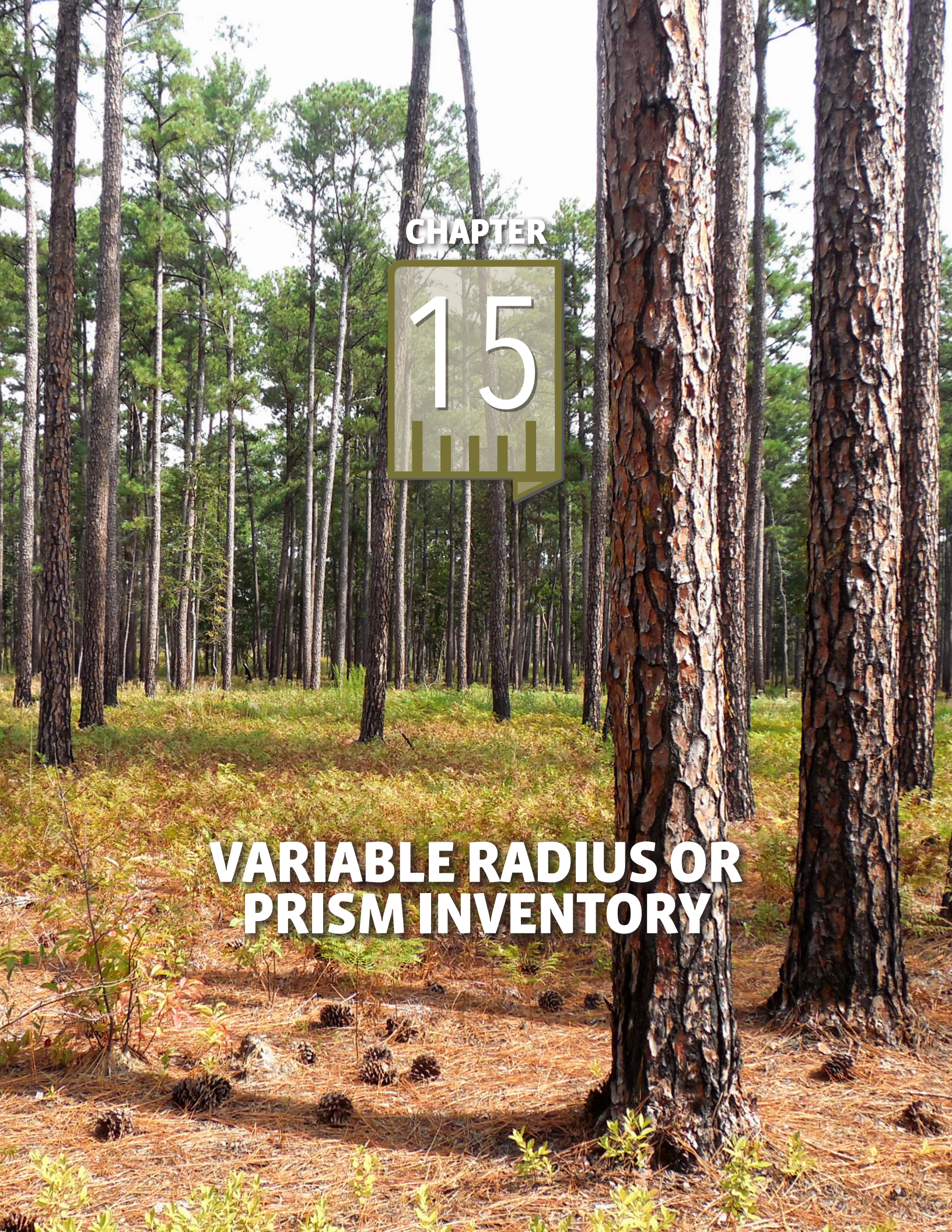

CHAPTER

15

VARIABLE RADIUS OR PRISM INVENTORY

Variable Radius or Prism Inventory

It is common for foresters to conduct a variable radius plot (VRP) inventory for landowners. There are many misconceptions, however, about this inventory method among both landowners and land managers.

