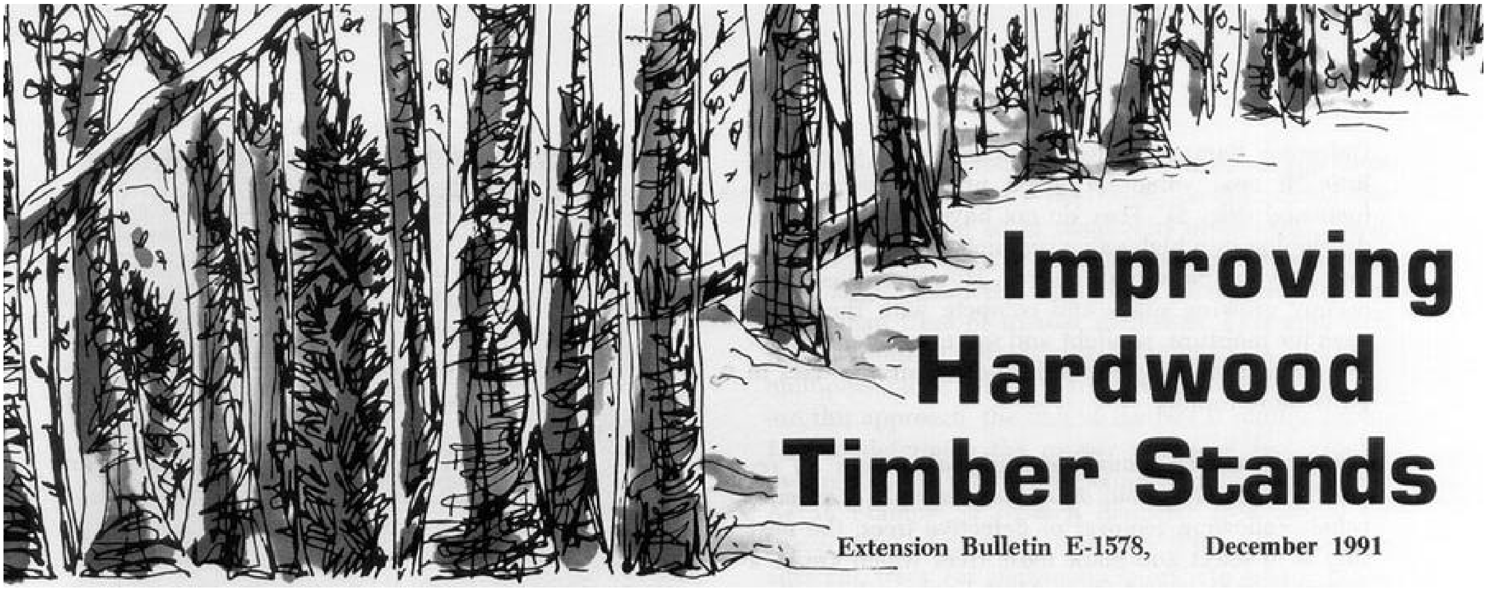

# Improving Hardwood Timber Stands

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More than 10.4 million of Michigan's 18.9 million acres of forest land are owned by non-industrial private landowners. There are estimated to be more than 180,000 of these individuals whose ownership objectives range from wildlife and recreation to aesthetics to fuelwood production. Commercial timber production has not been a major objective of most owners. However, as the costs of land ownership continue to increase and the value and demand for forest products improves, many forest owners are looking at timber production as a possible source of income. This bulletin offers suggestions and guidelines for improving and managing hardwood forest stands to produce commercial forest products.

In Michigan and elsewhere throughout the country, most privately-owned hardwood stands have been neglected, with little or no thought given to producing commercial forest crops (Fig. 1). In some cases, this lack of management is the result of the landowner not knowing what to do and how to do it, and not realizing that his forest can be a source of income.

Most hardwood timber stands will benefit from a timber stand improvement treatment. Timber stand improvement (TSI) is a conscious effort made in a forest stand to improve future growth and quality. This practice is applicable to woodlots which have grown past the sapling stage with trees more than 4 inches in diameter at breast height (dbh). After a TSI program, the growth potential of a given site will be concentrated on trees of potentially high quality and value. TSI can also have positive wildlife and environmental effects. However, the principal objective is to encourage a stand of high trees which will grow more rapidly than if left untreated.

