W 878

Quick Cruising to Estimate Board-Foot Volume of Standing Hardwood Timber

David Mercker, *Extension Specialist*
Sheng-I Yang, *Assistant Professor*
Department of Forestry, Wildlife and Fisheries

Introduction

Timber inventories are the main tool used to determine the volume and value of standing trees on a forested tract. A timber inventory, like any inventory, involves taking stock of how much material is available. While timber inventories are most often performed to place value on a stand before sale, they are also useful for providing information for the development of management strategies, estate planning, tax basis or litigation (Henning and Mercker 2014).

Nevertheless, timber inventories are time consuming and often expensive, and though the results are beneficial, full-scale inventories may produce more information than may be needed. More details about full-scale timber inventory can be found in "PB 1870 Conducting a Simple Timber Inventory" (Henning and Mercker 2014) at extension.tennessee.edu/publications/Documents/PB1780.pdf.

Many foresters, loggers and timber buyers (and in some cases landowners) have sought a quicker method of estimating the board-foot (bf) volume of standing timber. Sometimes full-scale inventories are not necessary and ballpark estimates are sufficient.

This publication addresses a method of timber inventory often called *quick cruising* that has been used for years in the forestry business. Quick cruising, when done properly, provides users with an estimate of standing timber volume that can assist in making decisions regarding selling, buying or evaluating timber.

Procedure

The quick cruise method converts the average number of 16-foot logs tallied **per plot** to an estimate of board feet **per acre**. Quick cruising uses the inventory method called variable-radius plot sampling. Also known as angle-gauge sampling, prism sampling or point sampling, this approach is a common and efficient sampling method.

When conducting a quick cruise, a 10-basal area factor (baf) prism or angle gauge is used to determine the number of "in" trees for each plot. The number of 16-foot merchantable logs tallied (to a 10-inch top diameter) in the "in" trees is recorded. *A conversion factor is then used to convert the number of logs tallied per plot to bf per acre, and it varies according to the average diameter at breast high (dbh) and average number of logs per tree.* Therefore, it is also beneficial to note the *number* of "in" trees and the average dbh of the "in" trees.

The accuracy of any timber inventory improves when data variability decreases. Therefore, to decrease data variability with quick cruising, these steps should be followed:

- Delineate a timber tract into uniform smaller stands and inventory each stand separately. This makes each plot more representative of the stand. For instance, a fine-quality mature oak stand should be inventoried separately from a degraded and/or younger stand.
- Increase the number of plots. A rule of thumb is to incorporate one plot per acre for the first 40 acres, then one per 2 acres for the next 60 acres, then one per 5 acres thereafter. Although increasing plot intensity improves accuracy, it is more time consuming and may defeat the purpose of a quick cruise.
- Place plots systematically in a grid-like pattern to avoid biasing the plots toward the better-quality timber or on terrain more easily traversed.
- Collect data accurately to ensure that the correct "in" trees are tallied and with a precise tally of the number of 16-foot logs within the tallied trees.

An example with a basal area factor of 10 (ft^2/ac) and the Doyle log rule for 16-foot logs is used to demonstrate the procedure. Assume that we establish three sample points: A, B and C. For each sample point, trees are tallied by a 10-baf wedge prism or angle gauge. Average dbh and average number of logs per tree for the three sample points are listed in **Table 1**.

Table 1. Average diameter at breast height (dbh) and average number of 16-foot logs per tree for three sample points: A, B and C. Trees are tallied using a 10 baf prism.

Sample point	Average dbh (in.)	Average # of logs/tree
A	14"	2.0
B	20"	2.5
C	26"	3.0

Importance of Tree Factor: In point sampling, tree factor is the number of trees on a per-acre basis represented by the diameter for each tallied tree and can be calculated as:

$$\text{Tree factor} = \frac{\text{BAF}}{\text{Tree basal area}} = \frac{\text{BAF}}{0.005454 * \text{dbh}^2}$$

Using a BAF of 10 (ft^2 /ac), tree factor can be simplified to:

$$\text{Tree factor} = 1833.46/\text{dbh}^2$$

The tree factor by dbh is summarized in **Table 2**. Note a 14-inch dbh tree has a tree factor of 9.35, thus *each* 14-inch tree tallied represents 9.35 trees per acre, calculated as $1833.46/14^2$. The corresponding tree factors for the dbh of 14, 20 and 26 inches are 9.35, 4.58 and 2.71 (trees/ac), respectively. For example, each 20-inch dbh tree tallied represents 4.58 trees per acre and so on. Notice that the tree factor is inversely related to dbh.

Table 2. Tree Factors by dbh (using a 10 baf).

DBH (in.)	Tree Factor (Trees/ac)
4	114.59
6	50.93
8	28.65
10	18.33
12	12.73
14	9.35
16	7.16
18	5.66
20	4.58
22	3.79
24	3.18
26	2.71
28	2.34
30	2.04

Table 3. Procedure for Estimating Conversion Factor per 16-foot Log Tallied.

