

Chapter 2:

Conducting a Woodland Inventory

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Good decisions require good information. An inventory of the woodland resources on your property is an important first step in developing a stewardship plan. Information gathered from the inventory provides you with a snapshot of the current condition and future potential of your woodlands.

Because woodlands are often viewed as a source of timber, a woodland inventory usually focuses on assessing trees as potential wood products. However, a woodland inventory is equally valuable for assessing wildlife habitat, planning trails for recreation, and understanding the quality of your soil and water resources. An inventory of your woodland should focus on what is most important to you and provide you with the information you need to make good decisions about the management of your land.

Your first step in conducting a woodland inventory should be to contract with a forestry professional to perform an inventory of your woodland. Since an inventory involves some time and expense, your forester must know your goals for the property and what resources are most important to you. A woodland inventory may include these and other features:

- Tree measurements:
 - Tree diameter
 - Tree height
 - Merchantable height
 - Tree defects
 - Tree volume
 - Tree grade
 - Biomass
- Stand measurements:
 - Stand volume
 - Stocking
 - Growth and yield tables
- Site quality:
 - Site index
 - Tree quality
 - Understory plant indicators

After analyzing this information, your forester will offer management alternatives for each stand. Knowing what is physically possible and financially realistic, you can select the management strategies that best meet your goals and resources.

Tree Measurements

Tree diameter, merchantable tree height, and grade can be used to determine the volume of useful wood in a tree.

Tree Diameter

Tree diameter is measured on the main stem 4.5 feet above ground on the uphill side of a tree. This is referred to as diameter at breast height (DBH). DBH usually is measured to the nearest inch using a steel diameter tape that is calibrated to permit direct tree diameter readings.

To measure tree diameter with a diameter tape, wrap the tape around the tree at breast height, perpendicular to the lean of the tree, standing on the uphill side of the tree (Figure 2-1). If there are branches or other protrusions at DBH, place the tape at the first unobstructed location above them. If the tree forks below DBH, consider each stem to be a separate tree and record separate measurements for each tree.

If you don't have a diameter tape, measure tree circumference by wrapping a normal tape measure around the tree at breast height, then dividing the resulting circumference in inches by 3.14 to determine DBH.

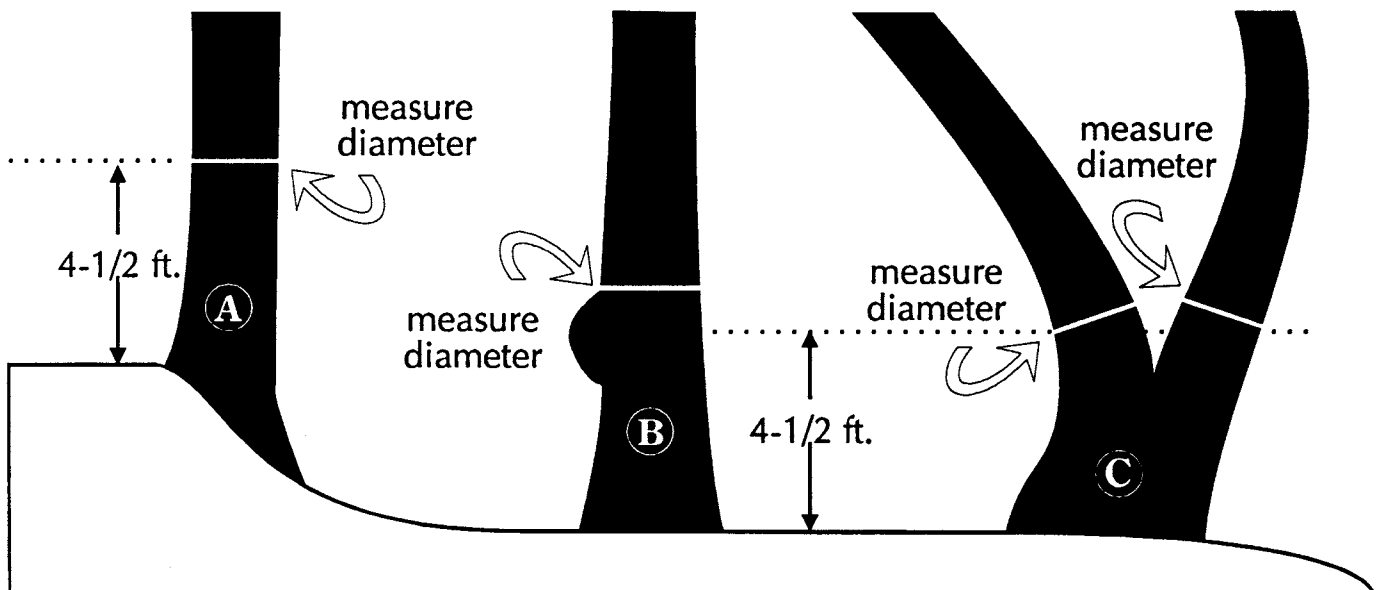


Figure 2-1. Measure stem diameter at breast height (DBH)

Tree Height

Total tree height is the distance in feet from the ground to the top of a tree. This height measurement is used mainly in conjunction with tree age to judge site quality, which is explained later in this chapter.

Merchantable tree height is the length of the main stem from the top of the expected stump to the upper limit of utilization in the tree. Stump height normally is 6 inches for softwood species and 12 inches for hardwood species, but varies depending on the volume table you use. The upper limit of utilization is where the main stem reaches a minimum usable top diameter, a main fork, or a serious defect such as a hole or a point of decay, or where excess limbs occur. Standards for merchantability vary widely depending on local product markets. The usual minimum top diameter inside the bark (DIB) is 4 inches for pulpwood, 8 inches for sawlogs, and 10 inches for veneer logs. Merchantable tree height usually is measured in 8-foot lengths called half-logs, sticks, or bolts, but may be measured to the nearest 2 feet on high-value trees. Your forester will determine a tree's height using a hypsometer, clinometer or a laser height finder (Figure 2-2). Measure the height of a leaning tree from a viewpoint where the tree is leaning to the left or the right, not from where it is leaning toward or away from you.

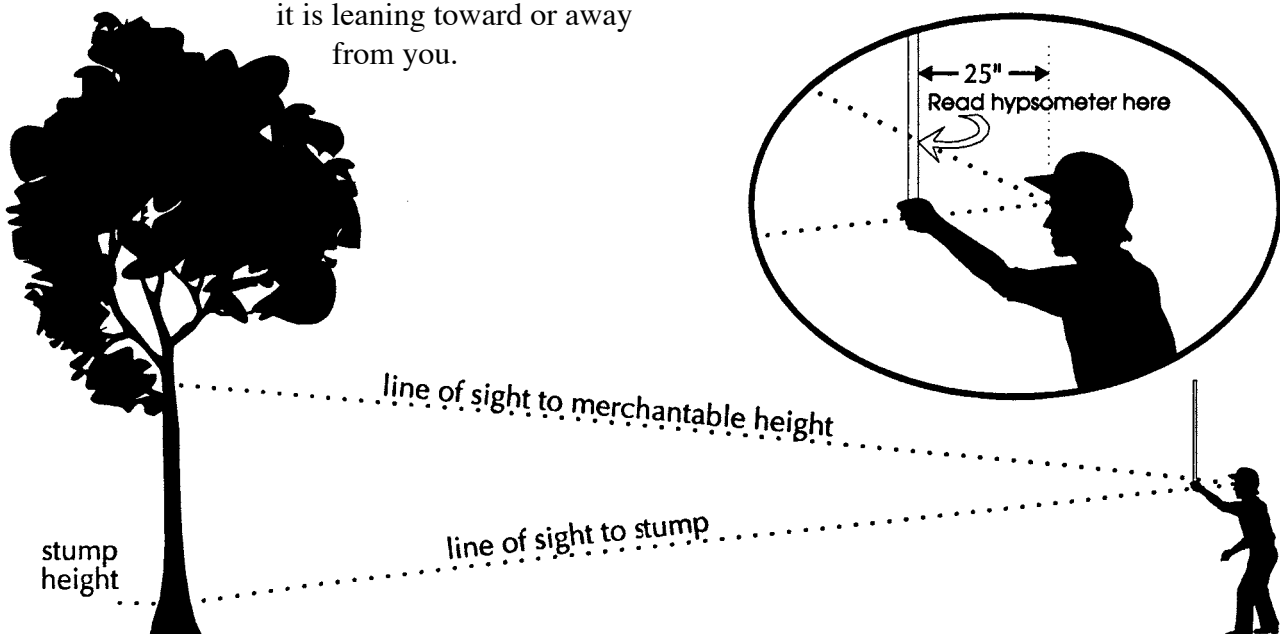


Figure 2-2. Measuring merchantable tree height with a hypsometer.