**Fig. 1. Many hardwood timber stands in Michigan have not been managed as a renewable crop and are in need of an improvement and/or thinning operation**

## Objectives of Timber Stand Improvement

The general purpose of a TSI treatment is to improve productivity of the forest. Three specific objectives are as follows:

1. *To develop a quality forest stand by removing defective, damaged and otherwise undesirable trees, thus concentrating growth on fewer, high quality trees.* Defective, damaged, diseased or deformed trees have little, if any, value for wood products other than fuelwood (Fig. 2). They do not have the potential of developing into high value products regardless of how long they are permitted to grow. However, these trees occupy growing space and compete with the better trees for moisture, sunlight and soil nutrients. Removing them from the stand will allow desirable trees to grow more rapidly.

2. *To promote growth of high value trees by removing species of low or no commercial (economic) value.* Following removal of defective trees, the next step is to select and mark those trees which are of a desirable species and form. Most hardwood woodlots contain an adequate number of trees, although not all are equal for producing high value products. The following species have high commercial value:

| | |
|---|---|
| American basswood | Black cherry |
| Black walnut | Yellow-poplar |
| White ash | White oak |
| Yellow birch | Northern red oak |
| Sugar maple | Black oak |
| Red maple | |

Species with low commercial value which should generally be discriminated against are listed below:

| | |
|---|---|
| Ironwood | Pin cherry |
| Sassafras | American beech |
| Hickories | Aspen (except for pulpwood) |
| Elm | Paper birch (except for pulpwood) |
| Cottonwood (except for pulpwood) | |

3. *To regulate stocking (number and distribution of trees) to encourage optimum growth of the residual stand.* Many woodlots contain too many trees for maximum growth. This condition may be present following removal of the defective and low value trees, or in young, even-aged second growth stands. Although the stand may be composed of desirable species, competition among the trees for available growing space can be severe. In such stands, thinning is needed to regulate spacing among residual trees so maximum growth can occur. Growing space requirements increase as trees increase in size; therefore, more than one thinning may be necessary in the life of the stand.

## Timber Stand Improvement Methods

Careful planning of a timber stand improvement operation is essential for the best possible return for time and effort expended. Where possible, selling the material removed will reduce the cost of the operation and may provide some income. Pulpwood and fuelwood are common products removed in TSI. In some areas, low grade logs may be sold to pallet or blocking mills.

Most hardwood timber stands will need more than one TSI operation in the life of the stand. To transform an unmanaged woodlot containing large numbers of competing desirable and undesirable stems into a vigorous stand of high quality and properly spaced trees is impossible in a single operation. Rather, a TSI treatment must be repeated over time to achieve a well-managed woodlot. In subsequent TSI operations in the same stand, products of increasingly higher quality and value will be removed. Eventually, TSI will be phased into regular harvesting operations.

Two basic methods are suggested for performing a TSI operation. Each will achieve about the same result although different approaches are followed.

### 1. Crop Tree Selection Method

Individual trees are selected based on species, form and distribution. The number selected per acre will vary depending on tree diameter and species mixture. Undesirable trees 4 inches dbh and larger are removed to permit maximum growth to occur on the selected trees. The selected trees are "crop trees" which will be managed for the production of high quality products, primarily sawlogs and veneer. Increased growth on crop trees after TSI is often 40 to 60 percent greater than before. Increases in tree value will be rapid since the growth is being concentrated on the selected, potentially high value trees. The earlier TSI occurs, the greater the opportunity to produce larger amounts of higher value products from the crop trees.

**Selecting Crop Trees.** Selection of crop trees should be started as soon as individual trees of potentially high quality can be recognized. In most unimproved forest stands this will not occur before the average tree is 3 to 4 inches dbh. Selection should be made before any cutting or improvement operations are started.

In selecting crop trees, look first for species of the highest value and of most desirable form. Most woodlots contain an adequate number of such trees. Crop trees should possess a relatively straight bole, large crown, and have no cull or other apparent defects. They should have the potential of occupying a dominant position in the future stand.

