FOREST MEASUREMENTS & TOOLS

INTRODUCTION AND OBJECTIVES

Forestry is a science based on measurements. In this section you will learn to use the same instruments and collect the same data that professional foresters use to learn and manage forest resources.

At the end of this chapter, you should:

- Demonstrate proficiency in pacing to measure distances and determine how many paces you have in a chain (66 ft.).
- Demonstrate proficiency in the use of the Biltmore Stick and Wedge Prism.
- Conduct a sample plot as part of a forest inventory using forestry instruments.
- Apply data to specific charts and tables to determine forest growth conditions.

PACING

The most basic forest measurement is pacing or counting your number of steps to determine how far you've traveled in the woods. A compass helps you determine which direction you are walking, but pacing allows you to determine distance.

In forestry the standard unit of distance measurement is the ***chain*** or ***Gunter's chain***, which equals 66 feet. Years ago surveyors literally dragged a 66-foot-long chain around with them to measure properties, which were measured in chains and links. It may seem like an awkward number to use, but the number 66 divides evenly into 5,280, which is the number of feet in a mile. There are exactly 80 chains in a mile. In addition, if you have an area of 10 square chains, you have exactly an acre. These numbers are easy to remember.

Today, foresters measure chains by knowing how many ***paces*** they take in 66 feet. A pace is equal to two steps. To determine your pace, measure out 66 feet using a 100-foot measuring tape, and count every other step (for example, every time your left foot hits the ground). People range between 10-17 paces per chain.

CHAIN FACTS:

- 1 pace = 2 relaxed steps
- 1 chain = 66 feet.
- 80 chains = 1 mile
- 10 square chains = 1 acre
- Several forestry tools are calibrated to be accurate from a distance of one chain.

TREE MEASUREMENT

Trees are measured to determine the volume and growth of both the individual tree and the entire forest stand. Measurements taken from trees form the data on which forestry policies are based. Decisions such as cutting schedules, thinning, and regeneration are dependent on tree measurements. Tree measurements also determine timber value and are used in predicting the future conditions of forested areas.

Diameter

Fig. 10.1. Diameter is measured 4.5 feet above ground.

Diameter is always measured outside the bark at 4.5 feet above the ground. This is called ***Diameter Breast Height***, or ***DBH*** (Figure 10.1).

Diameter measurements are used to determine the type of product for which a tree may be used. Minimum diameters vary from product to product and from mill to mill, but some general rules apply in Florida for pulpwood and sawtimber. ***Pulpwood*** is timber suitable for chipping and processing into pulp and paper products. ***Sawtimber*** is suitable for lumber production.

Minimum dbh for pine pulpwood is 4.6 inches. Trees with smaller dbh are usually considered too small for pulpwood. Minimum dbh for pine sawtimber is 9.6 inches. See Figure 10.2.

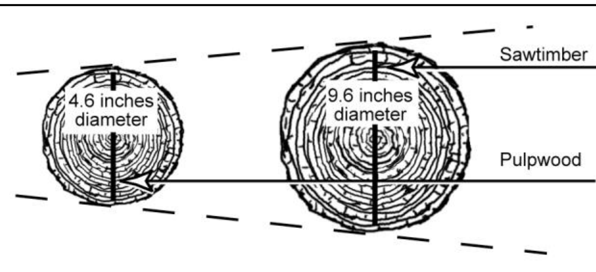

Figure 10.2. .Minimum DBH for product types.

Diameter is measured with a variety of instruments. The most frequently used tool is the logger's tape, which is calibrated to determine diameter by measuring girth (Figures 10.1 and 10.3). Diameters may also be measured using a tree scale or ***Biltmore stick*** (Appendix A explains how to make your own Biltmore stick). Diameters are usually tallied to the nearest inch. See Figure 10.4.