You can make a simple hypsometer by placing marks at 4-inch intervals along a stick or lath. Each mark represents one 8-foot bolt when the stick is used as follows:

1. Stand 50 feet from the tree center in a direction such that the tree does not lean toward or away from you.
2. With the stick in hand, extend your arm out 25 inches from your eye. Hold the stick vertically and in line with the stem of the tree being measured.
3. Find the upper limit of utilization. (Upper limit of utilization is different forest products. This is the minimum diameter at the small end of the log that a mill will accept to use that log for a certain product.) Remember that point.
4. Raise or lower the stick as needed until you can sight along the bottom of the stick to stump height. Then, moving your eyes, not your head, look up and read the stick measurement that corresponds to the upper limit of utilization point. Count the number of bolts between the stump and the merchantable height and record this number.

If you are unable to get a good sight on the tree from a distance of 50 feet, stand 25 feet from the tree and divide the resulting height measurement by two.

Tree Defects

The main stem is the most useful part of a tree for conventional wood products such as pulpwood, posts, poles, and lumber. Defects that reduce the total volume of usable wood in the

tree include sweep, crook, cracks, decay, forks, and imbedded objects (Figure 2-3). Your forester will note the percentage of defect in each tree stem by product type. This percentage is then deducted from the overall estimate of tree volume. Because tree diameter decreases with increasing height in the tree, a defect occurring near the top of the tree will require a smaller percentage volume deduction than a similarly occurring defect near the base. Percentage deductions for tree defects are best estimated by a forester and recorded on a tally form. If the entire tree is unusable because of an excessive amount of defect, your forester will not measure it for wood products. This is a cull tree, and while not usable for wood products, it can be valuable for wildlife habitat.

Defects such as burls, bird pecks, dead limbs, insect holes, live limbs, and knots will not affect the total volume of usable wood, but they will reduce wood quality, or grade (Figure 2-4). Tree grade influences the types of products that can be made from a tree and therefore the stumpage price. Higher grade trees have fewer defects.

Tree Volume

To estimate the wood volume of a tree's stem, your forester will measure the tree diameter and merchantable height, then find the corresponding volume in a table.

Sawtimber and Veneer Trees

Trees that are large enough and of high enough quality to produce logs that can be sawed into lumber are referred to as sawtimber. To qualify as

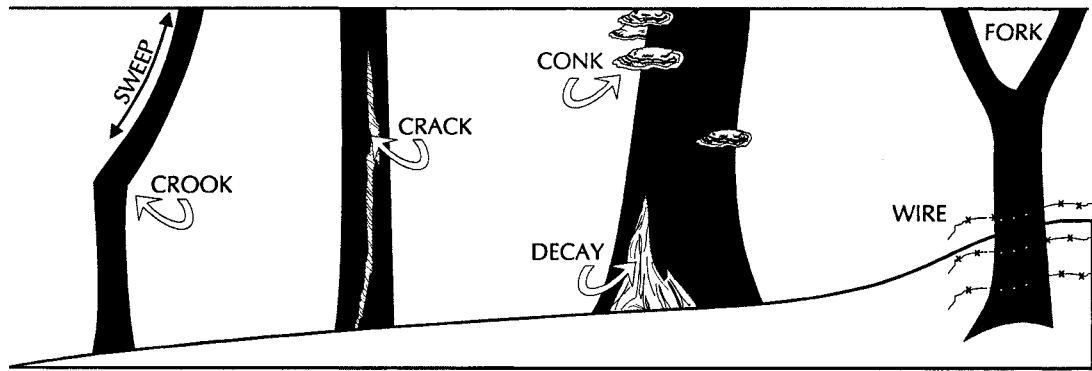


Figure 2-3. Tree defects that reduce the total volume of usable wood.

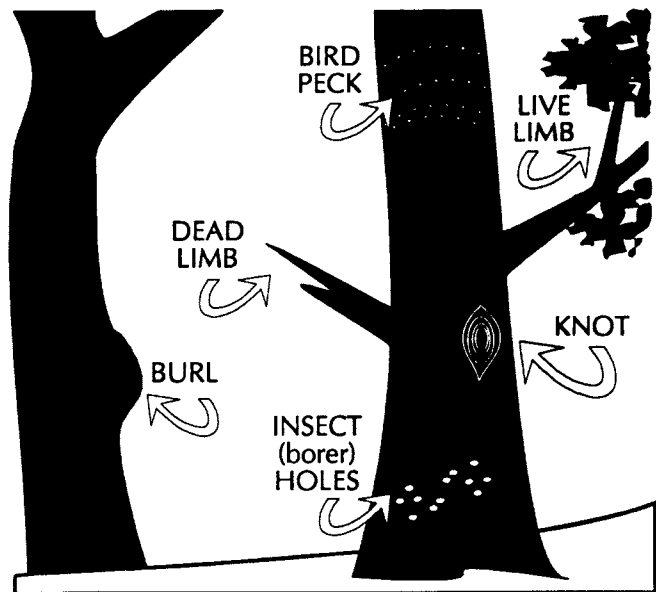


Figure 2-4. Tree defects that reduce wood quality.

sawtimber, trees should have at least one 8-foot bolt, be at least 10 inches DBH, and have a top diameter inside bark (DIB) that is the larger of either 8 inches or 50 percent of DBH. For example, to be a sawlog, a tree of 20 inches DBH should have a minimum top DIB of 10 inches. These specifications are typical, but individual buyers may have different specifications. Sawtimber trees must not contain too many defects that reduce wood volume such as decay, scars, cracks, bulges, bark distortions, holes, branch stubs, or crook.

Individual trees of many species (such as black walnut, white ash, sugar maple, red oak, white oak) that are of exceptional quality, have at least one 8-foot bolt, are at least 16 inches DBH, and contain



bolts that have a top DIB of at least 10 inches often can be sold as veneer trees. Logs harvested from these trees will be sliced or peeled into thin sheets. Such trees are more valuable than sawtimber.

The basic unit for estimating wood volume for both sawtimber and veneer trees is the board foot. A board foot is a piece of wood of any shape that contains 144 cubic inches of wood (for example, 12 inches by 12 inches by 1 inch, or 6 inches by 6 inches by 4 inches). Timber value is often described in dollars per thousand board feet (MBF).

Formulas called log and tree rules have been developed to estimate the number of board feet in a tree or log. A tree rule refers to a table that estimates wood volume in a standing tree. A log rule refers to a table that estimates wood volume in a cut log.

These rules differ in their assumptions about factors such as tree taper, board thickness, kerf (saw thickness), and minimum and maximum board width. They are never totally accurate, because:

- The assumptions on which they are based seldom occur.
- It is difficult to accurately measure volume losses from defects.

The Scribner rule (see Table 2-1 below) is used most often in the Lake States. For example, a tree with a DBH of 22 inches and four bolts (32 feet) of merchantable height will yield about 286 board feet. If the tree had a 10 percent defect then the total tree volume would be reduced to 257 board feet.