A stand is adequately stocked when there are at least 40 crop trees per acre, although in most stands considerably more will be selected. This low stocking level is particularly acceptable if high-value species, such as black cherry, black walnut or yellow birch are present. The maximum number of selected crop trees

**Fig. 2. Low value, cull trees should be removed to allow desirable trees to grow more rapidly. This removal material is an excellent source of**

will vary for each stand depending on the size of the trees present, site conditions and potential market for products removed in improvement cuttings and thinnings. For example, fewer crop trees will be selected in a stand with an average diameter of 12 inches than in a stand with a 6-inch average diameter. Likewise, more trees can be selected per acre if the stand is growing on well-drained, productive soil than if growing on droughty sites or infertile soils. If a market is available for products removed in improvement cuttings and thinnings, a few extra crop trees may be retained when initial selections are made. In later years, these can be removed in successive thinnings. In such cuts, efforts are directed toward increasing the quality of the residual stand.

**Spacing Crop Trees.** The total number of crop trees on each acre will vary depending on the size of the trees present and other conditions of the site. Since more growing space is required as a tree increases in size, larger diameter trees must be spaced farther apart than trees of smaller diameters. One approach for determining correct spacing is to use a constant multiplier factor which is related to tree diameter. To use this approach, the dbh of the tree is multiplied by 1.67 to determine the proper radius in feet around the tree within which competing trees should be cut. As an example, a six-inch diameter tree should be spaced approximately 10 feet (6 X 1.67 = 10.02) from adjacent trees for maximum growth to occur. Since trees of varying sizes are present in most stands, different spacing requirements are necessary. Determine the average diameter for all trees in the stand and then compute an average spacing distance. For example, if 6-inch, 8-inch and 10-inch trees are present the average spacing distance would be 13.4 feet [the sum of (6 X 1.67) + (8 X 1.67) + (10 X 1.67) divided by 3 or (10.0 + 13.4 + 16.7)/3 = 13.4] (Fig. 2). Some adjustments within the woodlot may be necessary if groups of larger and/or smaller trees are present.

The following table has been prepared to indicate proper spacing and numbers of trees per acre for forest stands with trees of varying diameters.

**Table 1. Recommended distances between trees and numbers of trees per acre for trees of various diameters.**

| Diameter (inches) | Distance Between Any Two Trees (feet) | Number of Trees Per acre |
|---|---|---|
| 3 | 5.0 | 1742 |
| 4 | 6.7 | 970 |
| 5 | 8.4 | 617 |
| 6 | 10.0 | 435 |
| 7 | 11.7 | 318 |
| 8 | 13.4 | 243 |
| 9 | 15.0 | 194 |
| 10 | 16.7 | 156 |
| 11 | 18.4 | 129 |
| 12 | 20.0 | 109 |
| 13 | 21.7 | 93 |
| 14 | 23.4 | 80 |
| 15 | 25.0 | 70 |

These values represent ideal spacing which in practice may be difficult to achieve. Individual tree characteristics and position within the stand will probably not permit exactly this distribution. However, this is not a serious problem. Remember that growth will occur following TSI or thinning, and trees will increase in size. Within a few years, depending on how fast the trees respond, it will be necessary to thin the stand again. In this and later thinnings, spacing adjustments can be made.

Furthermore, all selected crop trees within a forest stand will not be of the same size, nor will they remain in the same size class in relationship to each other after their selection. Differences in species and site conditions will result in variations in growth rate and, consequently, tree size. This is a desirable condition since most mixed and northern hardwoods respond well to management under an uneven-aged, mixed-size forest condition. In addition to favoring reproduction and early seedling growth, uneven-aged management provides the landowner an opportunity for periodic harvests as opposed to less frequent harvests at longer intervals with even-aged stands.

To achieve an uneven-aged distribution in hardwood stands, trees of varying sizes should be selected. As the trees increase in size, subsequent cuttings will be necessary to maintain proper growing space among crop trees. These cuttings will do much to achieve an uneven-aged stand through regulation of stand density, size distribution, and encouragement of desirable reproduction.

For hardwood management on larger commercial or industrial tracts, even-aged management may be practical. This results from a uniform distribution of tree sizes in second-growth stands, allowing for increased efficiency in harvesting. Such operations are usually arranged so that use of small size and low quality material is obtained. Particular emphasis must be given to promoting regeneration of desirable species in even-aged management when the mature stand is harvested.