Figure 10.3 Logger's Tape

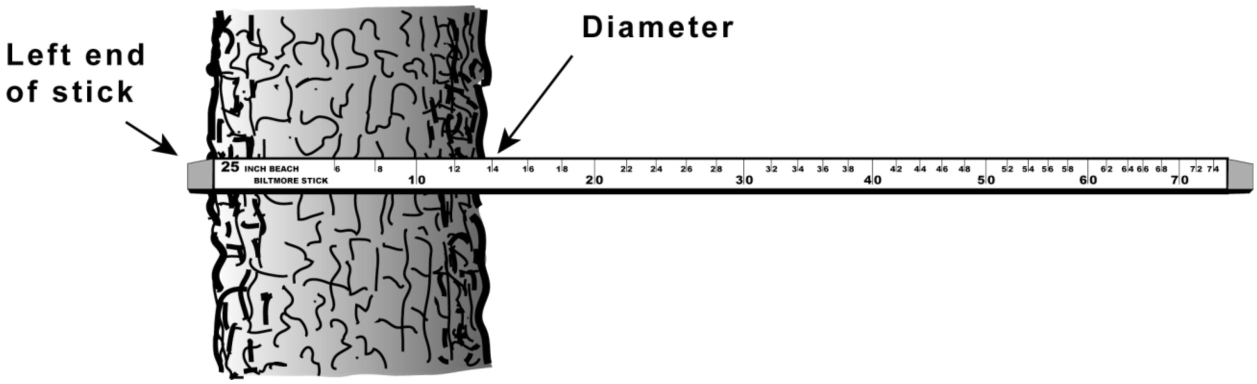

Figure 10.4. The Biltmore stick is a simple tool for reading tree diameters.

How to use measure diameter using the Biltmore stick:

1. Holding the Biltmore Stick <u>against the tree</u>, stand <u>25 inches</u> from the tree. Almost all Biltmore sticks are 25 inches in length which will help you determine how far away to stand. If you have a homemade Biltmore stick, stand the distance away from the tree for which you made calculations. For example, if the markings on your stick are taken from the calculations for a 21-inch stick; stand 21 inches from the tree.
2. Hold the Biltmore stick <u>at DBH</u>.
3. Using <u>only one eye</u>, line the left end of the Biltmore Stick with the left edge of the tree.
4. Line the right edge of the tree with the corresponding number on the Biltmore Stick. This is your first diameter measurement.
5. Move perpendicular to your first measurement and take a second diameter reading. (A second measurement is necessary since trees are not perfectly round!)
6. Take the average of your two measurements and *voila'*; you have your diameter.

Height

Foresters use tree heights to determine growth, site productivity, tree and stand volumes, and tree vigor. A distinction is made here between total tree height and ***merchantable height***. Merchantable height is the upper limit of usable wood for a given product on a tree stem. See Figure 10.5.

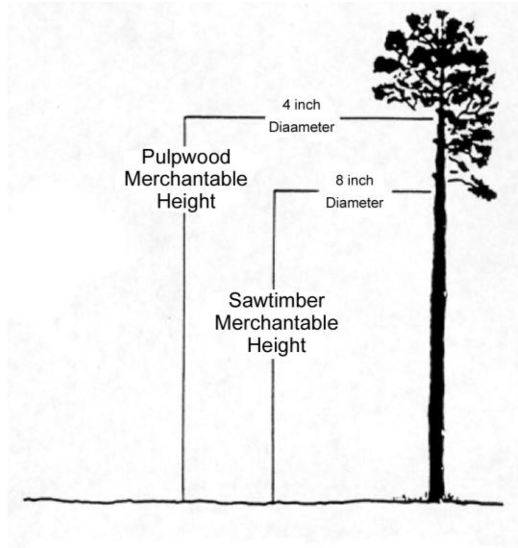

Figure 10.5. Merchantable height is dependent on the desired forest product and tree taper.

To determine the volume of a tree, we must first know how many ***logs*** or ***sticks*** are in the tree.

- A log is a unit of measurement equalling 16 feet. Merchantable height for sawtimber is measured in logs and is measured from the stump of the tree to an 8-inch diameter top.
- For pulpwood, we measure the number of 5-1/4 foot sticks from the base of the tree to a 4-inch diameter top. **NOTE: There are roughly 3 sticks per log

The insturment used to measure logs and sticks is the ***Merritt Hypsometer***, which can be found on one side of the Biltmore Stick. Here's how you use the Merritt Hypsometer:

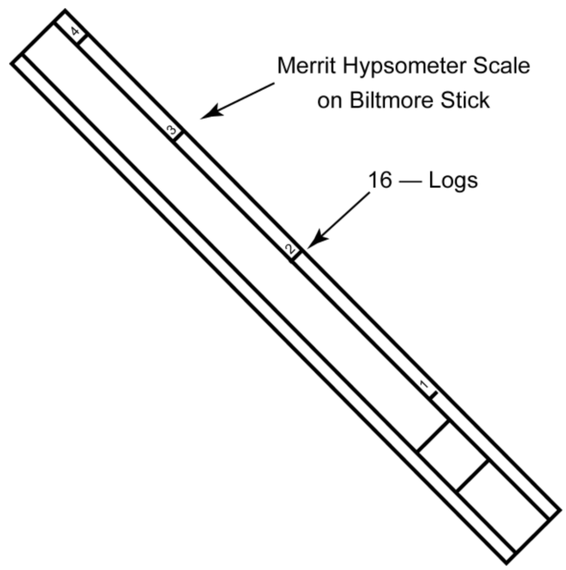

Figure 10.6. The Merritt hypsometer on a Biltmore stick can be used to measure merchantable height of pine sawtimber, as well as pulpwood.