Table 2-1. Tree volume in board feet (Scribner rule).

How to Use Table 2-1. As an example, a tree with a DBH of 22 inches and four bolts (32 feet) of merchantable height will yield about 286 board feet. If there were 10 percent defect in the tree, total tree volume would be reduced to 257 board feet. A reasonable range of volume estimates per acre is 1,000 to 15,000 board feet.

| DBH In Inches | Number of 8-Foot Bolts | | | | | | | | | | | |
|---------------------|------------------------|----|-----|-----|-----|-----|------|------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 9 | 14 | — | — | — | — | — | — | — | — | — | — | — |
| 10 | 16 | 34 | 52 | 65 | — | — | — | — | — | — | — | — |
| 11 | — | 37 | 58 | 79 | 100 | 117 | — | — | — | — | — | — |
| 12 | — | 42 | 64 | 89 | 114 | 139 | 164 | 181 | — | — | — | — |
| 13 | — | 48 | 71 | 97 | 129 | 156 | 185 | 214 | 244 | — | — | — |
| 14 | — | — | 80 | 109 | 140 | 177 | 207 | 240 | 273 | 306 | 334 | — |
| 15 | — | — | 90 | 122 | 156 | 195 | 233 | 268 | 305 | 342 | 380 | 417 |
| 16 | — | — | 102 | 136 | 174 | 215 | 260 | 299 | 340 | 382 | 424 | 466 |
| 17 | — | — | 118 | 158 | 201 | 249 | 301 | 345 | 393 | 442 | 490 | 538 |
| 18 | — | — | 135 | 180 | 230 | 285 | 344 | 395 | 450 | 505 | 560 | 615 |
| 19 | — | — | 153 | 205 | 262 | 323 | 490 | 447 | 510 | 572 | 635 | 697 |
| 20 | — | — | 177 | 230 | 294 | 364 | 439 | 503 | 573 | 644 | 714 | 784 |
| 21 | — | — | — | 258 | 329 | 406 | 490 | 562 | 641 | 719 | 797 | 876 |
| 22 | — | — | — | 286 | 365 | 451 | 545 | 625 | 711 | 799 | 885 | 973 |
| 23 | — | — | — | 317 | 404 | 499 | 602 | 690 | 786 | 882 | 978 | 1074 |
| 24 | — | — | — | 348 | 444 | 548 | 661 | 759 | 864 | 970 | 1075 | 1181 |
| 25 | — | — | — | 381 | 486 | 600 | 724 | 830 | 945 | 1061 | 1176 | 1292 |
| 26 | — | — | — | 416 | 531 | 655 | 789 | 905 | 1031 | 1157 | 1282 | 1408 |
| 27 | — | — | — | 452 | 576 | 711 | 857 | 983 | 1119 | 1256 | 1392 | 1529 |
| 28 | — | — | — | 489 | 624 | 770 | 928 | 1064 | 1212 | 1360 | 1507 | 1655 |
| 29 | — | — | — | 528 | 674 | 831 | 1002 | 1149 | 1308 | 1468 | 1626 | 1786 |
| 30 | — | — | — | 577 | 725 | 894 | 1078 | 1236 | 1407 | 1579 | 1750 | 1922 |

¹Board foot volume is assumed to be the gross scale above a one-foot stump to a top DIB that is the larger of either 8 inches or 50 percent of the tree DBH. Volumes outside the tabulated range may be estimated by applying the following formula to an 8-foot bolt and then summing values to provide tree volume estimates:

$$\text{Bolt volume (board feet)} = 0.395d^2 - d - 2$$

Where d = small end inside bark diameter of the bolt, in inches.

Source: Burk, T. E., T. D. Droessler, and A. R. Ek. 1986. *Taper Equations for the Lake States Composite Volume Tables and Their Application*. University of Minnesota, Department of Forest Resources, St. Paul, MN 55108.

Pulpwood

Trees that are too small or too poor in quality to be sold for sawlogs are often sold for pulpwood. Ultimately, these trees are chipped or ground up to manufacture products such as paper, hardboard, and various types of structural board.

Minimum DBH for pulpwood trees is 5 inches. Minimum DIB is the larger of either 4 inches or 50 percent of tree DBH. (The minimum DIB for a pulpwood tree with a DBH of 12 inches, therefore, is 6 inches.) In the Lake States pulpwood commonly is cut to 100-inch lengths.

The basic unit for estimating pulpwood volume in trees is the cord. A standard cord is a closely stacked pile of logs containing 128 cubic feet of wood, bark, and air spaces between logs. A cord

frequently is described as a stack of wood 8 feet long, 4 feet high, and 4 feet wide (Figure 2-5). The solid wood content (excluding bark and air space) of a cord varies from about 65 to 95 cubic feet depending on the diameter, roughness, and crookedness of the pieces. An accepted average value in the Lake States is 79 cubic feet of wood per cord.

Pulpwood also can be purchased by the ton. Different tree species have different wood densities. A 12-inch diameter red oak log will weigh much more than a 12-inch diameter aspen log because the oak log is much denser. For example, one cord of aspen weighs 2.4 tons, while one cord of red oak weighs 2.85 tons. Weight also varies depending on the season of the year because of the changing moisture content of logs.

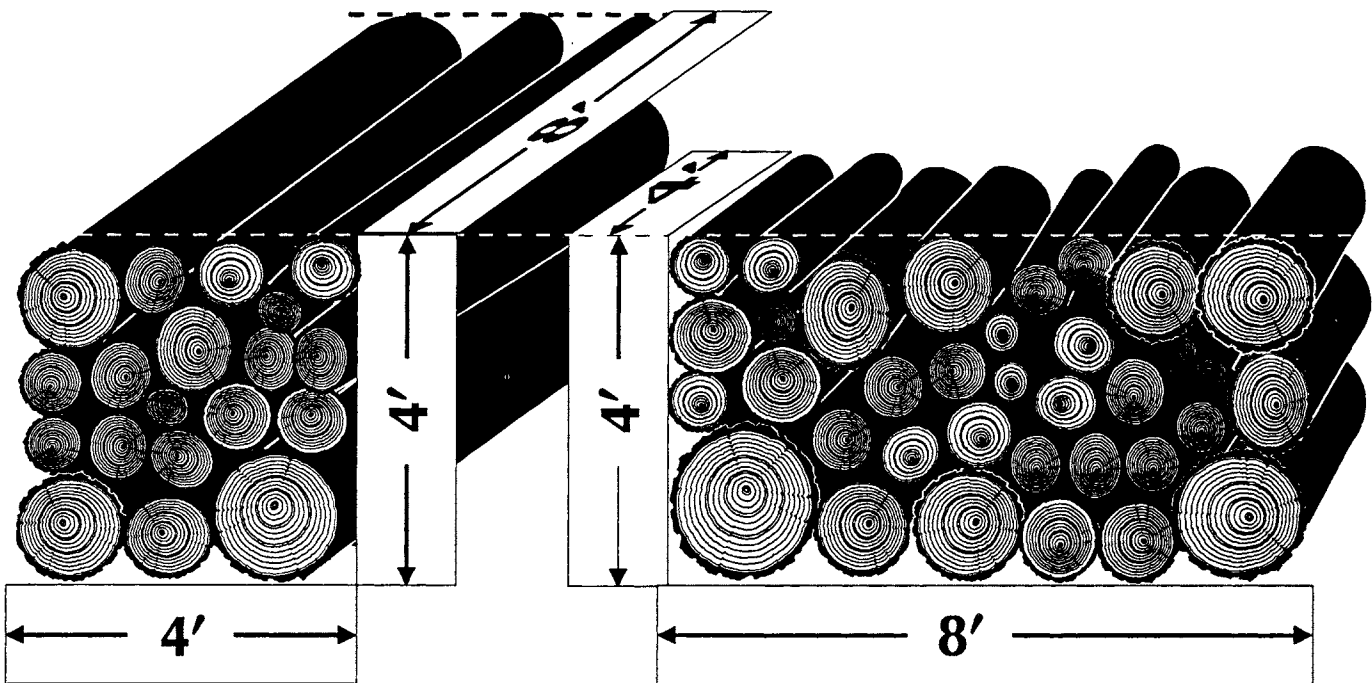


Figure 2-5. A standard cord of wood.

