CHAPTER 23

INTERMEDIATE TREATMENTS

Intermediate treatments include any silvicultural manipulation of forest vegetation occurring after establishment of regeneration and prior to final harvest of the stand (or cohort). These **tending** operations can occur throughout the life of the forest stand, but do not include efforts directed at establishing regeneration. Intermediate treatments are designed to enhance stand composition, structure, growth, health, quality, and the production of specific benefits desired by the landowner. These treatments can be non-commercial, requiring outright investment, or commercial, providing monetary income. **Timber stand improvement (TSI)** is a commonly applied term that refers to non-commercial intermediate treatments.

Intermediate treatments can be broadly grouped into **release**, **thinning** and **improvement**, **salvage** and **sanitation**, and **pruning**. TSI would include pruning, most release treatments, and some thinning, improvement, and sanitation applications.

Cutting is the primary silvicultural tool to manipulate forest vegetation and control forest development to satisfy landowner property goals and stand management objectives. Additional physical and chemical techniques, as well as fire, can be utilized in specific situations.

The basic methods to kill undesirable plants and control competition are:

- Cutting:
    - Most effective against species that don't sprout (e.g. most conifers).
    - Species that sprout may require repeated treatments to effectively control.
        - Cutting in late spring and summer is most effective.
    - Relatively expensive, unless a product can be harvested.
- Girdling:
    - Most effective against species that don't sprout.
    - Most effective when done in late spring and summer.
    - Generally applied only to trees greater than 4 inches dbh.
- Physically remove the plant from the soil:
    - A very effective but expensive method.
- Fire:
    - Usually kills trees by girdling.
    - In Wisconsin, generally not currently used for intermediate treatments for sustainable forest management.
- Herbicides:
    - Very effective, and often the most inexpensive method.
    - Methods of application include: aerial spraying, ground-level foliar spraying, basal spraying, stump application, and bark incisions.
    - Herbicides are toxic chemicals. Toxicity can be highly selective and short-term, depending on the herbicide used. Products and guidelines change rapidly. It is imperative that label directions be followed. Select the appropriate product for the job and determine the best method and rate of application. Local regulations governing herbicide use are highly variable.

Most of the guidelines provided in this chapter are designed to enhance forest tree and stand vigor and quality, and therefore generally coincide with long-term economic sustainability. Chapter 24, Marking Guidelines, provides additional guidelines and considerations in applying intermediate treatments for a variety of management goals, particularly timber and biodiversity. Chapter 24 defines crop trees and a standard order of removal. It also provides tree and snag retention guidelines to sustain wildlife and biodiversity.

RELEASE

Release is a treatment designed to free young trees (saplings and seedlings) from undesirable, usually overtopping, competing vegetation. The purpose is to regulate species composition and to improve growth and quality. Release is designed to provide potential crop trees with sufficient light and growing space, by freeing their crowns and controlling competition.

When assessing needs and planning release operations, it is necessary to predict how the vegetation, both the desired species and the competition, will respond and develop (e.g. relative growth rates and health). Biological and economic costs and benefits of different treatments and intensities (including no action) should be evaluated. Entire layers of vegetation can be controlled, or only selected individual trees can be favored.

Complete release:

- Entire layers of competing vegetation are controlled (kill or retard growth) to allow the desired species to gain dominance. Examples are cut or apply herbicide to all aspen saplings to release suppressed white pine saplings (following overstory removal), and cut or apply herbicide to all red maple stump sprouts to release oak saplings and seedlings (following shelterwood).
- Potentially provides the greatest beneficial effect on the desired stand, but costs typically are greater than for partial release.

Partial release:

- Release only selected exceptional individuals (crop trees).
  An example is: cut all crown competitors within 5 ft. of the largest and best formed, healthy oak sapling at approximately 20 ft. by 20 ft. spacing (full crown release of 100 crop trees per acre).
- Determine minimum crop tree selection criteria, based on landowner objectives, and tree species, vigor, quality, and health.
- Determine maximum number of well-spaced crop trees per acre; usually 50-200 trees/acre.
- Determine desired average spacing between crop trees.
  Crop tree average spacing calculation where S = spacing in feet, and n = number of crop trees/acre

  $$S = \sqrt{43{,}560 / n}$$
- Remove all trees with crowns that touch or interfere with each crop tree. A 5-7 foot opening around each crown is often recommended.
- Control only direct competitors. Remove only what is necessary to accomplish the purpose; there is no need to eliminate any plant that is not going to suppress, endanger, or hamper the growth of desired individuals.
- In sprout clumps, cut all but the best one or two stems. Individual sprout characteristics to favor include: low sprouts originating from the root collar, U-shaped stem attachment, vigorous spouts with well developed crowns, relatively large sized, well-shaped and healthy (see further discussion under “Thinning Clumps of Trees”).

When needed, release operations should be implemented early in the life of the stand, typically before 15 years of age. The best growth responses are generally exhibited by the youngest stands. However, when selecting crop trees, it may be necessary to wait until growth characteristics and competitive relations are expressed. Seedlings and saplings usually respond to release with significant increases in vigor and growth.

There are three types of release treatments: weeding, cleaning, and liberation. They are differentiated based on the type, age, and size of vegetation eliminated. Within a stand, they can be applied individually or in concert, and once or multiple times.

Weeding
Weeding is a release treatment that eliminates or suppresses undesirable vegetation (including shrubs and herbs) regardless of crown position. It is typically combined with cleaning or liberation treatments that control competing trees. Weeding can be used to control diseases (interrupt pathogen life cycles) or invasive plants.

Cleaning
Cleaning is a release treatment designed to free favored trees from less desirable individuals (trees) of the same age class that overtop them or are likely to do so. The main purpose is to regulate species composition; improving growth and quality

is an important secondary objective. In practice, trees eliminated or suppressed typically include undesirable species and any low quality individuals that are competing directly with desired crop trees.

Liberation

Liberation is a release treatment designed to free favored trees from competition with older, overtopping trees. It is applied when a young crop of potentially good trees is overtopped by older, less desirable trees. Considerations in removing the unwanted overstory:

- Effective methods of killing the older, overtopping trees are cutting, girdling, and applying herbicides.
- Cutting may allow the realization of income, but protection of the young stand from felling and harvesting operations is critical.
- Care should be taken that following liberation the increase in sunlight does not result in intense crown competition from sprouts or the release of fast growing weed species.