1. Standing one chain away from the tree, hold the stick upright 25 inches away from your eye with the Merritt Hypsometer side of the stick facing you. **Note; if you made a 21-inch Biltmore Stick, hold the Biltmore Stick 21 inches away from your eye.
2. With the butt of the stick aligned with the base of the tree, count the number of 16-foot logs by matching the graduations on the stick to the trunk of the tree until you reach an 8-inch top or the first major defect in the tree. A defect may be a large branch, a bend in

the trunk, or a hollow cavity that would cause that part of the tree to be unusable at the sawmill. Measure to the nearest half-log (for example: 1-1/2 or 3-1/2 logs is OK).

3. For pulpwood, measure to a 4-inch top, defects are less critical because the tree will be ground up into chips, not sawn into lumber. Don't forget to convert merchantable height into 5-1/4 foot sticks!

Volume

With diameter and merchantable height measurements in hand, the forester is able to determine timber volumes by referring to tree volume tables. Volume tables vary by product, species, geographic location, date, and user preference. The Florida Division of Forestry's county foresters use the Hawes pulpwood volume tables for pine pulpwood and the Mesavage and Girard Scribner 78 Form Class volume tables for pine sawtimber. Pulpwood volume tables give tree volumes in terms of cubic feet of solid wood.

Pulpwood is bought and sold on the basis of a ***cord***. A cord of wood is a stack of wood that measures 4 feet high, 8 feet wide, and 4 feet long and contains 128 cubic feet. However, the 128-cubic foot stack also includes air space and bark, so the conversion factor of 90 cubic feet of solid wood per cord is used for standing timber.

Sawtimber volume tables yield tree volumes in board feet. A board foot is a piece of lumber that is 12 inches wide, 12 inches long, and 1 inch thick. Sawtimber tables take saw kerf into account. ***Kerf*** is the amount of wood removed as sawdust in the sawing operation. Generally, 1 cubic foot of wood will yield approximately 6 board feet of lumber after removal of slabs, bark, and sawdust. Sawtimber is sold on the basis of 1,000 board feet (MBF). ***MBF*** is *Millen* Board Feet, not million. Millen is Greek for one thousand.

Listed below are volume tables and sample problems for both pulpwood and sawtimber. You must not memorize volume tables, but you must know how to work these tables for the contest.

Table 10.1 Pulpwood Volume Table. Volume is measured in cubic feet.

	Number of 5-1/4 foot sticks						
DBH	**4**	**5**	**6**	**7**	**8**	**9**	**10**
5"	2.0	2.5	-	-	-	-	-
6"	2.8	3.6	4.2	4.9	-	-	-
7"	3.7	4.7	5.6	6.5	7.4	-	-
8"	4.8	6.0	7.2	8.5	9.5	10.8	-
9"	5.9	7.4	8.9	10.4	11.9	13.4	14.9
10"	7.1	8.9	10.6	12.5	14.3	16.1	17.8
11"	8.5	10.6	12.7	14.8	16.9	19.0	21.2

Table 10.2 Sawtimber Volume Table. Volume is measured in Board Feet.

	Number of Usable 16-foot logs						
DBH	1	1-1/2	2	2-1/2	3	3-1/2	4
10"	28	36	44	48	52	-	-
11"	38	49	60	67	74	-	-
12"	47	61	75	85	95	100	106
13"	58	76	94	107	120	128	136
14"	69	92	114	130	146	156	166
15"	82	109	136	157	178	192	206
16"	95	127	159	185	211	229	247
17"	109	146	184	215	246	268	289
18"	123	166	209	244	280	306	331
19"	140	190	240	281	322	352	382
20"	157	214	270	317	364	398	432
21"	176	240	304	358	411	450	490
22"	194	266	338	398	458	504	549
23"	214	294	374	441	508	558	607
24"	234	322	409	484	558	611	665

To compute pulp or wood volume, simply measure the tree's DBH, find it on the table, then line it up with its corresponding height.

Example #1. A tree has a 5.7" DBH with 39' of merchantable height. What is this tree's volume? Answer: 6-in. DBH, 7 sticks; **4.9 cubic feet**

Example #2. A tree has an 8.9" DBH with a merchantable height of 51'. What is this tree's volume? Answer: 9-in. DBH, 9 sticks; **13.4 cubic feet**

Example #3 A tree has a 12.1" DBH with 33' of merchantable height. What is this tree's volume? Answer: 12-in. DBH, 2 logs; **75 board feet**

Example #4. A tree has an 22.6" DBH with a merchantable height of 55'. What is this tree's volume? Answer: 23-in. DBH, 3 logs; **508 board feet**

Example #5. How many cords are found within a load of 5490 cubic feet of pulpwood? Answer: 5690 cu.ft. / 1 cord per 90 cu.ft. = **61 cords**

Example #6. How many MBF are found in a load of sawtimber containing 895,430 BF? Answer: **895 MBF**

Growth Measurements

Tree growth is often measured to predict future forest characteristics and to determine effects of certain forestry management practices on growth rates. Growth can be measured in any of a number of ways, one of which is determining height growth. Total tree height is measured prior to the growth season and is measured again after the growing season. A drawback to this method is the time period required to complete the growing season.