## 2. Basal Area Method

The concept of basal area is another approach commonly used to regulate stocking in hardwood woodlots. Basal area refers to the cross sectional area of an individual tree measured at dbh. For example, if a given tree has a dbh of 10 inches, its basal area (actual stem cross-sectional area) is 78.54 square inches or 0.545 square feet. While basal area can be determined and calculated for an individual tree, it is more commonly expressed on a per acre basis for all trees 4 inches dbh and larger. For second growth hardwood timber stands on good sites in Michigan, a total basal area of 100 square feet per acre and above is fairly common.

The concept of basal area as an expression of stand density and its use in regulating tree stocking is founded on the assumption that individual tree spacing and distribution are not as important as total tree stocking per acre. Even though this method is based on total tree stocking per acre, individual trees are still important and should be distributed optimally. Accordingly, each acre of forest is managed to obtain optimal growing conditions (spatial distribution) while producing maximum volumes per acre. Optimal basal area stocking levels will vary depending on the type of forest present and the favorableness of the growing site. Also, total basal area of a particular forest stand changes during the life of the forest as trees increase in size. Therefore, repeated thinning and/or harvest operations are necessary at periodic intervals to maintain optimal stocking levels.

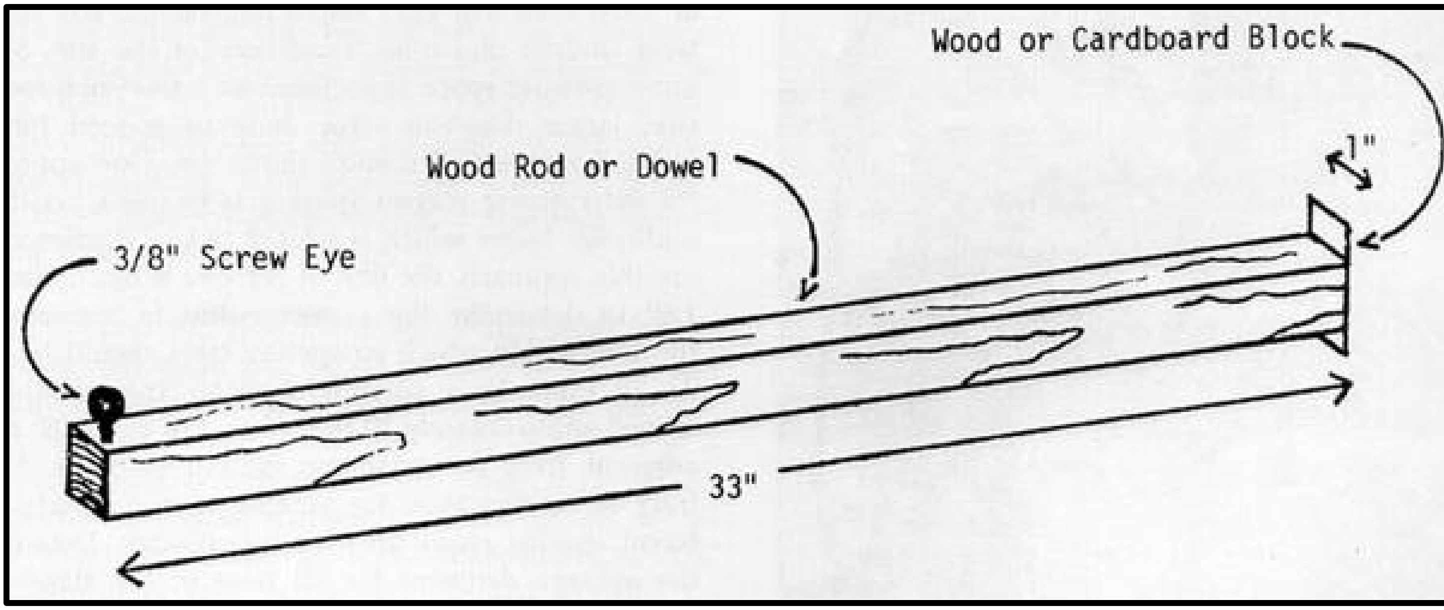


**Fig. 3. A simple angle gauge can be easily constructed to determine estimates of basal area.**

**Determination of Basal Area.** Basal area estimates are commonly determined using a point sampling procedure and an angle gauge or wedge prism. Point sampling is a quick method of estimating tree basal area per acre without actually laying out sample (area) plots, measuring tree diameters and converting to basal area. Rather, only representative sampling "points" or plot centers are selected in a woodlot. Estimates of basal area, using an angle gauge or wedge prism are taken directly above the established points. To obtain an accurate estimate of basal area per acre, however, it is important that several uniformly

**Fig. 4. To estimate basal area using an angle gauge, the observer turns a complete circle over the sampling point and counts the number of tree larger than the width of the block**

scattered "points" or plot centers be established and sample estimates taken with the results averaged.