Older, overtopping trees can be retained as reserve trees to achieve desired benefits (Chapter 24). These reserve trees will limit the availability of some resources needed for the most vigorous growth of younger trees in close proximity. Considerations when maintaining reserve overstory trees are:

- Reserve trees can provide benefits related to wildlife, aesthetics, water and soil quality, protection of special or sensitive sites, landmarks, and timber production.
- Older, overtopping trees can reduce the growth, cause stem deformation, and even cause mortality of young trees growing in their shade. In most cases, nearly full sunlight is preferred to promote optimum growth of young, established stands. Shade is increased by:
  - Increased numbers of overstory trees.
  - Trees with larger and denser crowns.
  - Crown expansion (growth) over time.
- Within a stand, the point at which the negative effects of overstory shade become significant depends on landowner objectives, site quality, the number and species of overstory trees, the number and species of understory trees, understory competition, and potential damaging agents.
- Where objectives include the retention of reserve trees, residual crown closures of <20% generally will not significantly impede the development of the young stand.

THINNING

Thinning is a cultural treatment conducted in stands past the sapling stage to reduce stand density, primarily to improve tree growth, enhance tree health, or recover potential mortality. It entails the removal of trees to temporarily reduce stocking to concentrate growth on the more desirable trees. Normal thinning does not significantly alter the gross production of wood volume. Thinning does impact stand growth, development, and structure. It provides the main method, implemented between regeneration and final harvest, to increase the economic productivity of stands. Individual thinnings can be commercial or non-commercial (TSI), depending on landowner objectives and local markets for materials cut in the thinning operation. Regeneration is not an objective of thinning; overstory gaps are small and should close rapidly.

Objectives of thinning include any of the following:

- Enhance the vigorous growth of selected trees through the removal of competitors. Larger diameter, more valuable trees can be grown in a shorter period of time.
- Enhance tree health. Thinning anticipates losses, and maintains tree vigor and strength.
- Harvest most merchantable material produced by the stand during the rotation. Trees that would die from competition are harvested and utilized for timber products.

Application of thinnings can increase economic yields:

- Harvest anticipated losses of merchantable volume.
- Yield of income and control of growing stock during rotation.
- Increased value from rapidly growing larger diameter trees.
- Increased value from improvements in product quality.
- Opportunity to modify stand composition, prepare for the establishment of the next rotation (manipulate sources of regeneration), and reduce the risk of damage (maintain more vigorous and structurally sound trees).

How and when thinnings are applied depend on:

- Landowner objectives and desired benefits.
- Ecological considerations (e.g. site quality, species composition, stand structure, and stand condition).
- Economic considerations (e.g. costs and benefits, incentives, local markets).
- Social considerations (e.g. regulations, aesthetics).
- Other past and planned management activities.

A schedule of thinning for a stand should identify the thinning methods to be used, the intensity of application, and when thinnings will occur. Ideally, the application of a thinning schedule should be a systematic, yet flexible endeavor consistently followed throughout the rotation.

Thinning Methods

There are four basic methods of thinning: mechanical thinning, low thinning, drown thinning, and free thinning. Figure 23.1 identifies and defines the four crown classes used to help differentiate the thinning methods and to guide tree selection during thinning operations. The positive action of selecting which trees will remain should be emphasized. Stand conditions and thinning needs vary over time, often resulting in the application of more than one method over a stand's rotation.

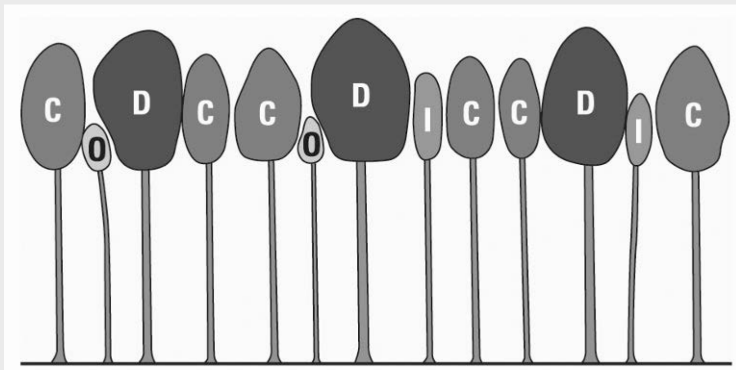

Figure 23.1: This illustration shows the relative positions of trees in the different crown classes in an even-aged stand that has not been thinned. *(Adapted from © David M. Smith, 1962, The Practice of Silviculture, Seventh Edition, John Wiley & Sons, Inc.)*

Dominant (D): Dominant trees have crowns extending above the general level of the crown cover, and receive full light from above and partly from the side. Dominant trees are larger than the average trees in the stand, and have well-developed crowns that may be somewhat crowded from the sides.

Codominant (C): Codominant trees have crowns forming the general level of the crown cover, and receive full light from above but comparatively little from the sides. These trees usually have medium-sized crowns that are often crowded on the sides.

Intermediate (I): Intermediate trees are shorter than dominant and codominant, but have crowns extending into the crown cover formed by codominant and dominant trees. Intermediate trees receive a little direct light from above, but none from the sides. They usually have small crowns that are considerably crowded on the sides.

Overtopped (O): Overtopped, also called suppressed, are trees with crowns entirely below the general level of the crown cover. Overtopped trees receive no direct light either from above or from the sides.

1. Mechanical Thinning
Mechanical thinning is the removal of trees in rows, strips, or by using fixed spacing intervals.

Application:

- Mechanical thinnings are typically applied as the first thinning(s) in young stands that are densely crowded or relatively uniform with little differentiation into crown classes. The method becomes less suitable as variation in the size and quality of the trees increases.
- Row thinning (figure 23.2):
  - Trees are cut in lines or strips at fixed intervals throughout the stand.
  - Often utilized for the first thinning(s) in plantations where the rows are readily apparent. The removal of every second or third row are common practices.
  - Utilized to provide systematic access for machinery in dense, unthinned stands.
- Spacing thinning:
  - Trees at fixed intervals are chosen for retention and all others are cut.
  - Most commonly applied as the first thinning in very overcrowded young stands developed from dense natural reproduction.