Table 2-2. Tree volume in cords.

How to Use Table 2-2. As an example, a tree with a DBH of 10 inches and 3 bolts (24 feet) of merchantable height will yield about 0.10 cords. If the tree contained 10 percent defect, then the tree volume would be reduced to 0.09 cords. A reasonable range of volume estimates per acre is 5 to 45 cords.

| DBH In Inches | Number of 8-Foot Bolts | | | | | | | | | | | |
|---------------------|------------------------|-----|-----|------|------|------|------|------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | Cords ¹ | | | | | | | | | | | |
| 5 | .01 | .02 | .03 | — | — | — | — | — | — | — | — | — |
| 6 | .02 | .03 | .04 | .05 | .06 | — | — | — | — | — | — | — |
| 7 | — | .04 | .05 | .06 | .08 | .10 | .11 | — | — | — | — | — |
| 8 | — | .05 | .06 | .08 | .10 | .12 | .14 | .15 | .17 | — | — | — |
| 9 | — | .06 | .08 | .10 | .12 | .15 | .17 | .20 | .22 | — | — | — |
| 10 | — | .07 | .10 | .12 | .15 | .18 | .21 | .24 | .27 | .30 | — | — |
| 11 | — | .09 | .12 | .15 | .18 | .22 | .26 | .29 | .33 | .37 | .39 | — |
| 12 | — | — | .14 | .18 | .22 | .26 | .31 | .35 | .39 | .44 | .48 | — |
| 13 | — | — | .16 | .21 | .25 | .31 | .36 | .41 | .46 | .51 | .56 | .61 |
| 14 | — | — | .19 | .24 | .29 | .35 | .42 | .47 | .53 | .59 | .65 | .71 |
| 15 | — | — | .22 | .27 | .34 | .41 | .48 | .54 | .61 | .68 | .75 | .82 |
| 16 | — | — | .25 | .31 | .38 | .46 | .55 | .62 | .70 | .78 | .86 | .93 |
| 17 | — | — | .28 | .35 | .43 | .52 | .62 | .70 | .79 | .88 | .97 | 1.05 |
| 18 | — | — | .31 | .40 | .49 | .59 | .69 | .78 | .88 | .98 | 1.08 | 1.18 |
| 19 | — | — | .35 | .44 | .54 | .65 | .77 | .87 | .98 | 1.10 | 1.21 | 1.32 |
| 20 | — | — | .39 | .49 | .60 | .72 | .86 | .97 | 1.09 | 1.21 | 1.34 | 1.46 |
| 21 | — | — | — | .54 | .66 | .8 | .94 | 1.07 | 1.20 | 1.34 | 1.47 | 1.61 |
| 22 | — | — | — | .59 | .73 | .88 | 1.03 | 1.17 | 1.32 | 1.47 | 1.62 | 1.77 |
| 23 | — | — | — | .65 | .80 | .96 | 1.13 | 1.28 | 1.44 | 1.61 | 1.77 | 1.93 |
| 24 | — | — | — | .70 | .87 | 1.04 | 1.23 | 1.39 | 1.57 | 1.75 | 1.92 | 2.10 |
| 25 | — | — | — | .76 | .94 | 1.13 | 1.34 | 1.51 | 1.70 | 1.90 | 2.09 | 2.28 |
| 26 | — | — | — | .83 | 1.02 | 1.22 | 1.45 | 1.64 | 1.84 | 2.05 | 2.26 | 2.47 |
| 27 | — | — | — | .89 | 1.10 | 1.32 | 1.56 | 1.76 | 1.99 | 2.21 | 2.44 | 2.66 |
| 28 | — | — | — | .96 | 1.18 | 1.42 | 1.68 | 1.90 | 2.14 | 2.38 | 2.62 | 2.86 |
| 29 | — | — | — | 1.03 | 1.26 | 1.52 | 1.80 | 2.04 | 2.29 | 2.55 | 2.81 | 3.07 |
| 30 | — | — | — | 1.11 | 1.35 | 1.63 | 1.92 | 2.18 | 2.45 | 2.73 | 3.01 | 3.28 |

¹Volume is standard unpeeled cords and includes the stem wood above a 1-foot stump to a top DIB that is the larger of either 4 inches or 50 percent of the tree DBH. Careful piling of harvested bolts is assumed, equivalent to 79 cubic feet of wood or 92 cubic feet of wood and bark per cord. Volumes outside the tabulated range may be estimated by applying the following formula to each 8-foot bolt and then summing values to provide tree volume estimates:

$$\text{Bolt volume} = 0.0003(d_2 + D_2)$$

Where d = small end inside bark diameter of the bolt, in inches; D = large end inside bark diameter of the bolt, in inches.

Source: Burk, T. E., T. D. Droessler, and A. R. Ek. 1986. *Taper Equations for the Lake States Composite Volume Tables and Their Application*. University of Minnesota, Department of Forest Resources, St. Paul, MN 55108.

Woody Biomass

Woody biomass usually refers to any wood that can be used to produce energy. Buyers typically pay less for woody biomass than for veneer, sawtimber, and pulpwood; therefore, biomass usually is produced from small-diameter trees, branches, dead trees, downed logs, brush, and stumps. Woody biomass harvesting has the potential to expand forest management options by offering a market for low value trees and materials that interfere with the growth of better trees or that contribute to a fire hazard. Biomass harvesting guidelines have been or are being developed in each of the Lake States

to ensure that biomass harvests help promote sustainable forest management. Biomass is commonly bought and sold on a tons-per-acre basis.

Stand Measurements

It is impossible to measure every tree in a stand, let alone an entire woodland. Each acre in a fully-stocked, mature woodland may have several hundred trees. Your forester will measure trees in sample plots and project those values to the whole stand. Sampling assumes that the measured trees represent all trees throughout the stand.

The number of sample plots needed is determined by the size of your woodland and the variability of tree species, sizes, and age classes. The number of sample plots generally will increase as the size of a property increases and as the number of the species, sizes, and age classes increases. If the trees contain highly valuable products, such as black walnut veneer, each tree containing that product may be measured. Your forester will determine the number of plots needed for management purposes in your woodland. Too many plots will waste time and money. Too few plots will yield imprecise estimates. Not every property needs a thorough inventory. If your woodland is less than 20 acres, it might be sufficient for a forester to simply walk through the woods with you to identify the different species and site characteristics, then recommend management alternatives based on the forester's experience in similar woodlands.

Sample plots should be randomly distributed across your property—not located in what appear to be “average” parts of your woodland or in those

areas that are most convenient to reach. This is especially important on properties where tree size, species composition, and stand density vary.

Depending on the data to be collected, your forester may use fixed radius or variable radius plots. Fixed radius plots are circular plots that typically cover 1/10th acre (37.25 ft. radius) or 1/5th acre (52.67 ft. radius). Trees that fall within or on a fixed radius plot boundary can be included as part of the inventory. Fixed radius plots are generally used when inventorying all of the resources on your woodland property since they can be used to sample many stand attributes.

Variable radius plots are based on mathematical principles, but a simple wedge prism or angle gauge is used to determine which trees are in a plot (Figure 2-6). These gauges typically are calibrated to identify trees in 1/10th- or 1/5th-acre plots. Such gauges work best in stands where trees are pole-sized or larger.