An easier and quicker method of determining growth is to measure diameter growth using an ***increment borer***, which extracts a small core of wood from the tree at dbh. The forester can then count the annual rings in the core to determine growth and also the age of the tree. The increment borer enables the forester to measure growth and predict future volumes of the forest without cutting the tree down to count the rings.

Fig. 10.7 Increment borer (blue handle with hollow, threaded bit).

Fig. 10.8 The forester inserts the increment borer by turning the threaded tip into the tree.

Fig. 10.9 The core extractor is inserted into the hollow increment borer.

Fig. 10.10 The core is removed. Growth rings can be counted and observed for growth patterns.

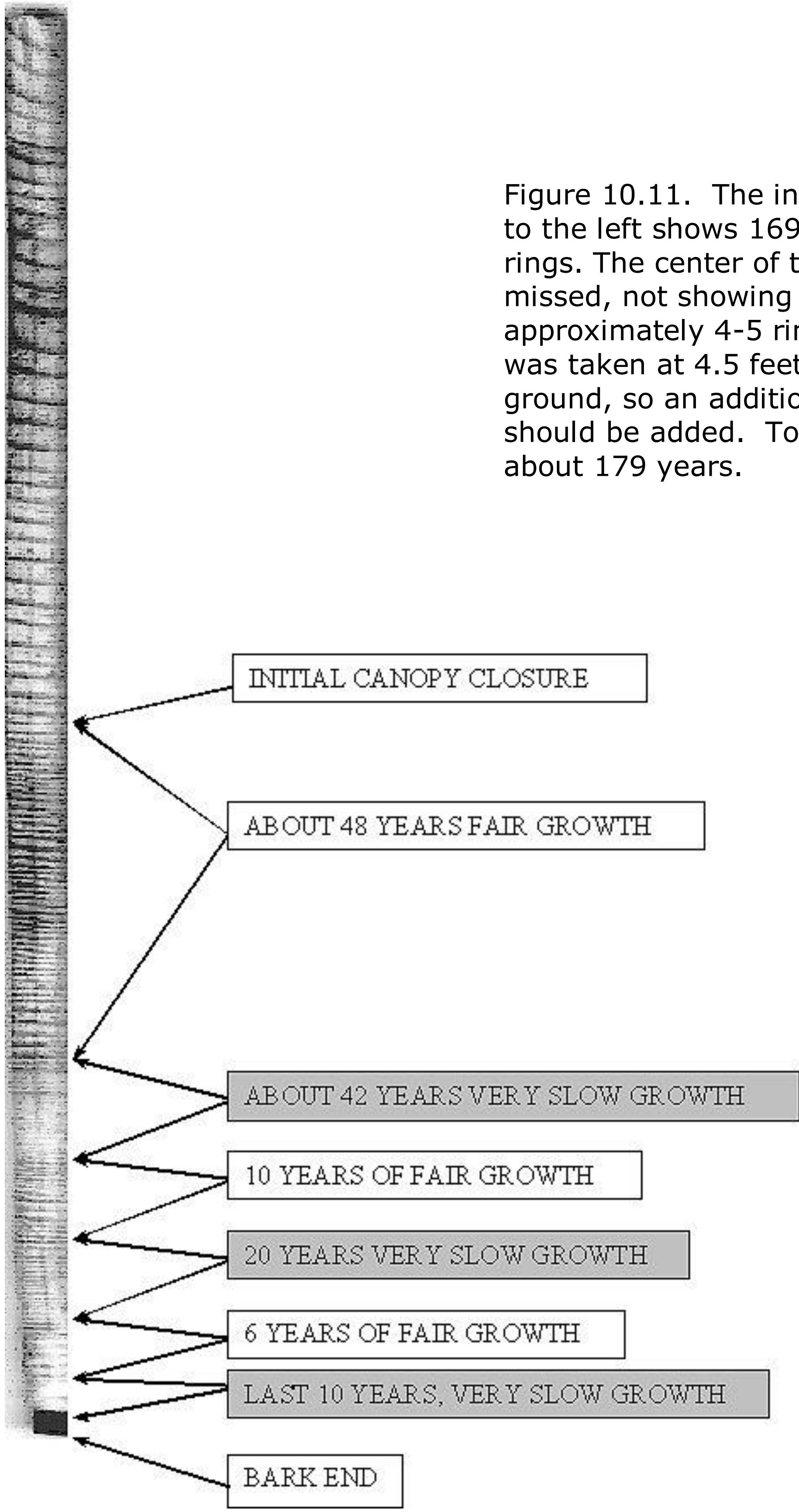

Figure 10.11. The increment core to the left shows 169 annual rings. The center of the tree was missed, not showing approximately 4-5 rings. The core was taken at 4.5 feet from the ground, so an additional 5 years should be added. Total age is about 179 years.