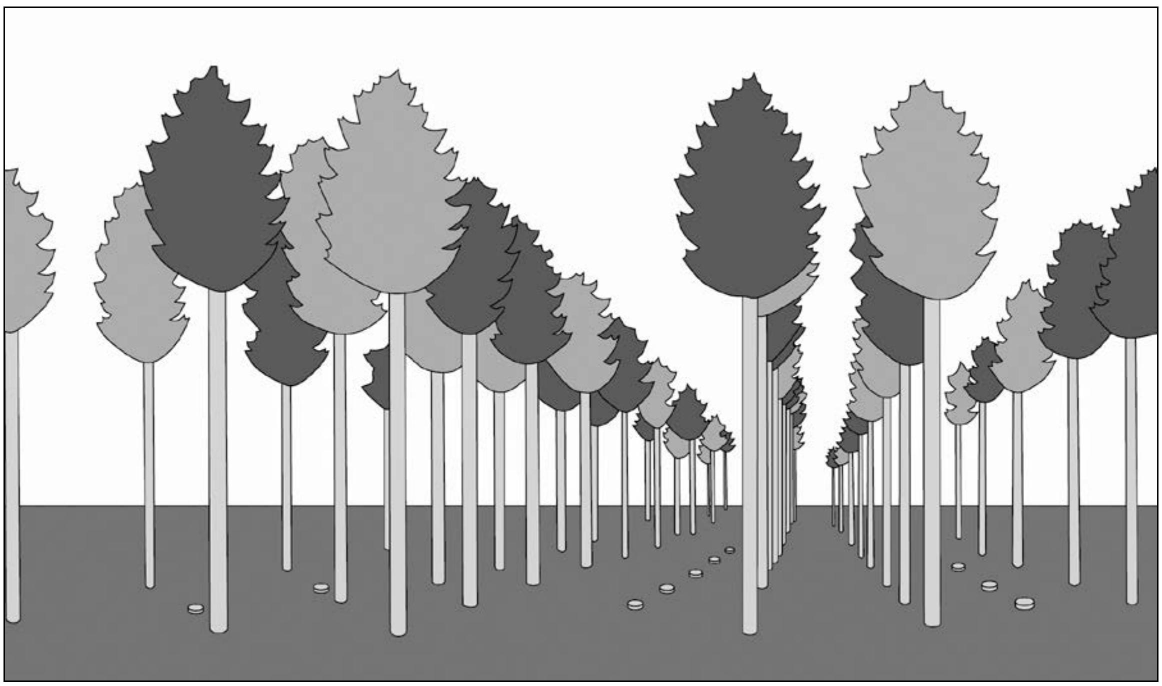

Figure 23.2: A mechanical row thinning in a pine plantation in which every third row of trees has been removed. The opening in the canopy should close in a few years. *(Adapted from Fact Sheet G3398, Wisconsin Woodlands: Intermediate Cuttings in Forest Management, University of Wisconsin Extension)*

2. Low Thinning (Thinning From Below)

Low thinning (figure 23.3) is the removal of trees from the lower crown classes to favor those in the upper crown classes. This strategy accelerates and simulates somewhat the natural elimination of the lower crown classes through competition.

Application:

- The marketability of the relatively small trees removed can sometimes be difficult.
- Light to medium intensity low thinnings remove only suppressed to intermediate trees. These strategies generally are not recommended except in specific cases. They facilitate utilization of the trees that would probably die due to suppression (competition), but the release of the remaining trees from competition is minimal.
- Heavy low thinning generally is recommended. This strategy removes suppressed, intermediate, and the poorest codominant trees (least desirable competitors, high risk, low vigor, poor quality). The removal of some codominants creates canopy openings and releases the crowns of crop trees to stimulate their growth.
  - Utilize stocking guides to help determine target residual stand density (of evenly spaced codominant and dominant trees).
  - Crop tree selection and order of removal criteria (Chapter 24) help define characteristics of which codominants to favor and which to preferentially remove.

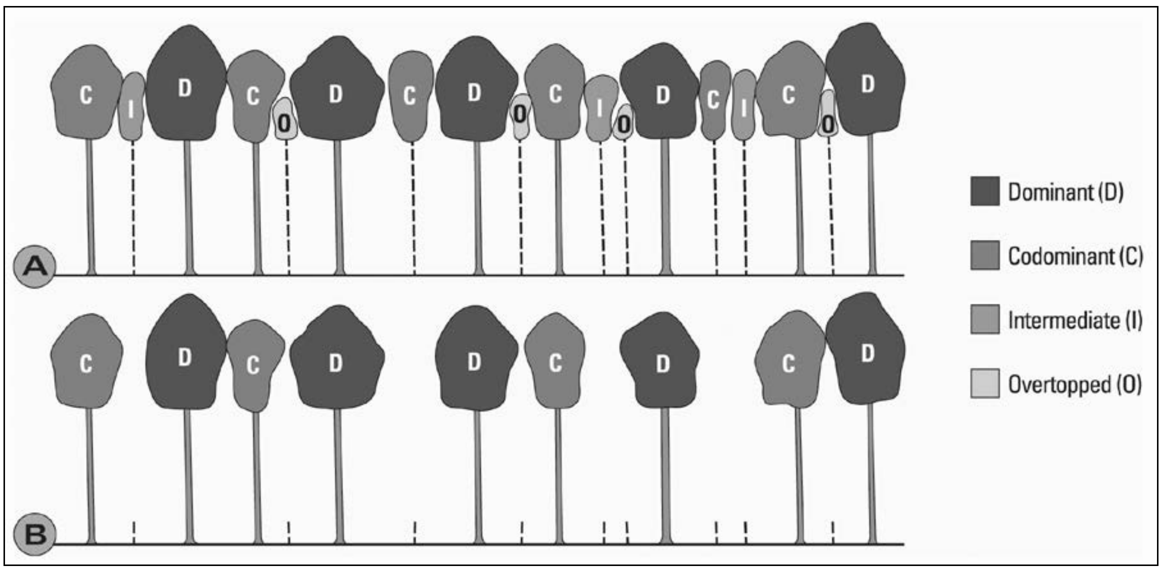

Figure 23.3: How a stand might look before (A), and after (B), a low thinning.
The letters on the tree crowns denote crown classes.
(Adapted from © David M. Smith, 1962, The Practice of Silviculture, Seventh Edition, John Wiley & Sons, Inc.)

3. Crown Thinning (High Thinning, Thinning From Above)
   Crown thinning (figures 23.4 and 23.5) is the removal of trees from the dominant and codominant crown classes in order to favor the best trees of those same crown classes. Large intermediates that interfere with crop trees also can be removed. The method stimulates the growth of selected, preferred trees (quality) without sacrificing the production of quantity. Crown thinning is recommended to develop and manage quality hardwood stands for the production of high value sawtimber and veneer logs.

   Application:
   - Often conducted as commercial operations. The trees removed are relatively large.
   - Release the best dominant and codominant crop trees. Ideally, these crop trees are selected, favored, and carried through the entire rotation.
     - Determine minimum selection criteria (see crop tree selection criteria in Chapter 24).
     - Determine maximum number of well-spaced sawtimber crop trees per acre, and average desired spacing.
       - Usually, 40-150 crop trees per acre.
       - Landowner objectives.
       - Tree species, vigor, quality, strength, and health.
     - Mark to release crowns.
       - Remove strong crown competitors
       - 4-sided, in fast growing, young stands, with small-crowned competitors.
       - 1-3 sided, in slower growing, older stands, with larger-crowned competitors.
   - To optimize stand growth, it is recommended to thin through the remaining stand, releasing the best dominant and codominant trees (these trees may be removed in later thinnings) by removing higher risk, lower vigor, and lower quality competitors (see standard order of removal in Chapter 24).
     - Utilize stocking guides to help determine target residual density (of evenly spaced trees).
   - The intensity and timing of thinnings can be varied to manage stem form and natural pruning.
   - Requires skill to apply (tree selection, density management, and timing).