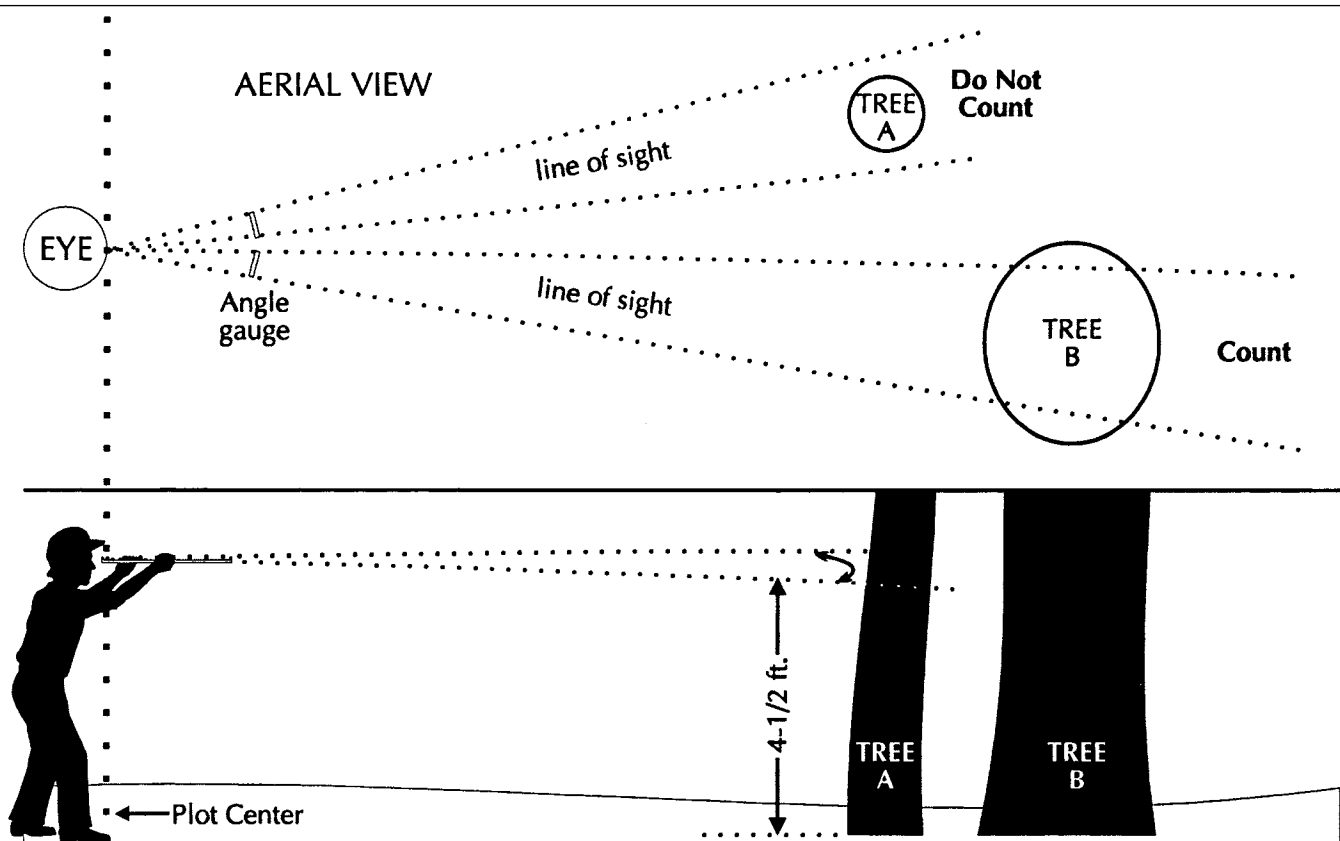


Figure 2-6. An angle gauge can be used to identify trees in a variable radius plot.

A 10-factor, stick-type angle gauge consists of a rod 33 inches long with a piece of metal exactly 1-inch wide attached to one end and protruding above the stick about 1 inch. To use the angle gauge, stand in a fixed spot (plot center) with the “open end” of the stick near your eye and the 1-inch metal intercept pointed at a nearby tree. As you slowly pivot in a circle, keeping your eye over the plot center, look at each tree. Consider a tree to be within the plot if its stem at DBH (4.5 feet above ground) is wider than the 1-inch metal intercept. Each tree in the plot represents 10 trees per acre. For example, if you count 12 trees from a fixed point that all have diameters appearing larger than the 1-inch metal intercept, they represent 120 trees per acre.

Stocking

Stocking, also known as stand density, is a measure of tree crowding. A stand may be under-stocked (too few trees), fully stocked (just the right amount of trees), or over-stocked (too many trees) for good tree growth. Stocking is a relative concept—a stand that is over-stocked for one management objective may be under-stocked for another. Knowing your stand’s stocking level can help guide its management by helping you determine whether to let trees grow longer or to thin the stand now and provide more growing space around the residual crop trees. Foresters use several measures of stocking, including basal area, stocking charts, and crown cover.

Basal Area

The basal area of a tree is the cross-sectional area of its main stem in square feet measured 4.5 feet above ground. Basal area per acre is the sum of cross-sectional areas (in square feet) of all trees on an acre (Figure 2-7). The optimum basal area for a stand depends on its species composition and tree size or age. Look for basal area recommendations in Chapter 6: Managing Important Forest Types.

The wedge prism and angle gauge described in Stand Measurements (see pg. 15) can be used to measure basal area. When using a 10-factor wedge prism or angle gauge, count all the trees in the variable radius plot and multiply by 10 to determine

basal area. For example, if there are 14 trees in a plot, multiply 14 by 10 to determine that the basal area is 140 square feet per acre. Take several basal area measurements and average them to determine the average basal area for a stand.

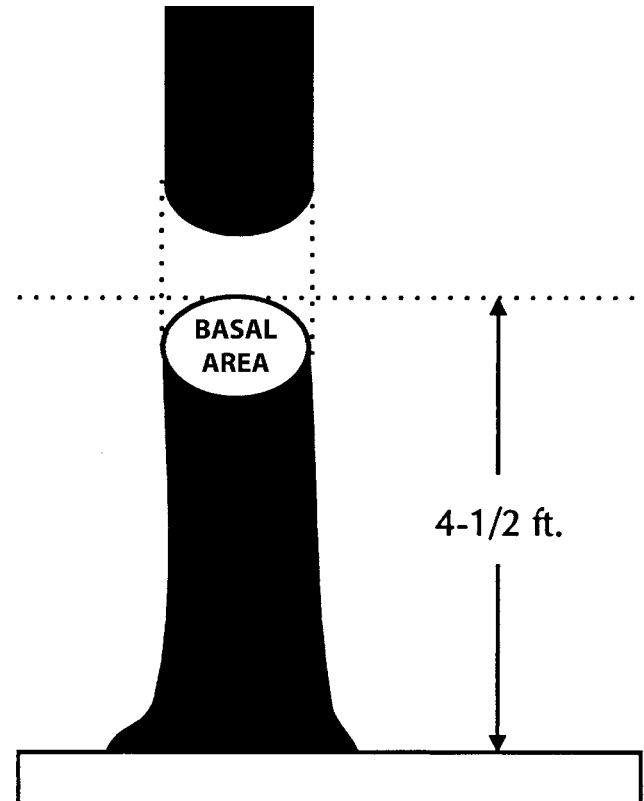


Figure 2-7. The basal area of a tree is its cross-sectional area in square feet measured 4.5 feet above ground.