MAPS

Maps are used in forestry to locate land boundaries, determine timber types, calculate areas, locate wildfires, and help keep a person unfamiliar with an area from getting lost.

Two of the more common maps used in Florida forestry are the U.S. Geological Survey topographic ("topo") quadrangle maps and the Florida Department of Transportation county highway maps. Topo maps are highly detailed, showing locations of structures, trails, and depressions as well as ground elevations and land contours. The county highway maps are useful for establishing property boundaries and land locations.

Legal Descriptions

Distances between two points can be determined through the proper use of the map scale. For purposes of standardizing property lines throughout the state, Florida is divided into blocks, called ***townships***, measuring 6 miles by 6 miles (Fig. 10.12). The sides of the townships running east and west are called ***township lines***. Those running north and south are called ***range lines***. The numbering system for the whole state begins from a concrete monument called the ***Prime Meridian*** marker near the state Capitol in Tallahassee. The numbers grow larger as distance from the Prime Meridian marker increases. Each township line also is designated either north or south and each range number as east or west, depending upon the direction from the Prime Meridian marker.

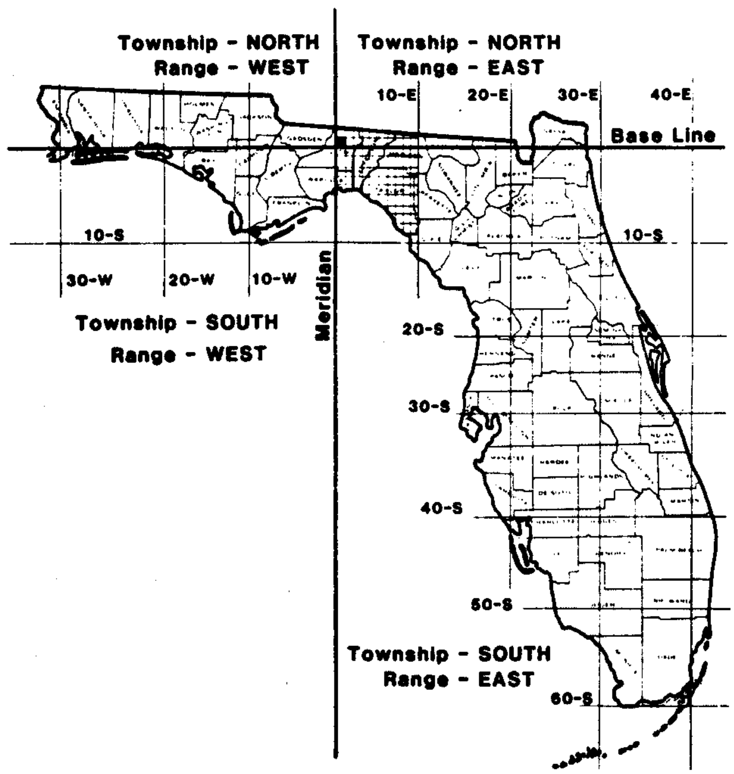

Figure 10.12 Florida is divided into townships. Range lines run N-S; Township lines run E-W.

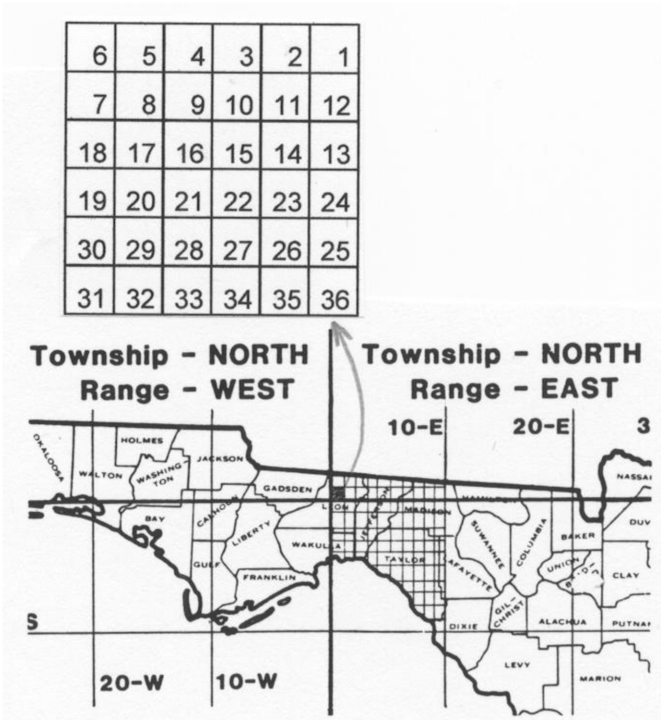

Figure 10.13. There are 36 sections in each Township.