Canopy gaps created during each thinning are mostly filled through crown expansion of residual dominants and codominants, however some may be partially captured through the growth of released intermediate or suppressed trees. Crown thinnings are most applicable to stands composed of shade tolerant species or a mixture of species. When applied to stands of intolerant or mid-tolerant species, alternation of crown thinnings with low thinnings may be preferable, if utilization of the suppressed and intermediate trees is desired (free thinning integrates crown and low thining methods into a single application).

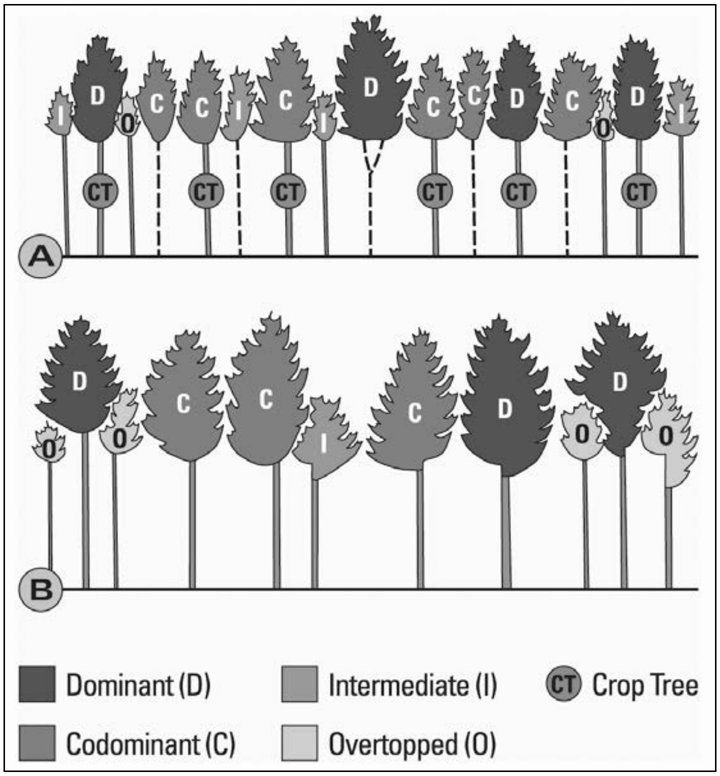

Figure 23.4: The upper sketch (A) shows a coniferous stand immediately before a crown thinning. The crop trees are indicated by the circles marked "CT". The lower sketch (B) shows the same stand about 20 years after the crown thinning, which has reclosed to the point where a low thinning would be desirable. *(Adapted from © David M. Smith, 1962, The Practice of Silviculture, Seventh Edition, John Wiley & Sons, Inc.)*

Figure 23.5: This crop tree, released on two to three sides by cutting competing trees, is now free to grow.
(Photo by J. Martin, J-Mar Photography)

4. Free Thinning
   Free thinning is the removal of trees to control stand density and favor desired crop trees using a combination of thinning criteria without strict regard to crown position. In application, this method is a free combination of selected concepts and techniques garnered from both low and crown thinning methods. **Follow crop tree selection and order of removal guidelines (Chapter 24).** Utilize stocking guides to help determine target residual density. Free thinning is recommended to develop and manage quality hardwood stands for the production of high value sawtimber and veneer logs. To be most effective, free thinning requires considerable skill in tree selection and density management.

Application of Thinning Methods
To manage stands to develop quality sawtimber without sacrificing quantity:
- Free thinning is a recommended thinning method.
- Crown thinning is a recommended thinning method.
- Occasional low thinnings can be incorporated.
- Mechanical thinnings can be prescribed for the initial thinning when appropriate.

To manage stands to produce pulpwood, poles, or other small diameter wood products:
- Low thinnings are often recommended.
- Occasional crown thinnings can be incorporated.
- Occasional free thinnings can be incorporated.
- Mechanical thinnings often are appropriate for the initial thinning(s).

Thinning operations are more critical to increase value from the production of quality sawtimber, especially at reduced time scales, than to the production of timber quantity. Where timber production objectives are of minor importance, creative thinning regimes can stimulate the development of specific tree and stand conditions to satisfy other landowner objectives.

Intensity of Thinnings

The intensity of thinning refers to the regulation of stand density. Thinnings that remove a greater proportion of the stand are heavier, while those that remove lesser proportions are lighter or less intense. As intensity increases, the frequency of thinnings usually decreases. A thinning schedule should indicate the intensity of thinning at each entry.

If the production of quality sawtimber is a management objective:

- Identify three categories of trees at each thinning: the best sawtimber crop trees, trees to be retained until later thinnings, and trees to be removed in the current thinning.
- The primary objective of thinning is to crown release the sawtimber crop trees, and also harvest high risk trees (those not retained as wildlife trees). The intensity depends on the number of crop trees and the degree of release, and the number of high risk trees. In some cases, this may be the only operation.
- To optimize stand growth and yield, the rest of the stand should also be thinned, favoring the best and removing the less desirable individuals, while considering risk, vigor, quality, species composition and spacing (see Chapter 24). Apply stocking guides.

Stocking guides (figure 23.6) can help define target residual stand density:

- Stocking charts provide a statistical approach to density management based on observed relationships between stand density, growth, and wood value. Target stocking levels are determined based on optimizing stand growth and merchantable yield for a specific forest cover type.
- The area between the A-line and B-line indicates the range of stocking where trees can fully occupy and utilize the site (fully stocked stand). Within this range, optimum stand growth and volume yield can be maintained.
  - The A-line represents the maximum stocking level that can maintain optimum stand growth and yield. Allowing stand density to surpass the A-line (overstocked) will reduce merchantable board-foot volume growth and yield. Maintaining stocking levels near (but below) the A-line will produce comparatively more trees, but of smaller diameter.
  - The B-line represents the minimum stocking level that can maintain (fully occupy the site) optimum stand growth and yield. Reduction of stand density below the B-line (understocked) will reduce stand volume growth and yield. Maintaining stocking levels near (but above) the B-line will produce larger diameter trees faster, but comparatively fewer trees.
  - The C-line, on some charts, show the limit of stocking necessary to reach the B-line level in 10 years on average sites.
- Stocking charts display the relationship between basal area, number of trees, and mean diameter.
- To utilize stocking guides, statistically accurate estimates of at least two stand variables must be obtained, including basal area per acre, number of trees per acre, and/or mean tree diameter. Depending on the specific stocking guide, these variables may be measured only for canopy trees or for all trees ≥5 inches dbh.
  - Mean diameter is the calculated quadratic mean diameter (QMD, dbhq), which is the diameter corresponding to the mean basal area of the trees in the stand (the tree of average basal area); it is not the arithmetical mean of the diameters.
  - QMD calculation where B = basal area/acre, and n = number of trees/acre

$$QMD = \sqrt{B/(0.005454 * n)} \quad \text{or} \quad QMD = \sqrt{(B/n)/0.005454}$$

