Lesson 10: Basic Inventory Calculations

Review and Introduction

In the preceding lessons, you learned how to establish and take measurements in **sample plots**. You can use a program like LMS to calculate things like **basal area**, **trees per acre (TPA)**, and volume (Lesson 9), or you can calculate these values on your own.

Learning Objectives:

By the end of this lesson, you will be able to use your inventory data to compute the following for your forest:

1. Basal area
2. Trees per acre (TPA)
3. Volume

Materials Needed:

1. Completed plot data recording sheets
2. Calculator (or a spreadsheet program)

I. Determining Basal Area

Basal area is the cross-sectional area of a tree trunk at **breast height**. Basal area is computed at the stand level as the sum of the basal area values for each individual tree, which is usually expressed as square feet per acre.[1] The amount of basal area in a stand is a function of the number of trees and the size of the trees. As such, it is a measure of the overall level of **competition** for resources between trees in the stand, and it is frequently used to determine whether a stand should be **thinned**.

Determining basal area from fixed plots

1. Determine the **expansion factor** (the number of trees per acre a given plot tree represents) for plot trees by taking the denominator of the plot size (e.g. 20 for a 1/20th acre plot) and dividing by the number of plots.

   For each plot tree, determine the basal area (in square feet) by multiplying the DBH (in inches) by itself (i.e. square it) and then multiplying by 0.005454:

   $Tree\ BA = .005454 \times DBH^2$

2. Multiply the basal area for each tree by the expansion factor to determine the basal area per acre represented by each tree.

BA/acre = Tree BA x Expansion Factor

3. Repeat this procedure for the rest of the trees in the rest of the plots, and then add together the basal area per acre for each tree to get the total basal area per acre for the stand.

Example: Suppose you acquired data on two 1/20th acre plots. Suppose that there were 11 total trees in your plots (6 in the first plot, 5 in the second) and that the first tree in the first plot was 14.5 inches DBH.

1. With two 1/20th acre plots, the expansion factor would be 20 / 2 = 10.

2. The basal area of the first tree = 14.5 x 14.5 x 0.005454 = 1.15 square feet.

3. Multiply 1.15 by the expansion factor of 10 to get 11.5 square feet/acre of basal area represented by that tree.

4. Repeat this for all the other plot trees and add the values together to get the total basal area for the stand (*Table 10-1*).

Table 10-1: Here is an example of computing the total basal are per acre for a stand with two 1/20th acre plots. Basal area is computed for each tree and then multiplied by the expansion factor (in this case 10) to put it on a per acre basis. The basal areas per acre for each tree are then added together to determine the total basal area per acre for the stand.

Plot	Tree	DBH (in)	Tree Basal Area (sqft)	Basal Area per acre (sqft)
1	1	14.5	1.15	11.5
	2	11.2	0.68	6.8
	3	8.7	0.41	4.1
	4	10.4	0.59	5.9
	5	11.1	0.67	6.7
	6	7.1	0.27	2.7
2	1	9.9	0.53	5.3
	2	11.4	0.71	7.1
	3	13.8	1.04	10.4
	4	16.0	1.40	14
	5	7.9	0.34	3.4
Total basal area per acre (square feet):				**77.9**

Determining basal area from <u>variable plots</u>

Determining basal area is a little easier for variable plots, because each "in" tree in a plot represents a given amount of basal area, as determined by the **Basal Area Factor (BAF)**. For example, if you established variable plots using a BAF of 30, each tree would represent 30 square feet of basal area.

Here are the steps for determining trees per acre from variable plots:

1. Add up the total number of trees for all the plots in the stand.

2. Multiply the total number of plot trees by the BAF (*Trees x BAF*).

3. Divide by the number of plots to get the total basal area per acre for the stand.

   Total BA/acre = (Trees x BAF) / Plots

   Example: Suppose you did two variable plots using a BAF of 30. If there were 11 total trees in the two plots, you would multiply 30 x 11 and then divide by 2 to get a total of 165 square feet of basal area per acre for the stand.

II. Determining trees per acre (TPA)

One of the most important things an inventory can tell you is how dense the trees are in your **stand.** The most basic measure of stand density is the number of trees per unit of area, which is often expressed as **trees per acre (TPA)**.[2]

Determining TPA from fixed plots

Here are the steps for determining TPA from **fixed plots**:

1. Determine the **expansion factor** (the number of trees per acre a given plot tree represents) by taking the denominator of the plot size (e.g. 20 for a 1/20th acre plot) and dividing by the number of plots.

   Expansion factor = Plot size denominator / Plots

2. Add up the total number of trees <u>for all the plots</u> in the stand.

3. Multiply the total number of plot trees by the expansion factor to determine total TPA for the stand.

   TPA = Trees x Expansion factor

   Example: Suppose you acquired data on two 1/20th acre plots (i.e. you sampled a tenth of an acre total, or 1/20 + 1/20). Suppose that between the two plots there were 11 total trees.