An angle gauge is a simple wooden rod with a peep sight at one end and a small block of a predetermined width at the other end (Fig. 3). The length of the rod and width of the block will vary depending on the multiplying factor used. For most hardwood timber stands, a ten-factor angle gauge is adequate for measuring basal area and can be simply constructed using a 33-inch wood rod with a 1-inch wide block at one end and a 3/8-inch screw eye at the other end. The angle gauge is used by standing at a representative sampling point within the woodlot and viewing the dbh of each tree in the vicinity of the point through the peep sight. With the sight held close to the eye, each tree which appears larger than the width of the block at the end of the rod is counted (Fig. 4). The observer turns a complete circle (directly over the sampling point) looking at all trees 4 inches dbh and larger. The total number of trees tallied is multiplied by 10 to arrive at an estimate of total basal area per acre. If a wedge prism (10-factor) is used, the same procedure is followed; all trees which appear partially offset when viewed through the prism (Fig. 5) are tallied, and the total number is multiplied by 10.

**Use of Basal Area in Stand Management**. Once total basal area per acre has been determined, it should be compared with guidelines obtained from research studies. These have been prepared for similar forest types making allowances for site variances. This comparison will indicate if the stand is over- or under-stocked. Suggested stocking levels for different forest types present in Michigan are presented in Table 2.

**Table 2. Recommended stocking levels for several Michigan hardwood forest types.**

| Forest Type | Recommended Stocking Level (Basal Area/Acre–sq. ft.) |
|---|---|
| Aspen | 100 |
| Lowland hardwoods | 90-100 |
| Oak-Hickory | 70-80 |
| Northern hardwoods | 90 |

If overstocked, the differential between the suggested stocking guideline and the amount actually present can be used to determine the amount of TSI and/or thinning necessary to obtain ideal stocking. The same guidelines as suggested for crop tree spacing, e.g., removal of defective trees and low value species to provide additional growing space, will apply in using this method. Although the approach is different, applying TSI and thinning in a stand using either the crop

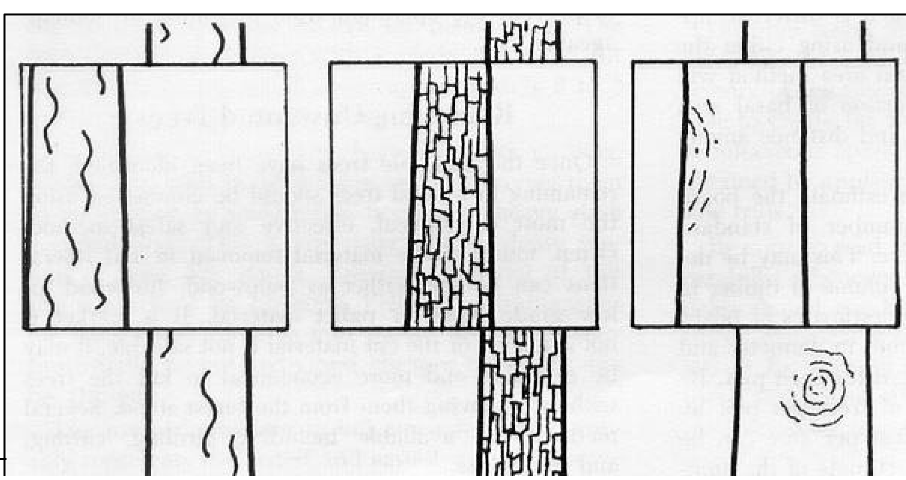

**Fig. 5. A 10-factor wedge prism can be used to determine basal area.**

tree selection method or basal area method will produce similar results. A comparison of basal area values, number of trees per acre and distance among trees is illustrated in Table 3.