  - QMD calculation where d = dbh of tree, and n = number of trees measured

$$QMD = \sqrt{\left(\sum d\hat{}2\right)/n}$$

- Stocking charts function as useful guides for when and how much to thin. Stand density is allowed to fluctuate between defined limits (A- and B-lines). When designing and implementing a thinning regime for a stand, do not reduce stand density to below the B-line or allow it to surpass the A-line. Thinning can occur at any time as long as stand density is maintained between the A-line and B-line. The A-line is not a thinning "trigger." When and how much to thin depends on management objectives, stand conditions, and feasibility.
  - Typically, for the production of quality sawtimber, thinning is implemented when average stand stocking is halfway or more between the B-line and A-line, and then stocking is reduced to slightly above the B-line. Regular reduction of stand density to the lowest level at which full occupancy is maintained (near B-line) should result in the most rapid diameter growth that can be maintained without reduction in total merchantable board-foot volume yields. As stands age, residual density should slowly increase.
  - Higher levels of residual density may be desired where greater yields of pulpwood or poles are the objective of management. Other reasons to maintain higher densities include considerations for natural pruning, stem taper, specific wood characteristics, and landowner objectives.

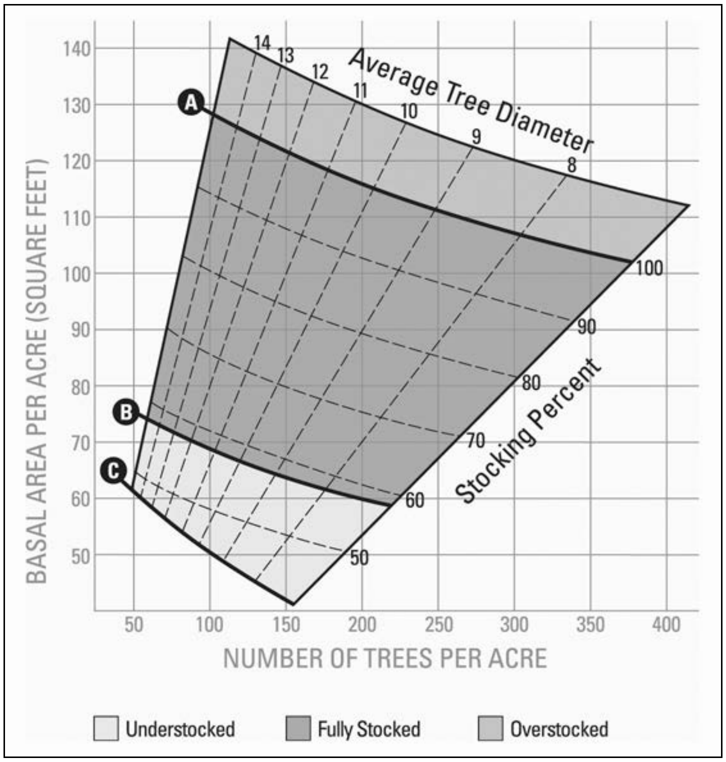

Figure 23.6: Stocking guide/chart for upland central hardwoods displaying the relation of basal area, number of trees, and average tree diameter (the tree of average basal area) to stocking percent. The area between A-line and B-line indicates the range of stocking where trees can fully utilize the site. C-line shows the limit of stocking necessary to reach the B-line level in 10 years on average sites. Similar guides are available for each major species. *(Adapted from I. L. Sander, 1977, Manager's Handbook for Oaks in the North Central States, USDA Forest Service Gen. Tech. Rep. NC-37, North Central Forest Experiment Station, St. Paul, MN)*

In overstocked stands, thin lightly and frequently, with increasing intensity, for the first several thinnings, to safely develop tree crown vigor and strength, and until target residual densities (near the B-line) are achieved. A general guideline is do not remove >50% of the basal area in any one thinning operation.

Within a stand, thinning gradually develops resistance to damage (insects, disease, wind, etc.), however it can also temporarily predispose stands to damage, particularly where trees are not vigorous or strong. It is also important to control logging damage when thinning; logging wounds can predispose the remaining trees to disease and decay. Consider space to fell trees and to maneuver equipment.

Variable Density Thinning (VDT)

Variable density thinning varies target residual stocking (thinning intensity) in even-aged stands and creates non-uniform conditions at the stand level. Portions of the thinned stand remain at different residual densities, from relatively close spacing (high density) to relatively open spacing (low density). VDT can provide the traditional benefits derived from thinning, but can also increase spatial heterogeneity and ecological diversity across the stand.

In application, the majority of the stand (matrix) is thinned to the target residual basal area selected to achieve landowner goals and stand management objectives. Delineated areas may be thinned to higher (denser) or lower (less dense, more open) residual basal areas, but residual stocking should be maintained between the B-line and A-line. Consider management goals and objectives, and stand and site conditions when locating areas of variable density. Sections of the stand thinned to different densities should be mapped.

Timing of Thinnings

If a landowner desires to realize the types of benefits associated with thinning, then the failure to thin is simply a lost opportunity to develop those benefits. In deciding when to thin, a landowner needs to clarify what investments they are willing to make and what benefits (economic, social, ecological) are desired. However, if stands become overstocked (above the A-line) or understocked (below the B-line), then stand growth and timber volume yield will be compromised.

Initial thinnings can begin once the crowns begin to touch each other. Precommercial thinning (TSI) requires an investment, but can increase net returns over the rotation. However, it is most typical to postpone the initial thinning until an immediate profit can be produced.

The effects of thinnings are temporary. After each thinning, the remaining trees grow taller, diameters increase, crowns expand, and canopy gaps close; stand density increases. Periodic thinnings can maintain crown vigor and accelerated diameter growth rates of crop trees.

Criteria that can be used to indicate the need for further thinning:

- Declining live crown ratios of crop trees.
- Declining rates of diameter growth of crop trees.
- Accumulation of sufficient timber volume to justify operations.
- Thinning often is prescribed when stand density increases to near specified upper limits (A-line) delineated in stocking charts developed as thinning guides. However, thinning can occur anytime that stocking is above minimum limits (B-line); regular reduction of stand density to the lowest level at which full occupancy is maintained should result in the most rapid diameter growth that can be maintained without reduction in total volume yields.

Thinning can improve tree and stand vigor, enhancing both growth and tree health. However, thinning is a disturbance and causes temporary stress to the stand and community. In addition, residual trees may be damaged during timber harvesting operations, and wounding predisposes trees to disease and decay. To encourage beneficial biological responses (e.g. tree growth and health) and minimize negative responses (e.g. disease and mortality) to thinning, sufficient time should be allowed between thinning operations for the stand to recuperate from stress and for vigorous development.

Thin every 8-15 years is a recommended general guideline for commercial thinnings. Frequent, light intensity thinnings can provide the best sawtimber yields. Less frequent, heavier thinnings are more common due to operational and biological considerations. Stands of young trees should be thinned more frequently (than stands of older, larger trees), because they close more rapidly due to high growth rates and small crowns.