Each township is divided into 36 ***sections***, each of which is 1 mile square (640 acres). Sections are numbered from east to west, top to bottom. Legal descriptions indicate section first, then township, then range. This is called the "***S-T-R***" of the property. For example Section 1, Township 10 S, Range 10 E.

Sections can be further divided into quarters and again into quarters (Figure 10.14). During the Indian River Lagoon Envirothon, you may be asked to identify the S-T-R for a location on a map.

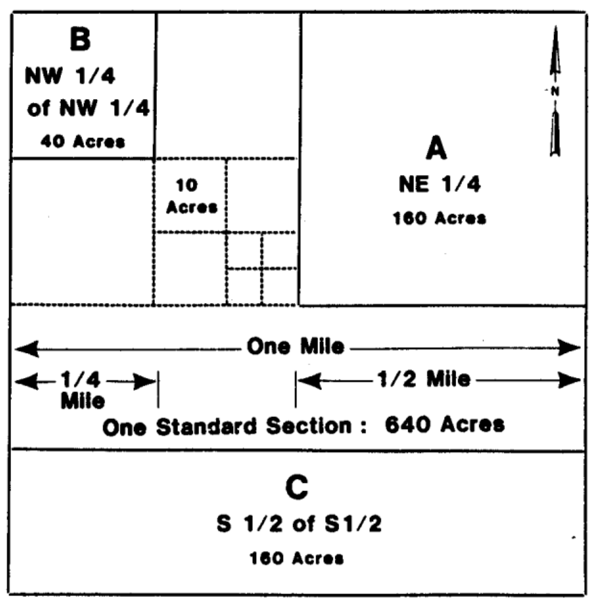

Figure 10.14. One standard section is 640 acres and is one mile square.

Land Area Calculations

It is important to know the size of the parcel when making land management decisions. Knowing the parcel size will determine the number of trees that will be needed for planting, the number of people required for a prescribed burn, or the cost of site preparation.

There 43,560 square feet in an acre. By measuring the dimensions of a parcel of land, either on foot, with a map or with an aerial photo, the acreage can be calculated utilizing geometry.

Example #1: Calculate the acres in Figure 10.15

2000 ft. x 2000 ft. = 4,000,000 sq. ft.

4,000,000 sq. ft. / (43,560 sq. ft./1 acre) =

91.8 acres

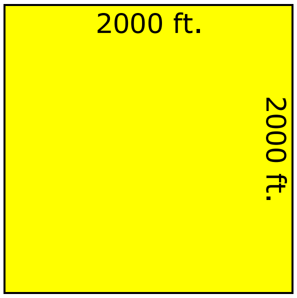

Figure 10.15

An alternative method of area calculation would be to measure the number of chains. On foot, it would be difficult to use a measuring tape to measure 2000ft. Pacing the number of chains is a quicker and easier method. In the above example, figure 10.15 is approximately 30 chains by 30 chains (2000ft / 66ft = 30.30).
The area of the parcel of land is 30 x 30 = 900 square chains.
Remember, there are 10 square chains in 1 acre. (*see* chain facts: page 84)
The number of acres is therefore 900 / 10 = **90 acres**. This is a good working approximation to the accurate answer, 91.8 acres. As you can see, using chains also makes the math a little easier!

Example #2: Calculate the acres in Figure 10.16

Area of the square: 2000 ft. x 2000 ft. = 4,000,000 sq. ft.

Area of the triangle: (1000 ft. x 2000 ft.)/2 = 1,000,000 sq. ft.

(4,000,000 sq. ft. + 1,000,000 sq. ft.)/(43,560 sq. ft./1 ac.) =
114.8 acres

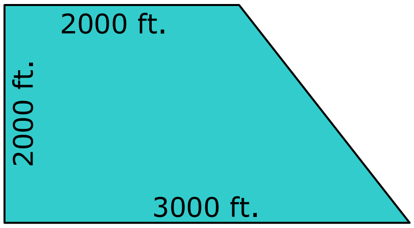

Figure 10.16

Assume that there are approximately: 15 chains in 1000ft, 30 chains in 2000ft and 45 chains in 3000ft.
Use the alternative method as in Example #1 to calculate the number of chains in Figure 10.16.
The approximate answer is 112.5 acres

SITE INDEX (S.I.)

Site index indicates the productive capacity of an area of forestland for a specific tree species. There are many ways to determine this productive capacity, but the most common is to measure the relationship between tree height and tree age.

To determine the site index, the heights of several dominant and co-dominant trees are measured. The age of these trees is found by taking a core sample and counting the growth rings.

The average age (in years) is located on the *x*-axis and the average height (in feet) is located on the *y*-axis. Where these lines intersect on the site curve is the site index. Site index curves showing average height of various ages have been prepared for different species, by region.

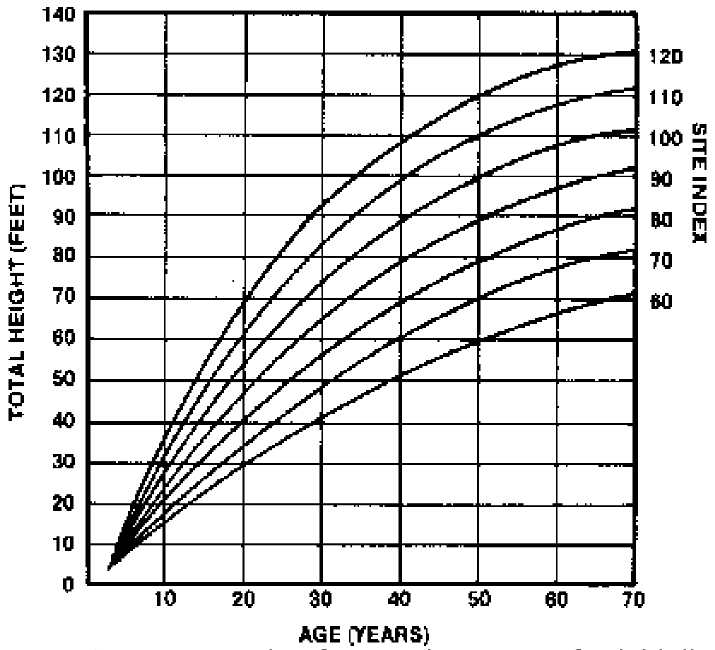

Figure 10.17. Example of site index curves for loblolly pine in Virginia, South Carolina, & North Carolina.

Example of how to use a site index curve:

What is the S.I. for longleaf pine whose height is 65 feet and age is 23 years? Answer **69**.

What is the S.I. for longleaf pine whose height is 40 feet and age is 20 years? Answer **45-46**.

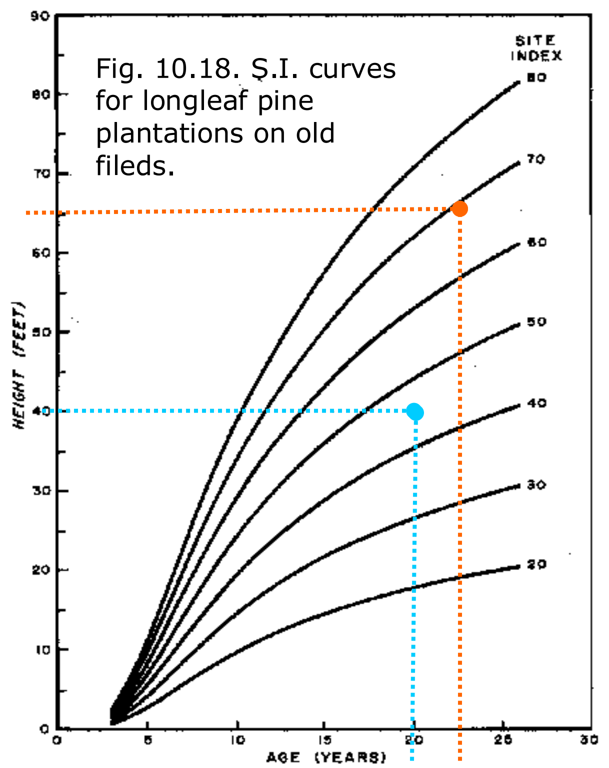

Fig. 10.18. S.I. curves for longleaf pine plantations on old fileds.

WEDGE PRISM

Once you've learned how to take measurements on individual trees, we will now look at the characteristics of the forest community. One important measurement is determining the ***basal area*** , or level of tree stocking on a particular site. Basal area is the measurement of the cross-sectional area of a given tree stem (or trunk) expressed in square feet at DBH. The basal area of a forest stand is the sum of the basal areas of individual trees, and is expressed in square feet per acre. The basal area of all trees in an area describes how much area is occupied by those trees.

Foresters use simple yet innovative instrument to determine the basal area on a specific site of a sample point. The ***wedge prism*** is a small piece of glass that has been ground to refract light rays at a specific offset angle, which creates an "optical illusion" (Figure 10.19). Each tree that is measured or *tallied* is equal to 10 square feet of basal area, so we are using a wedge prism that has a basal area factor of 10 (BAF=10).

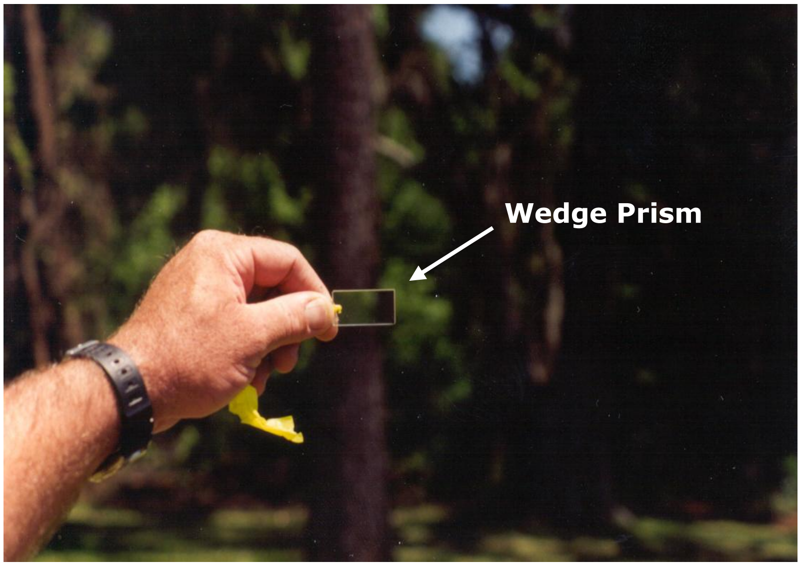

Figure 10.19

Foresters can determine the amount of basal area in a forest by measuring the trees in parts of the forest called plots. When a forester measures these plots, it is assumed that these small areas of the forest are representative of the entire forest. When using the wedge prism, it is very important to remember that the instrument must always be held directly above the "plot center" for accuracy.

The optical illusion the wedge prism creates appears to "offset" a portion of the tree's stem or trunk when viewed, preferably at DBH. If the offset portion appears to connect with the main stem of the tree, you tally that tree as "in" or "countable." If the offset portion appears completely removed from the main stem of the tree, do not tally that tree because it is considered "out" or "not countable." For trees that appear to be borderline or on the edge, simply count the first borderline tree then tally every other borderline tree after that. See Figure 10.20.

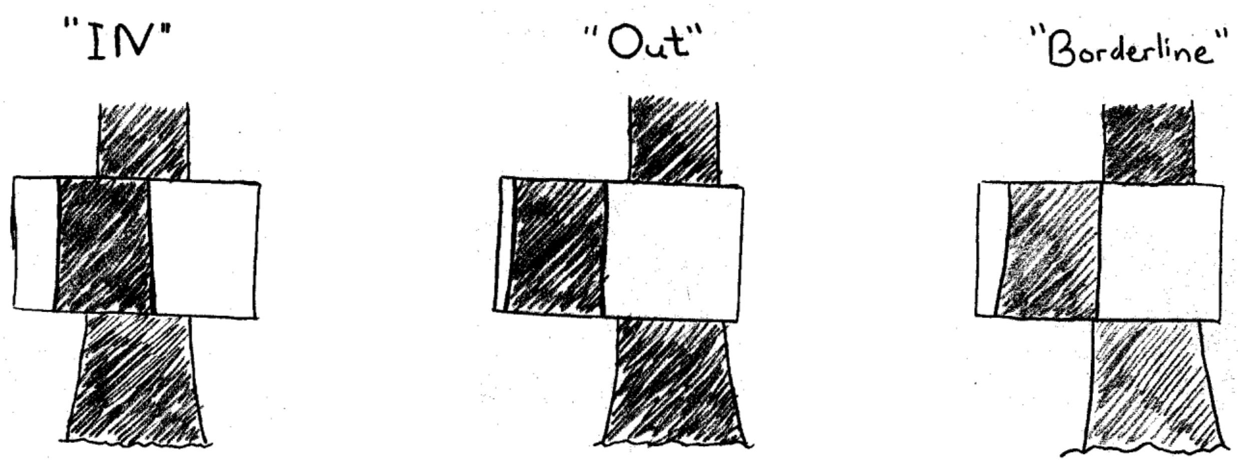

Figure 10.20 This is what trees will look like when viewed through a wedge prism. Remember, view all trees at DBH. Tally the first borderline tree in your sample plot, then tally every other borderline tree after that.

After determining the number of “in” or countable trees, as well as every other “borderline” tree, multiply that number by 10 to determine your basal area (because you are using a 10 BAF prism). For example, if you have 8 “in” trees, your basal area is 80, or you have 80 square feet of basal area per acre. If you were using a wedge prism with a BAF of 5, your basal area would be 40.