Sample point	Avg. dbh (in.)	Avg # of logs /tree[1]	Avg. Tree Factor (Trees/ac)	Avg. bf/tree	Avg. bf/ac	Avg. bf/ac/log tallied[2]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
A	14	2.0	9.35	75	701	350
B	20	2.5	4.58	261	1195	480
C	26	3.0	2.71	619	1677	560
Method of Calculation			$\frac{1833.46}{(2)^2}$	**Doyle Table**	**(4) x (5)**	**(6) / (3)**

[1] Often this number is estimated, but users may wish to calculate the avgerage number of logs per tree.
[2] Also known as the conversion factor.

When the tree factor is multiplied by the bf volume/tree, the product is bf volume/acre. Dividing this number by the average number of logs/tree produces a conversion factor (**Table 3**, *column 7*).

Table 4 shows an overall summary of the conversion factor based on dbh and the average number of logs per tree. *Column 3* is the conversion factor and is the component sought. For example, a sample plot has an average of 2.5 logs per tree and an average dbh of 20 inches. If nine logs are tallied on this plot, then the bf volume per acre would be 9 x 480 bf = 4,320 bf **per acre**. **Table 4** could be expanded by using odd-numbered dbh's and by increasing the average number of logs per tree.

Table 4. Conversion Factor Used for Quick Cruising.

Avg. DBH	Avg. # of logs/tree	Conversion Factor[1]
14	2.0	350
16	2.0	415
18	2.0	465
20	2.5	480
22	2.5	520
24	2.5	550
26	3.0	560
28	3.0	585
30	3.0	610

[1] Conversion factor multiplied by the average number of 16-foot logs per plot can be used to estimate total bf volume/acre, and here has been rounded to the nearest five bf.

Discussion

It is important to note that as dbh increases and the average number of logs per tree increases, the conversion factor also increases. This is one reason why the quick cruise method may not be as accurate as a full-scale inventory because *users often apply a fixed conversion factor (for all stands) rather than a variable factor* (depending on the average tree dbh and average number of logs per tree). Average dbh and average number of logs are not consistent plot to plot or stand to stand. Forest practitioners often settle on the conversion factor that seems to work for them; 450-500 bf per acre per 16-foot log tallied fits many hardwood stands that have reached the point of financial maturity (trees measuring roughly 18-22-inch dbh), but readers should verify the number themselves.

Applying a price to volumes derived from a quick cruise is challenging, too, since often the logs are not separated by species and grade. These steps are necessary to apply market price and doing so may defeat the purpose of a "quick" cruise.

Conclusion

To reiterate, quick cruising may not be as accurate as a full-scale timber inventory. The consequences of being inaccurate may lead one away from quick cruising. Still, for some there is application with this method. **Quick Cruising is especially useful for a point-in-place estimate of bf volume**. Previous experience with the process of timber inventory is recommended prior to engaging in quick cruising. It may be beneficial to first conduct a full-scale timber inventory, then follow up with a quick cruise to determine the log conversion factor that is best suited to your region and timber type.

Example

Estimating Board Foot Volume Per Acre Using Quick Cruise

This red oak is 20 inches dbh and has 2.5 logs that measure 16 feet each. Using Table 4 and a conversion factor of 480 bf per log suggests this single-tallied tree would represent a total of **1,200** bf per acre (2.5 x 480).

Users may confirm this figure using Table 2 and the Doyle board-foot volume table located in the appendix. In Table 2, each 20-inch dbh tree represents 4.58 trees per acre. The Doyle table indicates that a 20-inch dbh tree with 2.5 logs has 261 bf. Therefore, 4.58 trees per acre x 261 bf per tree = **1,195** bf per acre.

Disclaimer

Quick cruising is a method used by some in the forestry profession to provide a rough estimate of the board-foot volume of standing timber. Users of this method should understand that quick cruising may not produce the accuracy of a more thorough, full-scale timber inventory. **It has very good application for a point-in-place estimate of board-foot volume.**

Reference

Henning, J. and D. Mercker. 2014. PB 1780 Conducting a Simple Timber Inventory. University of Tennessee Extension.

Appendix

Doyle Board-Foot Volume Form Class 78

	Merchantable Height in Logs									
DBH (in)	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5
12	20	29	36	43	48	53	54	56		
14	30	48	62	75	84	93	98	103		
16	40	72	94	116	132	149	160	170		
18	60	100	132	164	190	215	232	248		
20	80	135	180	225	261	297	322	346	364	383
22	100	174	234	295	344	392	427	462	492	521
24	130	216	293	370	433	496	539	582	625	668
26	160	266	362	459	539	619	678	737	793	849
28	190	317	434	551	650	750	820	890	961	1032
30	230	376	517	658	778	898	984	1069	1160	1251
32		441	608	776	922	1068	1176	1283	1386	1488
34		506	700	894	1064	1235	1361	1487	1608	1730
36		581	808	1035	1234	1434	1583	1732	1878	2023
38		655	912	1170	1402	1635	1805	1975	2148	2322
40		740	1035	1330	1594	1858	2059	2260	2448	2636

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