**Table 3. A comparison of number of trees per acre, distances among trees and basal area per acre for trees of different diameters.**

| Dbh (in.) | No. of Crop Trees Per acre | Distance Between Any Two Trees (ft.) | Basal Area Per Acre (sq. ft.) |
|---|---|---|---|
| 4 | 970 | 6.7 | 84.6 |
| 5 | 617 | 8.4 | 84.1 |
| 6 | 435 | 10.0 | 85.4 |
| 7 | 318 | 11.7 | 85.0 |
| 8 | 243 | 13.4 | 84.8 |
| 9 | 194 | 15.0 | 85.7 |
| 10 | 156 | 16.7 | 85.1 |
| 11 | 129 | 18.4 | 85.1 |
| 12 | 109 | 20.0 | 85.6 |
| 13 | 93 | 21.7 | 85.7 |
| 14 | 80 | 23.4 | 85.5 |
| 15 | 70 | 25.0 | 85.9 |

Basal area can also be used to estimate the board foot volume of wood and/or number of standard cords of pulpwood present per acre. This may be desirable if a rapid estimate of the volume of timber in a woodlot is needed. For example, estimates of board foot volumes in trees 10 to 12 inches in diameter and up can be determined and averaged for each plot. By multiplying the average number of trees per plot by 600, an estimate of total board feet per acre can be obtained. Moreover, to obtain an estimate of the number of standard cords present, multiply the total number of 8-foot logs or 100-inch "sticks" present in all trees 4 inches dbh and larger on the average plot by 0.6. If a combined sawlog-pulpwood volume is desired, trees in the 4- to 11-inch dbh classes should be measured for pulpwood and trees 12 inches dbh and larger should be counted for sawtimber.

## Carrying Out TSI and Thinning Operations

Implementing a TSI program requires putting the recommended suggestions into practice. Admittedly, these suggestions represent ideal conditions that may be difficult to achieve due to variations in forest type, stocking, site quality and other factors. In general, some hardwood timber stands, especially those where a large initial number of desirable trees are present, will respond better than will lower quality stands. However, all woodlots will benefit from a TSI program. With subsequent thinnings, woodlots containing a large number of trees of poor form and quality will be gradually improved over time, if a TSI program is conscientiously applied throughout each thinning operation.

Regardless of the approach chosen, the first step is to mark the selected crop trees. One convenient method of temporarily marking crop trees is to tap selected trees with an old cotton sock filled with powdered lime. Vinyl flagging tape, tree marking paint, or similar commercial products can also be used. However, the use of powdered lime or flagging tape is often preferred since either can be easily removed from a tree if adjustments in spacing or crop tree selection are necessary in planning the cutting operation. Once the crop trees have been identified and the proper spacing determined, selected trees should be permanently marked. Moreover, it is recommended that most individual owners undertake TSI in only a small portion of a woodlot at a time (3 to 5 acres in size) to prevent the operation from becoming an unmanageable task.

## Removing Unwanted Trees

Once the desirable trees have been identified, the remaining unwanted trees should be eliminated using the most economical, effective and safest method. Often, much of the material removed in TSI operations can be sold either as pulpwood, fuelwood, or low grade block or pallet material. If a market is not available or the cut material is not saleable, it may be desirable and more economical to kill the trees without removing them from the forest stand. Several methods are available including girdling, cutting, and herbicides.

A girdle must sever the cambium layer (tissue located just beneath the bark) completely around the tree to insure a complete kill. A girdled tree dies slowly, and later, comes down in pieces, thereby doing less damage to the residual stand. However, girdled, dead standing trees may pose a hazard to people using the woodlot for hunting, hiking or other recreational purposes. Stump-sprouting from girdled trees is not a serious problem for northern hardwood species, especially trees over 10 inches in diameter. Girdling may be accomplished by using an ax or chain saw.

Ax girdling is done by cutting a double-hack notch completely around the circumference of the tree stem. If a chain saw is used to girdle unwanted trees, care must be taken to make a complete girdle; otherwise the tree will continue to live for many years. The best method of girdling with a chain saw is to cut two saw rings around the tree, approximately 2 to 3 inches apart on the trunk

In addition to being more hazardous than girdling, felling trees with an ax or chain saw and leaving them to decay may be undesirable because of heavy slash accumulations. This is especially true in dense sapling or pole size stands. However, material of this size is excellent for firewood. Felling is advantageous for trees under three to four inches dbh, since they can

**Fig. 6. A chain saw girdle is a simple way to remove unwanted trees from a woodlot.**

**Fig. 7. Herbicides can be injected directly into the tree through use of specialized equipment.**

usually be cut faster and cheaper than they can be girdled.