Thinning Clumps of Trees

Clumps are defined here as root, root collar, or stem sprouts, as well as trees of seed origin growing in close proximity to one another so their lower boles contact each other or have the potential to contact each other. They commonly occur in hardwoods. Clump thinning is the removal of some, but not all, tree members of a clump. This practice can predispose residuals to butt rot, stain, or wilt disease, which enter directly from adjoining cut sprouts or wounds made while clump thinning (Campbell 1938, Houston 1993, Roth 1956). To minimize decay in the lower bole and to avoid some wilt diseases, it is generally recommended to avoid clump thinning pole-sized or larger clumps by either leaving or removing all stems in a clump.

When deciding whether or not to thin, leave all, or cut all stems occurring in clumps, one should consider several factors:

- logging operability, equipment, and proximity of clump stems
- origin of clump stems (e.g. root, root collar, or stem sprouts)
- shape and angle of clump stem unions (e.g. V- or U-shaped union)
- stem size
- stem quality
- vigor
- species susceptibility to decay and disease
- stocking
- stand quality
- future stand treatments and timeline

Seedling and Sapling-sized Clumps

Thinning seedling or sapling-sized clumps as early as possible is most desirable (Campbell 1938, Godman 1992, reviewed in Tubbs 1977). One reason for this is the earlier the clumps are thinned, the less likely it is their boles will be close to one another and the smaller the chance for residual damage. Also, young clump members generally have not formed heartwood, so decay transfer from a cut stem to an adjoining stem is less likely. When thinning young sprouts, one needs to consider all the factors listed above, but the general recommendation is to remove those that arise from the parent stump above the root collar (i.e. retain those that attach to the parent stump at the root collar), and reduce clumps to one or two vigorous stems, which should be well spaced and not connected to one another. Doing this work before stands are 20 years old is recommended (Campbell 1938). If stands are over 20 years old, see recommendations in the below section, "Pole-sized and Larger Clumps."

If young clump stems are connected to one another, stems less than 2 inches DBH can be thinned without concern for promoting significant decay, regardless of their stem union shape or stem origin (Campbell 1938, reviewed in Roth 1956). If the stems are greater than 2 inches DBH, see the section below, "Pole-sized and Larger Clumps."

Pole-sized and Larger Clumps

Though it is best to thin clumps before trees reach pole-size or larger, many stands will have an overabundance of clumps in larger diameter classes for a variety of reasons. The proximity of stems to each other (i.e. logging operability), the origin of clump stems, and stem union shape and angle are three important factors to consider when deciding whether or not to thin clumps of pole-sized or larger trees. See other factors listed above that should also be considered.

Stems connected in a V-shape above the root collar share stem pith (Figure 23.7). These are defined here as stem sprouts. This trait promotes the development of decay in the residual stem once connected stems are cut. Therefore, trees connected by V-shaped unions above the root collar (i.e. stem sprouts) should all be removed or none removed (Roth 1956). Stems originating at the root or root collar but meeting in a V-shape are not as susceptible to decay after clump thinning (Campbell 1938, Shigo and Larson 1969). However, during thinning, the likelihood of damaging a residual stem connected by V-shaped union, especially one where the stems meet in a narrow angle, is high, regardless of stem origin (i.e. the logging operability is poor) (Figures 23.8 and 23.10). Logging damage is a common source of decay in residual clump members (Campbell 1938, Shigo and Larson 1969).

Thinning clumps with U-shaped unions has been shown to cause less decay in the residual, in contrast to thinning V-shaped unions (Roth 1956). Also, trees connected by U-shaped unions oftentimes lend themselves to better logging operability, although it is still important to consider whether the equipment can harvest stems without damaging the residual stems (Figure 23.9). Unfortunately, field observations indicate V-shaped unions are much more common than U-shaped unions.

Finally, note that the flexibility and smaller sized equipment used in manual felling makes it a more desirable method for clump thinning than mechanized felling.

Species Considerations

Individual species' susceptibilities to decay and the timeline for subsequent stand entries should be considered when deciding whether or not to thin clumps. See cover type chapters in this handbook to review specific species' susceptibilities to decay.

Other disease introductions also need to be considered when deciding whether or not to thin a clump. Sapstreak disease in sugar maple occurs when the fungal pathogen enters the tree through a wound on the lower bole, which includes the stump created after cutting a connected tree (Houston 1993). Sugar maples are susceptible to infection by the sapstreak fungus from late spring through early summer. Therefore, leave all or take all connected sugar maples when thinning during times and in locations where sapstreak disease transmission is likely to occur (Figure 23.10).

Likewise, clump thinning could cause residual oaks to become infected by oak wilt if thinning occurred between April and October. Regardless of whether oak stands have clumps of oaks or not, intermediate treatments during this period in oak stands increase the risk of oak wilt transmission to the stands. Be sure to review the Wisconsin DNR's "Oak Wilt: Harvest Guidelines for Reducing the Risk of Introduction and Spread in a Forest Setting."

Management Recommendations Summary

If the stand has the potential to produce quality hardwood logs, consider the complete removal or full retention (versus thinning) of clumps, since hardwood stump sprouts tend to exhibit poor form and have a predisposition for butt rot that enters directly from the decaying parent stump or the stubs of adjoining cut sprouts (Campbell 1938, Roth 1956). When choosing to thin clumps, thin those whose tree members originate at the root or root collar, connect in a U-shape, and whose stems allow for thinning without wounding residuals. Do not thin sugar maple clumps during times and in locations where sapstreak transmission is likely to occur. See "Decision Model for Evaluating the Potential to Thin Clumps" (Figure 23.11) for a summary of these recommendations.

Figure 23.7. Avoid thinning sprouts that attach to each other above the root collar like the cut stem sprouts shown here (white arrows). These residual basswoods will develop butt-decay in them because of this practice.

Figure 23.8. A residual tree with butt-rot due to clump thinning. The cut stem appears to have been connected to the residual stem in a V-shape. Poor logging operability caused the logger to wound the residual (see white arrow pointing to chainsaw wound), which facilitated decay in the residual's butt log. Also, decay may have transferred directly from the cut stem into the residual stem.

Figure 23.9. One of these sprouts could be thinned without great risk for decay in the residual because they are connected in a U-shape at their root collars. Thinning clumps with U-shaped unions has been shown to cause relatively less decay in the residuals than thinning clumps with V-shaped unions.

Figure 23.10. A sugar maple clump with stems originating at the root collar and meeting in a narrow-angled V-shape. Thinning is not recommended because the chances of wounding the residual in this clump is high. It is recommended to take or leave both stems. In addition, if this clump was thinned between late spring and early summer, the residual may become infected with sapstreak disease.