Like fixed-radius plots, variable-radius plots, also referred to as point sampling or prism cruising, are often distributed across a forest along a grid and established from a predetermined plot center. Using a wedge prism (figure 15.1) held directly over the plot center (thus the name prism cruise), the observer rotates in a full circle, identifying and tallying “in” trees by looking through the prism at the stem of each tree at the diameter of breast height (DBH).

When using a wedge prism, “in” trees are those whose refracted section still overlaps the nonrefracted portion of the main bole, or stem (figure 15.2). "Out" trees do not overlap. Borderline trees appear to have the offset portion that is visible in the prism aligned with or barely touching the edge of the main bole of the tree.

Once all in trees are tallied, the results are multiplied by the basal area factor (BAF) of the prism to determine the basal area represented by this cruise/sample point. Using a prism basal area factor of 10 is common in the Southeast, but prisms in factors of 5, 15, 20, and 30 also are available. In general, selecting a prism factor that allows a sample of four to eight trees per plot is a good choice.

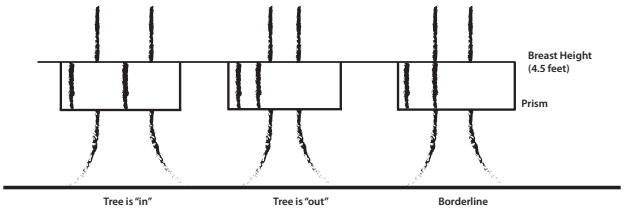

Figure 15.2. Determining if a tree is in, out, or borderline when using a prism to conduct a forest inventory.

WHEN A PRISM INVENTORY IS APPROPRIATE

Land managers sometimes decide to conduct prism inventories because they view them as faster and easier than using fixed-radius plots. If done correctly, however, a prism plot can sometimes take longer than a fixed-radius plot.

The prism inventory method is best for use in forest stands with larger-diameter, widely spaced trees, where you are looking for a quick estimate of average stand basal area. It is not well suited to younger and/or smaller-diameter stands. In addition, the use of a prism inventory is not recommended for management inventories where you want detailed information to make forest management decisions.

Figure 15.1. Prisms can come in many basal area factors (BAF), shapes, and sizes, so it is important to pay attention to the prism used and ensure that the prism matches the intended use.

CORRECT USE OF A PRISM IN THE FIELD

Stand with the plot center in front of you and the prism level and held over the plot center. Look at the tree in front of you at the point of 4½ feet off the ground. The stem of the tree will look offset, as if the section where you are looking has been pulled out. If that section is still touching the rest of the stem, then the tree is in, or counted. If the image is completely offset from the stem, then the tree is out and not counted in the tally. If the section is barely touching the rest of the stem, then the tree is considered borderline and may or may not be counted.

It might be tempting to simply count every other borderline tree, but this is not recommended. Borderline trees should be checked by measuring tree DBH and using plot radius factor (PRF) to calculate the critical distance for that tree; in other words, how far away that tree can be from the plot center and still be in the plot.

To calculate critical distance, multiply the tree's DBH measurement by a PRF. PRF for a 10 BAF prism is 2.75; therefore, if you are using a 10 BAF prism, multiply DBH times 2.75. The value you get is the maximum distance in feet that the tree can be away from the plot center and still be in the plot. Using your logger's tape or 100-foot tape, measure the distance from the plot center to the center of the tree. If the tree is within the critical distance calculated, then the tree is considered in the plot. True borderline trees should be tallied as a half tree, or every other true borderline tree should be tallied.