   1. The expansion factor would be 20 / 2 = 10.0 trees per acre. Thus, each plot tree represents 10 trees in the stand.

2. There are 11 total trees for all plots.

3. Multiply 11 (total number of trees) by the expansion factor of 10 to get 110 TPA for the whole stand.

Determining TPA from variable plots

Determining TPA from **variable plots** is more complicated, as each "in" tree in a plot does not represent a fixed number of trees per se, but rather an amount of basal area, as determined by the BAF used to establish the plots. We can compute an expansion factor by calculating each tree's actual basal area and dividing that into the BAF. This means that the expansion factor will be different for each tree depending on its diameter (**DBH).** Thus, in contrast to fixed plots where the expansion factor is the same for all trees, the expansion factor is different for each tree in a variable plot, based on its diameter.

Here are the steps for determining TPA from variable plots:

1. For each tree, compute its basal area (in square feet) by multiplying the DBH (in inches) by itself (i.e. square it) and then multiplying by 0.005454.

   Tree BA = .005454 x DBH^2

2. Divide the **basal area factor (BAF)** by the basal area of each tree (*BAF / Tree BA*).

3. Divide again by the number of plots to get the number of trees per acre represented by that tree, which is its expansion factor.

   Expansion Factor = BAF / Tree BA / Plots

4. Repeat these steps to compute the expansion factors for all of your plot trees for a given stand, and add these values up to get the total TPA for the stand. A spreadsheet program is particularly useful for this.

Example: Suppose you did two variable plots using a BAF of 30. The first tree in the first plot is 14.5 inches DBH.

1. The basal area of the first tree = 14.5 x 14.5 x 0.005454 = 1.15 square feet.

2. Dividing 30 (BAF) by 1.15 yields 26.09.

3. Dividing 26.09 by 2 (number of plots) yields approximately 13.05 TPA. This is the expansion factor for that first tree.

4. Expansion factors would now be computed for all the other plot trees in the stand and added together to determine the total TPA for the stand (*Table 10-2*).

Table 10-2: Here is an example of computing the total TPA for a stand with two variable plots done with a BAF of 30. Expansion factors are computed for each tree, then added together to determine the total TPA for the stand.

Plot	Tree	DBH (in)	Tree Basal Area (sqft)	Expansion Factor
1	1	14.5	1.15	13.05
	2	11.2	0.68	22.06
	3	8.7	0.41	36.59
	4	10.4	0.59	25.42
	5	11.1	0.67	44.78
	6	7.1	0.27	55.56
2	1	9.9	0.53	28.3
	2	11.4	0.71	21.13
	3	13.8	1.04	14.43
	4	16.0	1.40	10.72
	5	7.9	0.34	44.12
			Total TPA (rounded):	**316**

III. Determining Tree Volume

If you are managing for timber and wood products, knowing how much volume of wood you have will be of particular importance. Determining the volume of wood in a tree can be challenging, as the stem of the tree is not a perfect cylinder. Rather, the stem is **tapered**, meaning that it starts out wide at the bottom and becomes narrower as you go up the tree, giving the tree somewhat of a cone shape.

Equations have been developed for calculating tree volume for different species and locations. These equations are built into programs like LMS. They are also used to create **volume tables**, which allow you to look up the volume of a tree based on its DBH and height or sometimes just its DBH. Because volume tables are very specific to species and location, we have not included any here. Contact your local Extension Forester for information on obtaining volume tables that are appropriate for your area.

Once you have obtained an appropriate volume table, you can determine the volume of each of your plot trees based on the tree's DBH and height. Depending on the type of volume table, you may or may not need to have measured tree heights for all of your plot trees to do this. Once you have determined the volume of each tree, multiply that volume by the tree's expansion factor (which you determined above when calculating TPA and basal area) to get volume on a per acre basis. Add the per acre volumes for each of your plot trees to find the total volume per acre in your stand.

Once you have determined the volume per acre in your stand, you can multiply by the number of acres to find the total stand volume. If you know the current price per volume of wood in your area (you can ask your local Extension Forester about this), you can further estimate the approximate commercial value of the timber in your stand.

On your own:

Determine basal area and TPA for each of your stands. Find out from your local Extension Forester if there are volume tables available that are appropriate for your stand. Discuss your stand density (TPA) and basal area with your local Extension Forester and talk about whether or not your forest should be thinned. Make sure your Extension Forester understands what your overall management objectives are.

Next Steps:

- Test your knowledge by taking a Short Quiz.

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[1] In countries or applications in which the metric system is used, basal area for a stand would be expressed as square meters per hectare.

[2] In countries or applications in which the metric system is used, stand density would be expressed as trees per hectare.