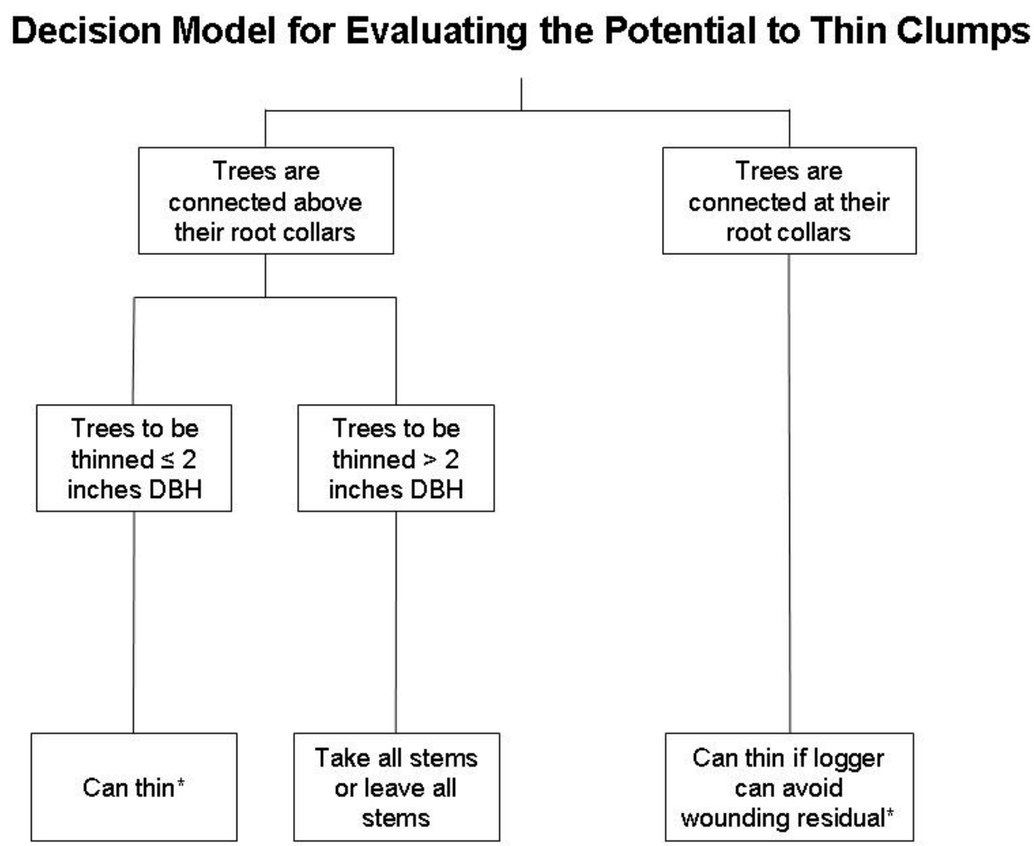

Figure 23.11. Use this key to determine whether or not thinning clumps is recommended.

*Note that thinning oak and sugar maple stands increases the risk of disease transmission during specific periods in the year.

IMPROVEMENT CUTTING

Improvement cutting is the removal of less desirable trees of any species in a stand of poles or larger trees, primarily to improve composition and quality to achieve landowner goals and objectives. Trees are removed to encourage the growth of more desirable trees within or below the main canopy. Trees considered for removal include undesirable species, trees of poor vigor, trees of poor quality, and injured or unhealthy trees (risk). Potential crop trees should be preferred species and relatively well formed, vigorous, and healthy. Management goals, objectives, and considerations, as well as crop tree selection criteria and standard order of removal guidelines (Chapter 24), guide marking for improvement cutting.

Improvement cutting is usually applied in stands that have been unmanaged, neglected, or poorly managed. Sometimes, improvement cutting is essentially a delayed release treatment. Sometimes, these stands consist of many poor quality trees of multiple size and age classes resulting from past abuses such as high-grading. The intent is to remove undesirable material and set the stage for productive management to accomplish landowner objectives. In cases where the current stand is of such poor quality that rehabilitation is untenable (depending on landowner objectives, cover type, number of crop trees, and site quality), the preferred choice may be to initiate regeneration to develop a vigorous, new stand.

Where needed, improvement cuttings should be implemented as soon as possible. They are preliminary operations leading to systematic thinnings and reproduction methods. In most cases, stand improvement can be completed in one to three operations. Improvement cuttings can be commercial or non-commercial, depending on landowner objectives, treatment intensity, tree characteristics, wood quality, and local markets. In practice, techniques of improvement and thinning often are combined during initial treatments.

SALVAGE AND SANITATION CUTTINGS

Salvage Cutting

Salvage cutting is the removal of dead, dying, or damaged trees resulting from injurious agents other than competition, to recover economic value that would otherwise be lost. Salvage operations are done for profit, with the intent of utilizing damaged trees and minimizing financial losses.

In forests, across large landscapes and long rotations, partial and catastrophic stand damage is inevitable. The intensity of salvage operations depends on the severity of damage, accessibility, potential economic losses, and landowner goals. Where landowner goals are in accordance, salvage should be conducted as soon as possible following the damaging event. Dead trees deteriorate rapidly during the first spring and summer following their death. Deterioration varies by species, tree size, site quality, and type of damage. Severe stand damage will require the implementation of regeneration methods.

Before implementing salvage operations, consider management goals and objectives relative to wildlife and biodiversity. Large diameter decaying trees, dying trees, snags, and down coarse woody debris provide critical habitat for many organisms. Following severe stand disturbance, these structures can provide habitat that facilitates species perpetuation on site, re-colonization, dispersion, and landscape connectivity.

During salvage operations, consider retaining some unsalvaged patches at least one tenth acre in size to provide habitat structure. These patches should include large diameter reserve trees, mast trees, cavity trees, snags, and down course woody debris if present. Unsalvaged patches can often be located to complement multiple management objectives and stand conditions; such as the protection of critical areas, riparian management zones, travel corridors, or areas with poor logging access. Many salvage operations will contain significant unsalvaged patches simply due to the operational constraints of working in severely disturbed stands. The extent and distribution of unsalvaged patches may need to be modified if retention would interfere with effective sanitation methods to control insect and disease outbreaks or be deemed a threat to human health and safety (e.g., wildland fire fuel treatments).

Presalvage cutting is the removal of valuable trees at high risk of injury or mortality from damaging agents. The method attempts to anticipate damage by removing vulnerable trees that are in imminent danger of being damaged or killed. Important tree criteria include species, vigor, mechanical structure, and position in the stand.

Sanitation Cutting

Sanitation cutting is the removal of trees to improve stand health by stopping or reducing the actual or anticipated spread of insects or disease. It is precautionary protection implemented to reduce the spread of damaging organisms or in anticipation of attacks in an attempt to prevent or delay the establishment of damaging organisms. Sanitation cuttings eliminate trees that are present or prospective sources of infection for insects or fungi that might attack other trees. The removal of trees must actually interrupt the life cycle of the organisms sufficiently to reduce their spread to other trees.