Stocking Chart

A stocking chart uses information about a stand’s basal area, trees per acre and their average diameter to recommend optimum stocking to sustain rapid tree growth. For example, Figure 2-8 (see pg. 18) is a stocking chart for red pine stands managed for maximum fiber production. Trees grow best when stocking is between the A and B curves. If a red pine stand had a basal area of 190 square feet and 350 trees per acre, those corresponding lines intersect at the A level. The closest average stand diameter is 10 inches. Follow the heavy black line for the 10-inch average stand diameter down to the B level and read the basal area and number of trees per acre at that point. We see that trees of this size

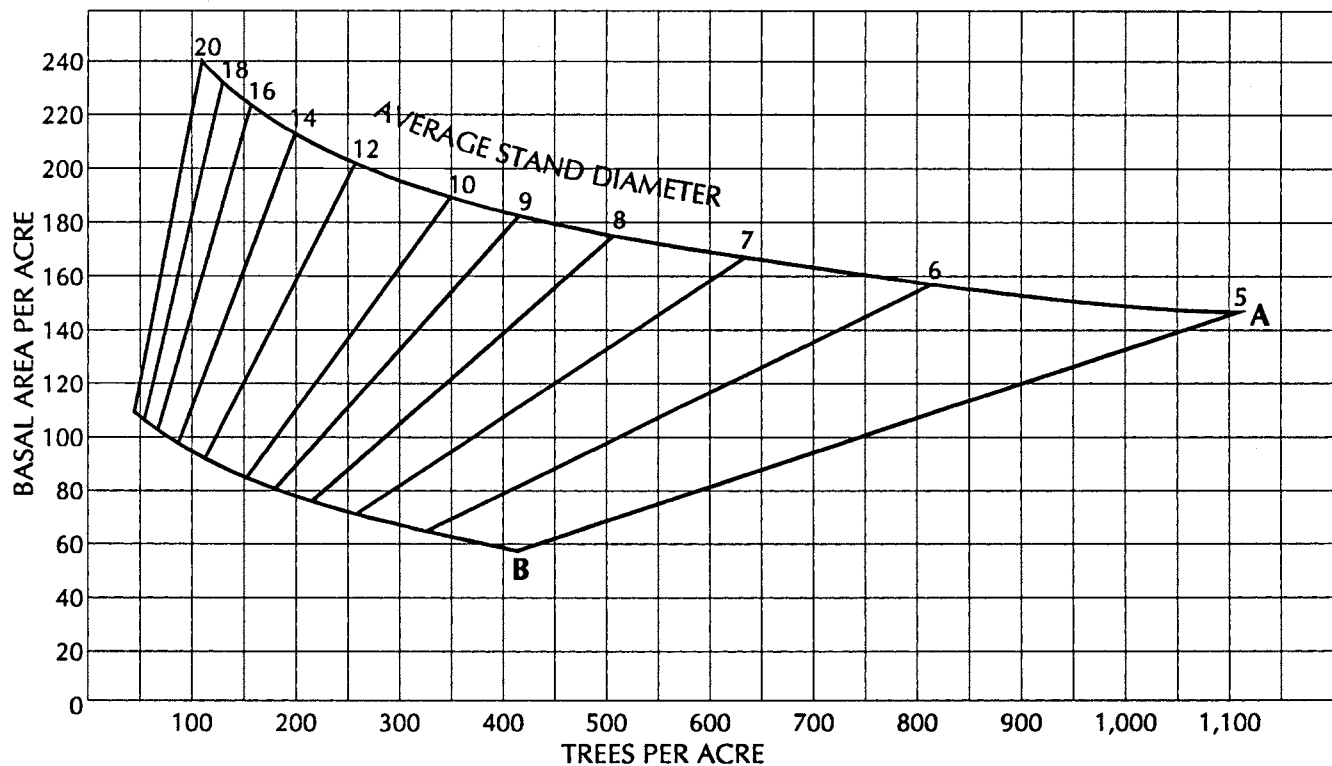


Figure 2-8. Stocking chart for red pine.

would grow faster if the stand were thinned back to approximately 85 square feet of basal area and 160 trees per acre. But a forester would point out that cutting 45 percent of the stand to reach that level is too much to cut at one time. The rule of thumb is to cut no more than 33 percent of the stand at any one time. It will take two thinnings over time to reduce this stand to a stocking level where red pines grow best. Stocking charts for selected tree species and forest types are shown in Appendix C. A forester can help you understand stocking charts and identify a target spacing for your stand.

Crown Cover

Crown cover refers to the percentage of sky area blocked by tree crowns when viewed from ground level. Some foresters use a mirror with grid lines on it to view the reflected canopy and measure crown cover, but most simply look upward at the sky from each plot center and estimate crown cover. Crown cover is used as a measure of stand density mainly when setting up a shelterwood harvest. This is a partial harvest aimed at allowing more sunlight to reach the forest floor where it can

sustain the growth of seedling trees (see Chapter 4: Regenerating Woodland Stands). For example, a shelterwood harvest may aim for a 75 percent residual crown cover after the harvest. More specific guidelines are in Chapter 6: Managing Important Forest Types for specific forest types that rely on shelterwood harvests for regeneration.

Growth and Yield Tables

Yield tables have been developed for some commercially important tree species showing the estimated volume of wood per acre that could be grown at different stand ages. Such tables usually estimate expected volumes in pure, even-aged stands on sites of different quality as measured by site index. Table 2-3 is a yield table for red pine. If you owned an even-aged red pine stand with a site index of 65, current stand age of 80 years, and basal area of 120 square feet, you could expect to have a volume of approximately 42.3 cords per acre. There also are computer programs that predict growth and yield at different stand ages based on inventory information.



Table 2-3. Volume in cords per acre¹ for even-aged red pine stands by site index, age, total tree height, and basal area.

| Total Age in Years | Total Height in Feet | Basal Area Per Acre ² | | | | | |
|-----------------------|----------------------------|----------------------------------|------|------|------|------|------|
| | | 30 | 60 | 90 | 120 | 150 | 180 |
| SITE INDEX 75 | | Cords Per Acre | | | | | |
| 40 | 61 | 7.2 | 14.5 | 21.7 | 29.0 | 36.2 | 43.5 |
| 60 | 86 | 10.2 | 20.4 | 30.6 | 40.8 | 51.0 | 61.3 |
| 80 | 103 | 12.2 | 24.5 | 36.7 | 48.9 | 61.2 | 73.4 |
| 100 | 115 | 13.6 | 27.3 | 41.0 | 54.6 | 68.3 | 81.9 |
| 120 | 124 | 14.7 | 29.4 | 44.2 | 58.9 | 73.6 | 88.3 |
| 140 | 130 | 15.4 | 30.9 | 46.3 | 61.7 | 77.2 | 92.6 |
| 160 | 134 | 15.9 | 31.8 | 47.7 | 63.6 | 79.6 | 95.5 |
| SITE INDEX 65 | | | | | | | |
| 40 | 53 | 6.3 | 12.6 | 18.9 | 25.2 | 31.5 | 37.8 |
| 60 | 74 | 8.8 | 17.6 | 26.4 | 35.1 | 43.9 | 52.7 |
| 80 | 89 | 10.6 | 21.1 | 31.7 | 42.3 | 52.8 | 63.4 |
| 100 | 100 | 11.9 | 23.7 | 35.6 | 47.5 | 59.4 | 71.2 |
| 120 | 107 | 12.7 | 25.4 | 38.1 | 50.8 | 63.5 | 76.2 |
| 140 | 112 | 13.3 | 26.6 | 39.9 | 53.2 | 66.5 | 79.8 |
| 160 | 116 | 13.8 | 27.5 | 41.3 | 55.1 | 68.9 | 82.6 |
| SITE INDEX 55 | | | | | | | |
| 40 | 45 | 5.3 | 10.7 | 16.0 | 21.4 | 26.7 | 32.0 |
| 60 | 63 | 7.5 | 15.0 | 22.4 | 29.9 | 37.4 | 44.9 |
| 80 | 76 | 9.0 | 18.0 | 27.1 | 36.1 | 45.1 | 54.1 |
| 100 | 85 | 10.1 | 20.2 | 30.3 | 40.4 | 50.5 | 60.5 |
| 120 | 91 | 10.8 | 21.6 | 32.4 | 43.2 | 54 | 64.8 |
| 140 | 95 | 11.3 | 22.6 | 33.8 | 45.1 | 56.4 | 67.7 |
| 160 | 98 | 11.6 | 23.3 | 34.9 | 46.5 | 58.2 | 69.8 |
| SITE INDEX 45 | | | | | | | |
| 40 | 37 | 4.4 | 8.8 | 13.2 | 17.6 | 22.0 | 26.4 |
| 60 | 51 | 6.1 | 12.1 | 18.2 | 24.2 | 30.3 | 36.3 |
| 80 | 62 | 7.4 | 14.7 | 22.1 | 29.4 | 36.8 | 44.2 |
| 100 | 69 | 8.2 | 16.4 | 24.6 | 32.8 | 41.0 | 49.2 |
| 120 | 74 | 8.8 | 17.6 | 26.4 | 35.1 | 43.9 | 52.7 |
| 140 | 78 | 9.3 | 18.5 | 27.8 | 37.0 | 46.3 | 55.6 |
| 160 | 80 | 9.5 | 19.0 | 28.5 | 38.0 | 47.5 | 57.0 |

¹Cords = 0.003958 (BA x Height). Rough cords for trees 3.6 inches DBH and larger to a 3-inch top DIB.