The use of herbicides to kill unwanted trees probably represents the fastest and easiest way to improve hardwood timber stands. Chemical thinning is accomplished using commercial herbicide formulations or "brush killers," depending on the species to be controlled. Contact a local county extension agent, chemical company salesperson, or Michigan State University forestry specialist for proper herbicide recommendations.

Foliar sprays of certain herbicides are effective on brush and younger trees. On larger trees up to four inches in diameter, basal sprays may be used. The entire circumference of the lower 12 to 18 inches of the trunk and root collar is sprayed to the point of run-off. Basal sprays can also be used effectively to treat fresh cut stumps and prevent sprouting if the stump is sprayed immediately after cutting.

On trees larger than four inches in diameter, herbicides may be applied in frills cut around the circumference of the tree. Hand-operated equipment is available to create the frill and apply the herbicide in one simultaneous operation (Fig. 7). Control may also be obtained by applying herbicide solution in ax or chain saw frills.

Be sure to read the label and follow the directions carefully whenever working with herbicides. Herbicides should not be used where wind drift or volatilized chemical will come in contact with trees that are to be kept in the residual stand. Furthermore spray equipment used for herbicides should not be used to spray insecticides, as it may be difficult to completely remove all traces of the herbicide from the sprayer.

## Special Considerations

Generally, trees originating from stump sprouts are not as desirable as those originating as seedlings in a forest stand. Stump sprouts have a greater likelihood of decay and poor form development. However, certain high value species, such as basswood, maple and oak, characteristically reproduce by sprouts. In many stands it will be necessary to thin some of these clumps to maintain proper spacing throughout the stand. In thinning sprout clumps, only 2, or at most 3, stems should be kept. Preference is given to stems of the best form which are widely spaced and have originated from the root collar or positions low on the stump. Sprout clumps of other species should be removed entirely from most stands unless stems of larger diameters are present. Twins (low forks) should be treated as clumps, although they may be kept in the stand if needed for stocking purposes during the earlier years of management. A general rule of thumb is to leave both or remove both.

To produce high quality sawlog and veneer log material, all limbs should be pruned from the lower bole of selected crop trees. Research studies indicate that pruning the bole of the tree for a distance equal to 50 percent of its total height will improve the quality of wood produced without reducing either height or diameter growth. In hardwoods, pruning to 17 feet to produce a clear 16-foot log is usually recommended.

All pruning should be done with a pruning saw cutting flush with the stem of the tree (Fig. 8). Live-limb scars, less than one inch in diameter will normally close completely within two to three years. Little if any new branch sprouting will result on pruned trees when they are thinned following the crop tree or basal area method.

In some locations, hardwood timber stands are understocked and not in need of a thinning operation. TSI, in these instances should be limited to removing defective cull tree material in the overstory, and seedlings of non-commercial species in the understory. This will allow desirable small trees to grow into the overstory, thereby increasing stocking of the stand.

The suggested TSI practices are not difficult to implement. Once the woodlot owner can properly identify tree species and select desirable trees with proper form, he can usually complete a TSI or thinning program on his own. Implementing such a program is an excellent means of obtaining fuelwood while improving the condition of the woodlot. Where larger acreages are involved, or time or other constraining factors are present, the use of consulting foresters or the services of landowner assistance programs of some forest industries may be appropriate. Management information, and sources of harvesting and marketing assistance, can be obtained from local Department of Natural Resources field offices, Soil Conservation Service offices or individual County Cooperative Extension Offices.

If the TSI-thinning recommendations in this publication are applied, the production of any treated woodlot will be greatly increased. The specific results obtained will depend on the original condition of the woodlot and on site factors such as moisture and fertility relationships. Obviously not all woodlots have the same potential for production; however, application of appropriate TSI and thinning programs will bring each area to more nearly its potential production.

**Fig. 8. Careful pruning will encourage rapid healing and increase bole quality.**



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