PRUNING

Pruning is a silvicultural technique, typically applied to improve timber quality and value. It is the removal, close to the branch collar or flush with the stem, of side branches and multiple leaders from a standing tree. Lateral pruning removes branches because they form knots, which are a common defect of lumber and reduce timber value. The retention of large, dead branches low on the trunk is particularly counterproductive. Corrective pruning removes multiple leaders to improve stem form. Sometimes, pruning is applied to control disease, improve aesthetics, or improve accessibility.

Natural pruning or self-pruning is the natural elimination of branches. It is a slow process that varies by species, tree vigor, and stand density. Maintaining dense stands promotes natural pruning, but vigor and diameter growth are reduced. For some species, poor natural pruning and slow growth rates in dense stands require long rotations to produce quality timber.

Pruning is expensive. Only the best quality crop trees on good sites (those that support acceptable tree growth rates) are selected for pruning. It is most commonly applied to conifer plantations for species which are poor natural pruners, but which can significantly increase value by producing clear lumber (e.g. white and red pines). Pruning can enable more aggressive thinning strategies, if the promotion of natural pruning is no longer a concern. Thinning promotes the production of clear wood and stimulates the rapid healing of wounds. Combining pruning and aggressive thinning can facilitate the production of increased value in a shorter period of time. Pruning is an investment and should be implemented carefully; careless, poorly implemented pruning can cause tree injury and damage quality. Keeping records of pruning operations could be economically beneficial.

Operational Considerations:

- Site quality: Prune only on good sites (those that support acceptable tree growth rates) for the target species.
- Tree characteristics: Most vigorous, healthy, dominant (tallest), and largest diameter crop trees for the dominant age class – the very best individuals.
- Number of trees: Typically 50-200 crop trees per acre.
- First pruning:
  - The first corrective pruning should occur in seedling or sapling stands.
  - The first lateral pruning should occur in young, vigorous poletimber stands before the lower branches become relatively large, and should follow early initial thinning.
- Pruning height:
  - The higher the pruning, the more difficult and expensive.
  - Typical final objective is a clear trunk to 17 feet; prune at least to 9 feet.
  - Each time, prune to topmost whorl of dead branches or into lower portion of live crown.
  - Maintain live crown:tree height ratio greater than 50%.
- Number of pruning operations: Typically 2-3.
- Season to prune: Dormant season – fall to late winter best.
- Prune branches less than 1½ - 2 inches diameter. Removing large, live branches can damage quality.
- Avoid excessive green pruning of live branches. The best time to remove a branch is just before death or within several years thereafter.
- How to cut (figure 23.12): Cuts should be made close to the branch collar. For species lacking a distinct branch collar or callus ridge, cuts should be made flush with the stem but without damaging any bark. Don't tear or loosen bark around branch stub. No splinters or broken stubs.
- Tools: Combining hand and pole saws provides an effective and economical choice. Other tools and machines are available, and may be preferable depending on species, limb characteristics, and pruning height.

Some of the cover type chapters contain additional species specific pruning guidelines.

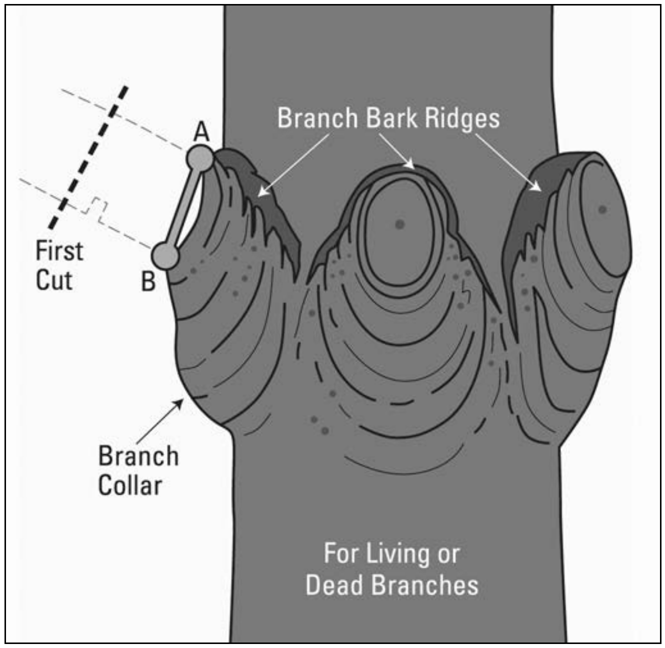

Figure 23.12: When pruning, leave the branch collar. Cut from point “A” to point “B”.

<u>REFERENCES</u>

Campbell, W. A. 1938. Preliminary report on decay in sprout northern hardwoods in relation to timber stand improvement. USDA Forest Service Occasional Paper 7, Northeast Forest Experiment Station, Upper Darby, Pennsylvania. 8 pp.

Curtis, R.O. and D.D. Marshall. 2000. Why quadratic mean diameter? WJAF 15(3):137-139.

Franklin, J.F., R.J. Mitchell, and B.J. Palik. 2007. Natural disturbance and stand development principles for ecological forestry. USDA For. Serv., N. Res. Stn., GTR NRS-19, 44pp.

Godman, R. M. 1992. Thinning sprout clumps. In: Hutchinson, J. G., ed. Northern Hardwood Notes. St. Paul, MN: USDA Forest Service, North Central Research Station: Note 3.11.

Helms, J.A. (Editor). 1998. The Dictionary of Forestry. Society of American Foresters.

Houston, D. R. 1993. Recognizing and managing sapstreak disease of sugar maple. USDA Northeast Forest Experiment Station Research Paper NE-675.

Huebschmann, M. and J. Martin. 1987. Intermediate Cuttings in Forest Management. Wisconsin Woodlands G3398. Univ. Wisc. – Extension.

Nyland, R.D. 1996. Silviculture: Concepts and Applications. McGraw-Hill.

Perkey, A.W., B.L. Wilkins, and H.C. Smith. 1993. Crop Tree Management in Eastern Hardwoods. NA-TP-19-93. USDA For. Serv., NESPF, Morgantown, WV.

Roth, E. R. 1956. Decay following thinning of sprout oak clumps. Journal of Forestry 54(1):26-30.

Shigo, A. L., and E.H. Larson. 1969. A photo guide to the patterns of discoloration and decay in living northern hardwood trees. USDA Forest Service Research Paper NE-127.

Smith, D.M. 1962. The Practice of Silviculture, 7th ed. New York: Wiley.

Tubbs, C. H. 1977. Natural regeneration of northern hardwoods in the northern great lakes region. USDA North Central Forest Experiment Station Research Paper NC-150.

Zeide, B. 2001. Thinning and Growth: A Full Turnaround. J. For. 99:20-25.