²For trees 3.6 inches DBH and larger.

Source: Benzie, J. W. 1977. *Manager's Handbook for Red Pine in the North Central States (General Technical Report NC-33)*. USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN 55108. 22 pp.

Yield information can be used as a basis for financial analyses of different investment alternatives. Yield tables are not always accurate, but are helpful for comparisons. Your forester may be able to provide growth and yield information for your woodland.

Site Quality

As part of a woodland inventory, site quality should be evaluated to help predict how well important tree species will grow. The rate that a tree grows depends partly on genetic characteristics and partly on site factors, including soil fertility and texture, moisture, climate, slope, and aspect (direction a slope faces). Soil maps with interpretive information about tree growth are very useful when available, but soil maps are more commonly available for farmland, not for woodland. To judge site quality, foresters are more likely to evaluate the condition of existing trees, measure site index based on tree age and height, or identify understory plants indicating site quality.

Tree Quality

Experienced foresters know what a good quality tree of a particular species should look like on a good site. Mature trees on good sites tend to be taller, have straighter stems, fewer limbs on main stems, and long merchantable stem heights, compared to trees of the same species on poor sites. When a majority of mature trees on a site exhibit desirable characteristics, a forester would judge that site to be good quality.

The difficulty in judging site quality by the condition of existing trees is that a stand with poor quality trees may not indicate a poor site. Trees may be poor because the best quality trees were harvested through repeated cuts (high-grading), leaving trees that were genetically inferior or damaged. A stand may have been lightly stocked at one time and pastured. Open grown trees develop short stems with large crowns, but their poor quality appearance may be due to low stocking density, not to site quality. Previous wind or ice damage also

may have damaged crowns of trees throughout a stand, leaving trees in poor condition.

Site Index

Foresters often judge site quality based on the total height that dominant and co-dominant trees will grow in a given time—usually 50 years in the Lake States. Trees are expected to grow taller on good sites than on poor ones in the same time period. This measure of site quality is called site index. Site index curves have been constructed for many tree species so that site quality may be determined for a stand of trees larger than saplings if average tree age and average total tree height are known.

Tree Age

Determine age on dominant or co-dominant trees (Figure 2-9) of a species that is to be favored by management and is common on the property.

If trees were planted in your woodland, look for records showing the year of planting to determine tree age. If some plantation trees were recently harvested, count the annual growth rings on a stump or log (Figure 2-10).

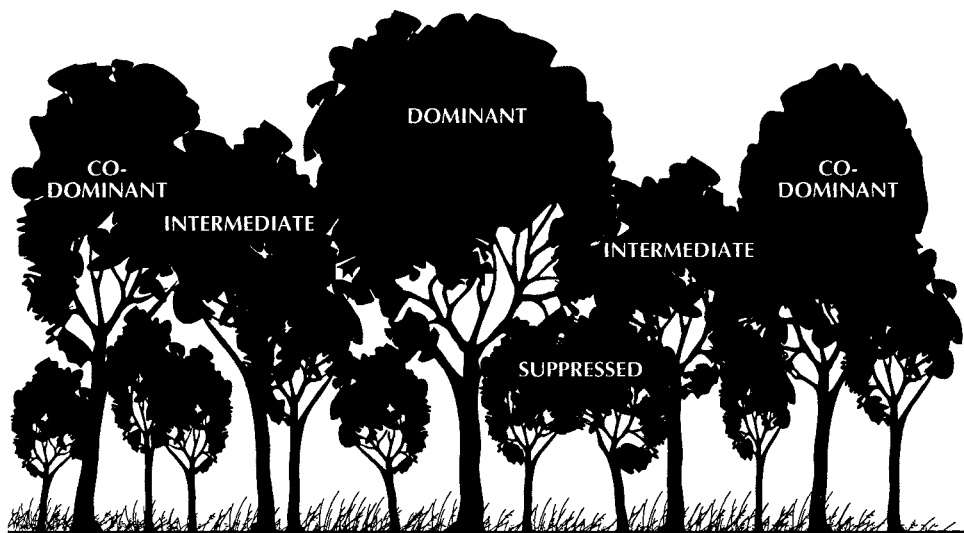


Figure 2-9. Tree dominance. The dominance of a tree refers to the position of its crown relative to other trees in the canopy. Dominant trees have relatively large crowns and are taller than most other trees in the stand. Co-dominant trees make up the general canopy level. Intermediate trees are slightly lower than the general canopy and have relatively small crowns. Suppressed trees are below the general canopy level.

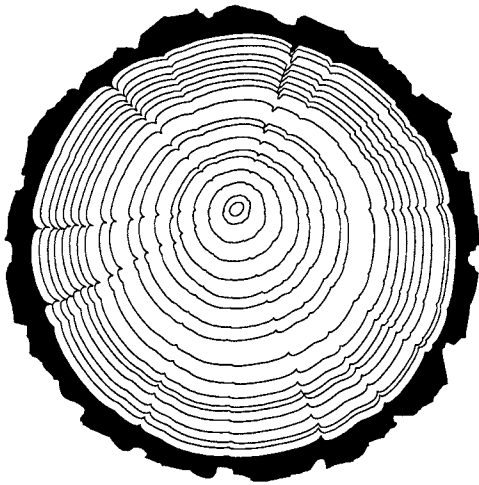


Figure 2-10. A tree grows a new ring of wood each year.

To measure the age of a living tree without cutting it down to count rings, you can take a core sample at 4.5 feet above the ground using an increment borer (Figure 2-11). An increment borer is similar to a hand drill, but has a hollow drill bit. It extracts a core of wood about the size and shape of a pencil. This core shows annual growth rings as bands of light and dark wood. By counting the rings in the core and adding the number of years it took the tree to grow to a height of 4.5 feet, your forester can determine tree age.

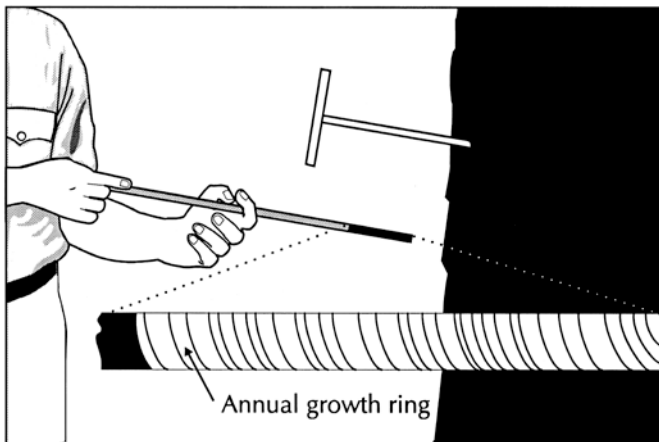


Figure 2-11. Tree core sample removed by an increment borer.