PITFALLS WHEN USING A PRISM

- The wrong basal area factor is selected.
- The forest stand is not well suited to a prism inventory.
- The light is poor, caused by factors such as very dense stands, overcast days, or the approach of evening.
- Vegetation on the tree makes it hard to see the tree bole.
- Trees are hidden by other trees.
- Large trees far away can be missed.
- There is carelessness in the field, such as not measuring borderline trees or not holding a prism level or over plot center.
- There is improper calculation of trees per acre.
- A 10 BAF prism inventory is perceived as being the same as using a 1/10 acre plot. They are not the same.

CALCULATING BASAL AREA USING A PRISM

Each tree tallied in a prism inventory represents the same amount of basal area on a per-acre basis, regardless of its size. Therefore, the formula to calculate the square feet of basal area per acre for a single plot is the following: trees tallied on plot times basal area factor.

Example: Assume you used a 10 BAF prism to sample a 50-year-old bottomland hardwood stand. You counted seven trees in your plot. What is the square feet of basal area per acre represented by this plot?

7 total trees × 10 BAF =
70 square feet of basal area/acre

CALCULATING MULTIPLE PLOTS

If you take multiple plots across your forest, you can use the previous process to estimate the square feet of basal area for each plot. You will then average the square feet of basal area for all plots to get the average square feet of basal area for the stand. See table 15.1 for an example.

Table 15.1. Average Square Feet of Basal Area Based on Multiple Plots

Plot Number	Tree Tally by Plot Using a 10 BAF Prism	Tree Tally × 10 BAF	Square Feet of Basal Area/Plot
1	7	7 × 10	70
2	6	6 × 10	60
3	8	8 × 10	80
4	7	7 × 10	70
5	8	8 × 10	80
6	9	9 × 10	90
Average square feet of basal area per acre (70 + 60 + 80 + 70 + 80 + 90 = 450 ÷ 6 plots)			75

YOUR TURN

You use a 10 BAF prism to sample a 30-year-old loblolly pine stand on your farm. You sample eight plots. Based on the tree tally in table 15.2, what do you estimate the square feet of basal area per acre on your stand to be?

Table 15.2. Calculate Average Square Feet of Basal Area on Multiple Plots

Plot Number	Tree Tally by Plot Using a 10 BAF Prism	Tree Tally × 10 BAF	Square Feet of Basal Area per Plot
1	10		
2	9		
3	9		
4	7		
5	11		
6	8		
7	9		
8	9		
	Average square feet of basal area per acre		

Answers to Calculation

Plot Number	Tree Tally by Plot Using a 10 BAF Prism	Tree Tally × 10 BAF	Square Feet of Basal Area per Plot
1	10	10 × 10	100
2	9	9 × 10	90
3	9	9 × 10	90
4	7	7 × 10	70
5	11	11 × 10	110
6	8	8 × 10	80
7	9	9 × 10	90
8	9	9 × 10	90
Average square feet of basal area per acre (100 + 90 + 90 + 70 + 110 + 80 + 90 + 90 = 720 ÷ 8 plots)			90

CALCULATING TREES PER ACRE FROM A PRISM INVENTORY

Using a prism to establish a variable radius plot, or point sample, is an easy way to determine basal area. But what if you also need to know trees per acre? When using a prism, you cannot just multiply by the basal area factor to estimate trees per acre. Per-acre conversion factors vary by tree diameter class.

To determine trees per acre for each tree that is tallied, you need to measure the DBH of each "in" tree. You calculate the basal area of the tree and divide that into the basal area factor for the prism used. This gives you an estimate of trees per acre that each tallied tree represents.

Example: You tally a 6-inch-diameter tree using a 10 BAF prism and want to know the trees per acre that the tree represents. First you calculate the square feet of basal area for the 6-inch-diameter tree:

$6^2 \times 0.005454 = 0.196$ square feet

Then you divide the number of square feet into the basal area factor, which in this case is 10, to determine trees per acre:

$10 \div 0.196 = 51.0$ trees per acre

How many trees per acre does an 11-inch tree represent when using a 10 BAF prism?

Basal area = $11^2 \times 0.005454 = 0.660$ square feet
Trees per acre = $10 \div 0.660 = 15.2$ trees per acre

As you can see, calculating trees per acre based on a 10 BAF prism inventory is not the same as using a 1/10-acre plot.

The prism inventory method is best used in forest stands with larger-diameter, widely spaced trees.

COMPLETING A FIELD INVENTORY TALLY CARD

Table 15.3 is an example of a forest inventory tally card that was competed in the field using a 10 BAF prism. Five trees were determined to be in this 10 BAF prism plot. Trees also were measured for DBH to the nearest 0.1 inch and total height to the nearest 10 feet. The following explains how to summarize this information to know a little more about the forest.

ESTIMATING SQUARE FEET OF BASAL AREA PER ACRE

To determine the square feet of basal area for this plot, take the number of trees counted on the plot and multiply that by the basal area factor of the prism used, which in this case is 10. The basal area factor for each tree goes under the "basal area per acre" column in table 15.3.

Total trees counted on the plot = 5
5 × 10 = 50 square feet of basal area per acre

ESTIMATING TREES PER ACRE

Estimating trees per acre on a prism plot is a two-step process. First you must determine the square feet of basal area for each tree by squaring each tree diameter and multiplying it by 0.005454. For tree one, for example, the per-tree basal area would be calculated as such:

$12.7^2 \times 0.005454 =$
$161.29 \times 0.005454 = 0.880$ square feet.

Then you divide the square feet of basal area for each tree into the basal area factor of the prism used. In this case, use the number 10. For tree one, the trees per acre would be calculated as such:

10 ÷ 0.880 = 11.4 trees/acre

This number may be rounded up or down as appropriate. Notice how smaller trees have a higher trees-per-acre conversion factor than the larger-diameter trees.

To determine the trees per acre represented by this plot, add up the trees-per-acre conversion factor for each tree. This plot represents 104 trees per acre. See "trees per acre conversion factor" column in table 15.3.

ESTIMATING INDIVIDUAL TREE WEIGHT OR VOLUME

Estimate the weight or volume of wood per tree and then the weight or volume per acre represented by your plot. Be sure to select a weight or volume table best suited to your tree species and region.

Table 15.3. Forest Inventory Using a 10 BAF Prism (Plot 1)

Stand description: Old field pines, Lee County, AL Plot number: 1				Acres: 37 Date: 2/2/2020			Names: Laura Landowner Plot size: 10 BAF	
Species	**Crown Class**	**DBH (in.)**	**Height Total (ft.)**	**Basal Area (ft.²) per Tree (0.005454 × dbh²)**	**Trees per Acre Conversion Factor (BAF ÷ BA per tree)**	**Basal Area per Acre (sq. ft.)**	**Weight (lb. per tree)**	**Weight/Acre (lb. per ac.) (wt. of tree × trees per ac. conversion factor)**
P	C	12.7	80	0.880	11	10	2,547	28,017
P	C	12.0	80	0.785	13	10	2,148	27,924
P	I	5.5	40	0.165	61	10	177	10,797
P	D	13.6	80	1.009	10	10	2,983	29,830
P	D	14.5	80	1.147	9	10	2,983	26,847
					104	50		123,415
								61.7 (tons per ac.)

For our example plot we use table 1 in "Tables for Estimating Total-Tree Weights, Stem Weights, and Volumes of Planted and Natural Southern Pines in the Southeast." Based on tree diameter and height, fill in the corresponding weights in pounds.

CALCULATING WEIGHT PER ACRE

The next step is to calculate weight per acre represented by each tree on the plot. Because this plot is a 10 BAF prism plot, you must multiply each tree's weight by its trees per acre conversion factor. Following is the calculation to use for the first tree on the plot:

2,547 × 11 = 28,017 pounds per acre

You then calculate the weight per acre for each tree and sum up those weights (table 15.3):

28,017 + 27,924 + 10,797 + 29,830 + 26,847 = 123,415 pounds per acre

Then, to calculate tons per acre, divide the total pounds per acre by 2,000 (pounds in a ton):

123,415 ÷ 2,000 = 61.7 tons per acre

CALCULATING FOR MULTIPLE PLOTS

A full prism inventory is based on more than just one plot. Tables 15.4 and 15.5 show the difference when two more completed plots are added to the example in table 15.3. In an actual forest inventory, more than three plots are usually needed, but we are using a small sample for demonstration purposes only.

In looking at these three plots, you see that they are different from each other even though they are based on measurements taken from the same forest stand. To summarize these to get an estimate for the stand, you average the basal area per acre, trees per acre, and tons per acre across all plots (table 15.6). You also can estimate the total tons on a stand by multiplying the average tons per acre across all plots and then multiplying that by the number of acres in the stand.

> A prism inventory is not well suited to smaller-diameter forests. It is best for forest stands with larger-diameter trees when you are looking for a quick estimate of the average stand basal area.

Table 15.4. Forest Inventory Using a 10 BAF Prism (Plot 2)

Stand description: Old field pines, Lee County, AL Plot number: 2					Acres: 37 Date: 2/2/2020		Names: Laura Landowner Plot size: 10 BAF	
Species	**Crown Class**	**DBH (in.)**	**Height Total (ft.)**	**Basal Area (ft.²) per Tree (0.005454 × dbh²)**	**Trees per Acre Conversion Factor (BAF ÷ BA per tree)**	**Basal Area per Acre (sq. ft.)**	**Weight (lb. per tree)**	**Weight per Acre (lb./ac.) (wt. of tree × trees per ac. conversion factor)**
P	D	12.7	80	0.880	11	10	2,547	28,017
P	D	13.0	70	0.922	11	10	2,255	24,805
P	D	14.0	80	1.069	9	10	2,983	26,847
P	D	12.6	70	0.866	12	10	2,255	27,060
P	I	6.5	50	0.230	43	10	320	13,760
P	I	5.8	40	0.183	55	10	261	14,355
					141	60		134,844
								67.4 (tons per ac.)

Table 15.5. Forest Inventory Using a 10 BAF Prism (Plot 3)

Stand description: Old field pines, Lee County, AL Plot number: 3					Acres: 37 Date: 2/2/2020		Names: Laura Landowner Plot size: 10 BAF	
Species	**Crown Class**	**DBH (in.)**	**Height Total (ft.)**	**Basal Area (ft.²) per Tree (0.005454 × dbh²)**	**Trees per Acre Conversion Factor (BAF ÷ BA per tree)**	**Basal Area per Acre (sq. ft.)**	**Weight (lb. per tree)**	**Weight per Acre (lb. per ac.) (wt. of tree × trees per ac. conversion factor)**
P	D	14.1	80	1.084	9	10	2,983	26,847
P	D	15.5	80	1.310	8	10	3,455	27,640
P	D	12.0	70	0.785	13	10	1,902	24,726
P	D	11.7	70	0.747	13	10	1,902	24,726
P	I	11.9	70	0.772	13	10	1,902	24,726
					56	50		128,665
								64.3 (tons/ac.)

It is interesting to see what happens to trees-per-acre numbers on a prism inventory when smaller-diameter trees are included. As with any forest inventory method, it is important to keep up with plot locations on a map so that you can tie data for a given plot back to a point on the ground. This can help you know where larger or smaller trees can be found and where dense or sparse pockets of trees are located.

Table 15.6. Total Tons per Acre Based on Multiple Plots

Plot	Square Feet of Basal Area per Acre	Trees per Acre	Tons per Acre
Plot 1	50	104	61.7
Plot 2	60	141	67.4
Plot 3	50	56	64.3
Average/acre for the stand	53	100	64.47
	Total tons for the stand (64.47 tons per ac.× 37 ac.)		2,385.39 total tons

YOUR TURN

Based on the three-plot sample in tables 15.7 to 15.9, determine square feet of basal area per acre, trees per acre, and tons per acre represented by each plot from a prism inventory of a 17-acre upland hardwood stand. Then, determine the average square feet of basal area, trees per acre, and tons per acre for the stand.

Always check the tally cards for specifications such as acres and plot size. Remember, for a full inventory, more than three plots may be needed. These three plots are provided as a sample dataset only.

For tree weights, we will use table 73 in "Total-Tree Weight, Stem Weight, and Volume Tables for Hardwood Species in the Southeast."

Table 15.7. Calculate Plot 1 Forest Inventory

Stand description: Upland hardwood stand, Coosa County, AL							Acres: 17	
Names: C. Wood and V. Wolfe				Plot number: 1		Date: 3/4/2020	Plot size: 10 BAF	
Species	**Crown Class**	**DBH (in.)**	**Height Total (ft.)**	**Basal Area (ft.²) per Tree** (0.005454 × dbh²)	**Trees per Acre Conversion Factor** (BAF ÷ BA per tree)	**Basal Area per Acre (sq. ft.)**	**Weight (lb. per tree)**	**Weight per Acre (lb. per ac.)** (wt. of tree × trees per ac. conversion factor)
H	C	10	50					
H	D	12	70					
H	D	17	80					
H	D	11	60					
H	C	12	60					
H	C	11	50					
					(trees per ac.)	(sq. ft. BA per ac.)		(lb. per ac.)
								(tons per ac.)

Poor lighting can affect results of a prism inventory.

Table 15.8. Calculate Plot 2 Forest Inventory

Stand description: Upland hardwood stand, Coosa County, AL							Acres: 17
Names: C. Wood and V. Wolfe				Plot number: 2		Date: 3/4/2020	Plot size: 10 BAF
Species	**Crown Class**	**DBH (in.)**	**Height Total (ft.)**	**Basal Area (ft.²) per Tree (0.005454 × dbh²)**	**Trees per Acre Conversion Factor (BAF ÷ BA per tree)**	**Basal Area per Acre (sq. ft.)**	**Weight (lb. per tree)**	**Weight per Acre (lb. per ac.) (wt. of tree × trees per ac. conversion factor)**
H	C	11	60					
H	D	13	70					
H	I	9	60					
H	C	10`	60					
H	D	13	70					
H	I	9	50					
H	D	14	80					
H	D	12	70					
					(trees per ac.)	(sq. ft. BA per ac.)		(lb. per ac.)
								(tons per ac.)

Table 15.9. Calculate Plot 3 Forest Inventory

Stand description: Upland hardwood stand, Coosa County, AL							Acres: 17	
Names: C. Wood and V. Wolfe				Plot number: 3		Date: 3/4/2020	Plot size: 10 BAF	
Species	**Crown Class**	**DBH (in.)**	**Height Total (ft.)**	**Basal Area (ft.²) per Tree** (0.005454 × dbh²)	**Trees per Acre Conversion Factor** (BAF ÷ BA per tree)	**Basal Area per Acre (sq. ft.)**	**Weight (lb. per tree)**	**Weight per Acre (lb. per ac.)** (wt. of tree × trees per ac. conversion factor)
H	C	15	80					
H	C	12	60					
H	D	14	70					
H	C	12	60					
H	C	12	50					
H	I	9	50					
H	D	13	70					
H	D	14	70					
					(trees per ac.)	(sq. ft. BA per ac.)		(lb. per ac.)
								(tons per ac.)

Table 16.10. Calculate Stand Summary

Plot	Square Feet of Basal Area per Acre	Trees per Acre	Tons per Acre
Plot 1			
Plot 2			
Plot 3			
Average/acre for the stand			
	Total tons for the stand (____ tons per ac. × 17 ac.)		total tons

Answers to Table 16.7 Calculations

Stand description: Upland hardwood stand, Coosa County, AL							Acres: 17	
Names: C. Wood and V. Wolfe			Plot number: 1		Date: 3/4/2020		Plot size: 10 BAF	
Species	**Crown Class**	**DBH (in.)**	**Height Total (ft.)**	**Basal Area (ft.²) per Tree (0.005454 × dbh²)**	**Trees per Acre Conversion Factor (BAF ÷ BA per tree)**	**Basal Area per Acre (sq. ft.)**	**Weight (lb. per tree)**	**Weight per Acre (lb. per ac.) (wt. of tree × trees per ac. conversion factor)**
H	C	10	50	0.545	18	10	973	17,514
H	D	12	70	0.785	13	10	1,937	25,181
H	D	17	80	1.576	6	10	4,939	29,634
H	D	11	60	0.660	15	10	1,371	20,565
H	C	12	60	0.785	13	10	1,680	21,840
H	C	11	50	0.660	15	10	1,160	17,400
					80	60		132,134
								66.07 (tons per ac.)

Answers to Table 16.8 Calculations

Stand description: Upland hardwood stand, Coosa County, AL							Acres: 17	
Names: C. Wood and V. Wolfe			Plot number: 2		Date: 3/4/2020		Plot size: 10 BAF	
Species	**Crown Class**	**DBH (in.)**	**Height Total (ft.)**	**Basal Area (ft.²) per Tree (0.005454 × dbh²)**	**Trees per Acre Conversion Factor (BAF ÷ BA per tree)**	**Basal Area per Acre (sq. ft.)**	**Weight (lb. per tree)**	**Weight per Acre (lb. per ac.) (wt. of tree × trees per ac. conversion factor)**
H	C	11	60	0.660	15	10	1,371	20,565
H	D	13	70	0.922	11	10	2,335	25,685
H	I	9	60	0.442	23	10	948	21,804
H	C	10	60	0.545	18	10	1,151	20,718
H	D	13	70	0.922	11	10	2,335	25,685
H	I	9	50	0.442	23	10	801	18,423
H	D	14	80	1.069	9	10	3,139	28,251
H	D	12	70	0.785	13	10	1,937	25,181
					123	80		132,880
								66.44 (tons/ac.)

Answers to Table 15.9 Calculations

Stand description: Upland hardwood stand, Coosa County, AL							Acres: 17	
Names: C. Wood and V. Wolfe			Plot number: 3		Date: 3/4/2020		Plot size: 10 BAF	
Species	**Crown Class**	**DBH (in.)**	**Height Total (ft.)**	**Basal Area (ft.²) per Tree (0.005454 × dbh²)**	**Trees per Acre Conversion Factor (BAF ÷ BA per tree)**	**Basal Area per Acre (sq. ft.)**	**Weight (lb. per tree)**	**Weight per Acre (lb. per ac.) (wt. of tree × trees per ac. conversion factor)**
H	C	15	80	1.227	8	10	3,688	29,504
H	C	12	60	0.785	13	10	1,680	21,840
H	D	14	70	1.069	9	10	2,776	24,984
H	C	12	60	0.785	13	10	1,680	21,840
H	C	12	50	0.785	13	10	1,421	18,473
H	I	9	50	0.442	23	10	801	18,423
H	D	13	70	0.922	11	10	2,335	25,685
H	D	14	70	1.069	9	10	2,776	24,984
					99	80		135,064
								67.53 (tons per ac.)

Answers to Table 16.10 Calculations

Plot	Square Feet of Basal Area per Acre	Trees per Acre	Tons per Acre
Plot 1	60	60	66.1
Plot 2	80	123	66.4
Plot 3	80	99	67.5
Average/acre for the stand	67	94	66.68
	Total tons for the stand (66.68 tons per ac. × 17 ac.)		1,133.56 total tons