The age of conifers such as red (Norway) pine, white pine, and balsam fir that produce one whorl of new branches each year can be estimated by

counting whorls (Figure 2-12). This approach works best when the trees are young (<25 years) because it is easier to see each whorl. False whorls can develop if more than one spurt of growth occurs in a year.

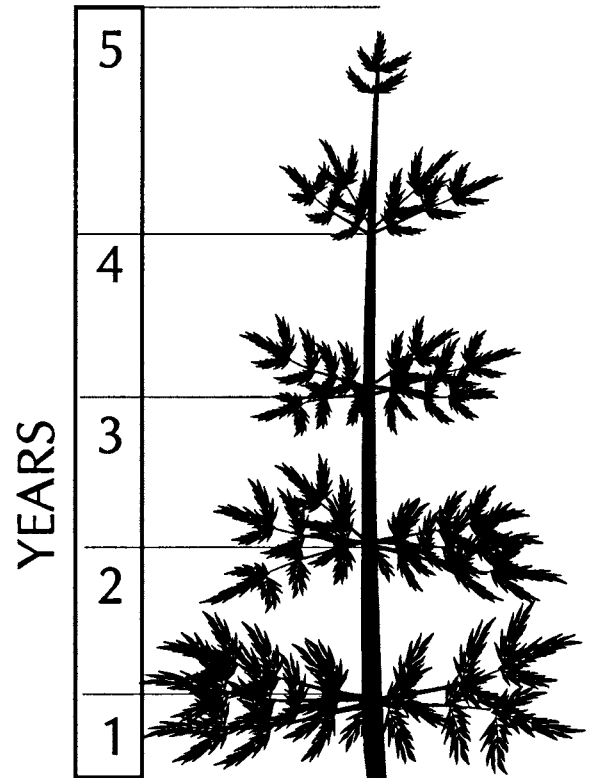


Figure 2-12. Count the whorls of branches to determine the age of a conifer.

Site Index Curves

If you know the average tree age and total tree height of a tree species of primary interest, refer to a set of site index curves for that species to determine site quality. Site index curves for red pine are shown in Figure 2-13. These curves were developed for use in pure, even-aged stands of red pine. A pure stand is one in which at least 80 percent of the trees are of the same species. An even-aged stand is one where the age difference between the youngest and oldest tree in a stand does not exceed 20 percent of the projected rotation length. A rotation is the number of years required to establish and grow trees to a specified size, product, or condition of maturity at which they can be harvested.

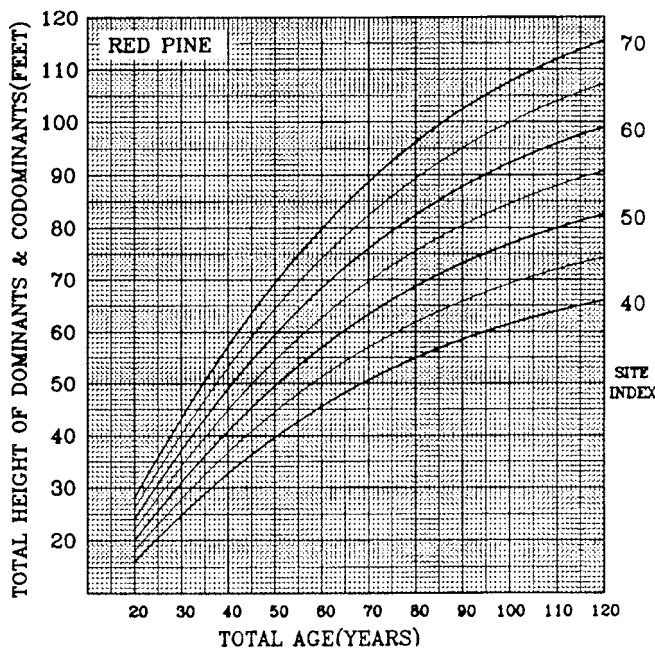


Figure 2-13. Site index curves for red pine plantations.

For example, if you measured several dominant and co-dominant red pines and determined their average age was 80 years and average total tree height was 90 feet, find 80 years on the bottom axis in Figure 2-13 above, then follow the vertical line upward from that point until it intersects the 90-foot level on the left vertical axis. Now follow the site index curve from the junction of those two lines to the right vertical axis, where you will find that the site index is 65. These trees would be expected to be 65 feet tall at age 50. The higher the site index, the better the site. Site index curves for common tree species are shown in Appendix B. Site index curves are reasonably accurate measures of site quality for stands older than 20 years. For younger stands, special equations are used to estimate site index.

Understory Plants as Site Indicators

Foresters increasingly use associations of understory plants to indicate site quality for particular tree species. Some understory plants grow on a wide range of sites, but those with more specific site requirements (for example, in moisture and

nutrients) are used for site classification. Understory plants tend to persist on sites regardless of past timber management, and the presence of a particular combination of understory species can indicate how well particular tree species will grow, even if those tree species are not currently found on a site. For example, if a combination of understory plants in north-central Wisconsin indicates a very dry to dry, nutrient poor site, a forester knows that site is best suited for growing jack pine, red pine, white pine, oaks, and red maple. Tree growth may not be particularly good on this poor site, but these tree species are the best adapted to it. Site type classifications have been developed for the Lake States, but their descriptions are beyond the scope of this book.

References

A list of online soil surveys by county is available at: <http://websoilsurvey.nrcs.usda.gov/app/>

A paper copy of an aerial photo can be obtained through your local Natural Resources Conservation Service office. You can find the office for the county you live in or where your property is located at <http://offices.sc.egov.usda.gov/locator/app>

Blink, C. R. and T. E. Burk. 1986. *Sampling and Measuring Timber in the Private Woodland* (NR-FO-3025). University of Minnesota Extension, St. Paul, MN 55108. 8 pp. Available online at: <http://www.extension.umn.edu/distribution/naturalresources/DD3025.html>

Carmean, W. H., J. T. Hahn, and R. D. Jacobs. 1989. *Site Index Curves for Forest Tree Species in the Eastern United States* (General Technical Report NC-128). USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN 55108. 142 pp. Available online at: <http://www.treesearch.fs.fed.us/pubs/10192>

Martin, A. J. 1989. *What Is a Board Foot?* Department of Forest Ecology and Management, University of Wisconsin, Madison, WI. Forestry Facts No. 42. 2 p. Available online at: <http://forest.wisc.edu/extension/Publications/42.pdf>

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Table 2-4. Sample tally form for recording number of pulpwood trees by DBH and number of eight-foot bolts per tree.

Tract location _____ Tract name _____

Date _____ Species _____ Plot number _____

| DBH (inches) | Number of eight-foot bolts | | | | | | | Totals |
|-----------------|----------------------------|---|---|---|---|---|---|--------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
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| | | | | | | | | |
| Totals | | | | | | | | |

The dot-dash tally method is a convenient way to record timber cruise data. Each dot or dash represents one tally tree with a specified DBH and merchantable height according to the following convention:

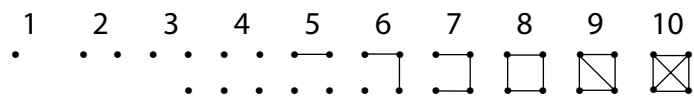


Table 2-5. Sample tally form for recording number of sawtimber trees by DBH and number of eight-foot bolts per tree.

Tract location (section, range, township) _____ Tract name _____

Date _____ Species _____ Plot number _____

| DBH (inches) | Number of eight-foot bolts | | | | | | | Totals |
|-----------------|----------------------------|---|---|---|---|---|---|--------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
| 14 | | | | | | | | |
| 15 | | | | | | | | |
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| | | | | | | | | |
| Totals | | | | | | | | |

The dot-dash tally method is a convenient way to record timber cruise data. Each dot or dash represents one tally tree with a specified DBH and merchantable height according to the following convention:

