FO-2213 Forest Measurement
Topic 18: Inventories with Point Sampling

Chapter 11

Fixed Area Samples (plots and strip segments):

Fixed area samples sample trees with probability proportional to frequency; i.e. if the sum of the sample areas is 10% then 10% of the trees on a tract are sampled.

The Concept of Point Sampling:

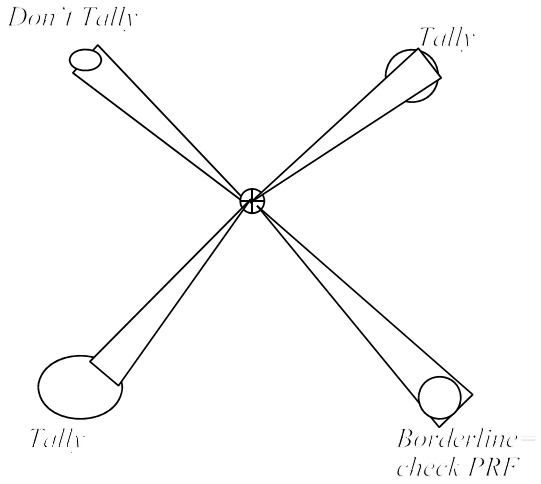
Point sampling is merely a method of selecting trees to be tallied on the basis of their sizes rather than by their frequency of occurrence. Sample "points", somewhat analogous to plot centers, are randomly or systematically located within a forested tract, and a simple prism or angle gauge that subtends a fixed angle of view is used to "sight in" each tree dbh. Tree boles close enough to the observation point to completely fill the fixed sighting angle are tallied; stems too small or too far away are ignored. Thus the probability of tallying any given tree is proportional to its BA, and consequently more time is spent on larger, high-value trees than is the case with conventional strip or line-plot cruising.

The concept of point sampling was developed and first reported in 1948 by Walter Bitterlich, a forest engineer of Salzburg, Austria. The introduction and adoption of the method in North America was largely due to the efforts of Lewis R. Grosenbaugh, a biometrician with the U.S. Forest Service. Grosenbaugh recognized the potential of the angle-gauge idea and expanded it into a complete inventory system that has largely supplanted strip and line-plot cruising in many regions. In the United States, the technique is usually referred to as the Bitterlich system or simply as point sampling. These two terms are more commonly used than variable plot-sampling or plotless cruising.

<u>The Basal Area Approach</u>

BAF is the basal area factor of the “angle-gauge”. Each tree tallied with an “angle-gauge” represents BAF square feet per acre. In essence a fixed angle is used to select trees whose dbh is equal to or larger than the angle.

Thus, In-tree = (tree at a distance) $\leq$ (PRF x dbh) ; where PRF = $8.696 \div (BAF)^{0.5}$



The Stick-Type Angle Gauge

This simple, horizontal angle gauge often consists of a wooden rod with a peep sight at one end and a metal intercept at the other. To establish a sighting angle of 104.18 min. (BAF 10), an intercept 1 in. wide on a 33-in. sighting base can be easily improvised. Regardless of the ratio desired, the sighting base should be at least 24 in. long; otherwise, it is difficult to keep both the intercept and the tree in focus simultaneously.

When the stick gauge is used, all tree diameters larger than the defined angle are counted; those smaller are ignored. Trees that appear to be exactly the same size as the intercept should be checked by measuring their exact dbh and distance from the sampling point. The product of dbh and the appropriate plot radius factor (2.75 for BAF 10) determines whether the tree is "in," "out," or a borderline case. Truly borderline trees are rare, but if they are encountered, they should be tallied as ½ tree.

With a stick gauge, the observer's eye represents the vertex of the sighting angle; hence the stick must be pivoted or revolved about this exact point for a correct tree tally. When properly calibrated for use by a particular individual, the stick gauge may be just as accurate as other more expensive point sampling devices. In dense sapling or pole stands and where heavy underbrush is encountered, the stick gauge is often easier to use than more sophisticated relascopes or prisms.

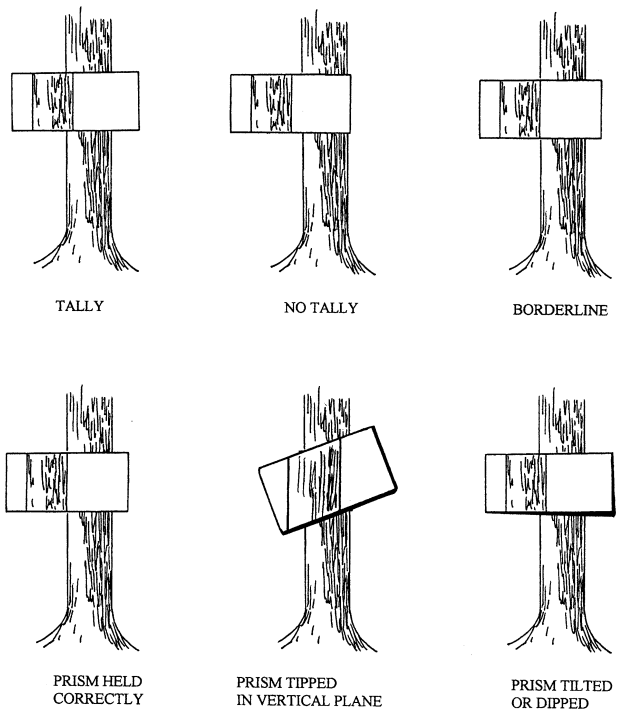
The Wedge Prism

A properly ground and calibrated prism is merely a tapered wedge of glass that bends or deflects light rays at a specific offset angle. When a tree stem is viewed through such a wedge, the bole appears to be displaced, as if seen through a camera range finder. The amount of offset or displacement is controlled by the prism strength, measured in diopters. As one prism diopter is equal to a right angle displacement of one unit per 100 units of distance, a 3.03-diopter prism will produce a displacement of one unit per 33 units of distance, i.e. a critical angel of 104.18 min..

Field use of the prism requires that it be held precisely over the sampling point at all times, for this point and not the observer's eye is the pivot from which the stand is "swept" by a 360º circle. All tree stems not completely offset when viewed through the wedge are counted; others are not tallied. Trees that appear to be borderline should be measured and checked with the appropriate plot radius factor. Do NOT arbitrarily decide to tally every other borderline stem.

The prism may be held at any convenient distance from the eye, provided it is always positioned directly over the sampling point. Proper orientation also requires that the prism be held in a vertical position and at right angles to the line of sight; otherwise, large errors in the tree tally may result.

The wedge prism is simple, relatively inexpensive, portable, and as accurate as other angle gauges when properly calibrated and used. Some sighting difficulties are found in dense stands where displaced bole sections offset into one another, and special corrections must be applied when slopes of 15 percent and greater are encountered. However, the latter disadvantage may be cited for all point-sampling devices except the Spiegel relascope.



The use of a wedge prism for point sampling.

Point Sample Formulae:

Plot Radius Factor(PRF) - the factor a tree's dbh is multiplied by to determine its plot radius

$$PRF = \frac{8.696}{\sqrt{BAF}}$$ = 2.75 for BAF 10

Plot Radius (PR) - a tree must be within this radius to be an in-tree

$$PR = (PRF)(dbh)$$

Plot Size (PS) - the plot size for a tree of specified dbh.

$$Plot\ Size\ (ac) = \frac{0.005454 dbh^2}{BAF} = \frac{ba_{dbh_i}}{BAF}$$

Per Acre Conversion Factor (PACF) - the number of trees per acre represented by a dbh class.

$$PACF = \frac{1}{plot\ size} = \frac{BAF}{ba_{dbh_i}}$$

Basal Area Factor (BAF) - basal area per acre represented by each in-tree

$$BAF = \frac{75.625}{PRF^2}$$

Prism Calibration with target width W and distance D at borderline in same units of measure

$$BAF = \frac{43{,}560}{1 + 4\left(\frac{D}{W}\right)^2}$$

Basal Area Per Acre (BA) - basal area per acre represented by the in-trees at a point

$$BA = (IN\text{-}TREE\ COUNT)(BAF)$$

Per Acre Conversion Factor (PACF) - number of trees per acre represented by an in-tree on a point

$$PACF_{dbh_i} = \frac{BAF}{(Tree\ basal\ area)} = \frac{BAF}{.0054541(dbh^2)} = \frac{183.3483BAF}{dbh^2}$$

Trees Per Acre (TPA) - number of trees per acre in i^{th} dbh class

$$TPA_{d_{dbh_i}bh_i} = (PACF_{dbh_i})(Trees_{dbh_i})$$

Volume Per acre(VPA) - volume per acre in i^{th} dbh class

$$VPA_{dbh_i} = (TPA_{dbh_i})(Tree\ volume_{dbh_i})$$

Average Cruise Intensity = (#points)*(plot size of quadratic mean dbh)/tract size

= (#points)*(ba of mean dbh/BAF)/tract size

Common Basal Area Factors and Angle Sizes used in Point Sampling

BAF English (ft^2/ac)	**BAF** Metric (m^2/ha)	**Angle Size** (Diopters)	**Ratio (tree Diameter to Plot Radius)**	**PRF** English (ft/1in. dbh)	**PRF** Metric (m/1cm dbh)
5	1.15	2.14	1/46.7	3.889	0.467
10	2.30	3.03	1/33.0	2.750	0.330
15	3.45	3.71	1/26.9	2.245	0.269
20	4.60	4.29	1/23.3	1.944	0.233
25	5.75	4.79	1/20.9	1.739	0.209
30	6.90	5.25	1/19.0	1.588	0.190
35	8.05	5.67	1/17.6	1.470	0.176
40	9.20	6.07	1/16.5	1.375	0.165

Sample Point-Sample Computations:
Cruise = BAF 10 prism
Tract Size = 40 acres
Volume equation = $CV_3 = 3.6058 + 0.0026(D^2H)$

Point#	Prod	dbh	height	no.		PACF	Tree/ac	Vol/Tree	Vol/ac	Vol/Pnt
1	Pulp	6	45	2		50.9	101.9	7.8	797	
		8	65	1		28.6	28.6	14.4	413	
		10	75	2		18.3	36.7	23.1	848	2058
	Sawt	12	85	2		12.7	25.5	35.4	903	
		14	90	1		9.4	9.4	49.5	463	
		16	95	2		7.2	14.3	66.9	958	2324
2	Pulp	6	50	1		50.9	50.9	8.3	422	
		8	70	2		28.6	57.3	15.3	874	1296
	Sawt	12	90	2		12.7	25.5	37.3	950	
		14	85	2		9.4	18.7	46.9	878	
		18	95	2		5.7	11.3	83.7	947	2776
3	Pulp	6	45	1		50.9	50.9	7.8	398	
		8	65	1		28.6	28.6	14.4	413	
		10	75	3		18.3	55.0	23.1	1272	2083
	Sawtr	12	85	1		12.7	12.7	35.4	451	
		14	90	2		9.4	18.7	49.5	926	
		16	95	2		7.2	14.3	66.9	958	2335
4	Pulp	6	45	2		50.9	101.9	7.8	797	
		10	75	3		18.3	55.0	23.1	1272	2068
	Sawt	14	85	2		9.4	18.7	46.9	878	
		16	90	1		7.2	7.2	63.5	455	
		18	95	2		5.7	11.3	83.7	947	2280
5	Pulp	8	50	2		28.6	57.3	11.9	684	
		10	75	3		18.3	55.0	23.1	1272	1955
	Sawt	12	85	2		12.7	25.5	35.4	903	
		14	90	1		9.4	9.4	49.5	463	
		16	95	2		7.2	14.3	66.9	958	2324
									Sum	**21499**

Point	Pulp	Saw	Total
1	2058	2324	4381
2	1296	2776	4072
3	2083	2335	4418
4	2068	2280	4349
5	1955	2324	4279
total	**9460**	**12039**	**21499**
Per Acre	**1892**	**2408**	**4300**

	$Pulp^2$	Saw_2	$Total_2$
	4233648	5399001	19194547
	1680899	7704731	16583096
	4339474	5453359	19522110
	4277003	5200533	18909969
	3822407	5399001	18307040
	18353431	29156625	92516761
s^2	113392.1	42761.3	18822.7
s	336.7	206.8	137.2
s_{xbar}	150.59	92.48	61.36
t	2.776	2.776	2.776
se%	22.1%	10.7%	4.0%

Stand and Stock Table Computations: (sort table by dbh and obtain sums by dbh class)

dbh	trees	volume	trees	volume	dbh	Trees/ac	Vol/ac
6	101.86	796.6					
6	50.93	422.1					
6	50.93	398.3					
6	101.86	796.6	305.59	2414	6	61	483
8	28.65	413.3					
8	57.30	874.4					
8	28.65	413.3					
8	57.30	683.6	171.89	2385	8	34	477
10	36.67	847.7					
10	55.01	1271.5					
10	55.01	1271.5					
10	55.01	1271.5	201.69	4662	10	40	932
Pulp						**136**	**1892**
12	25.47	902.7					
12	25.47	950.4					
12	12.73	451.3					
12	25.47	902.7	89.13	3207	12	18	641
14	9.35	463.0					
14	18.71	878.3					
14	18.71	926.0					
14	18.71	878.3					
14	9.35	463.0	74.84	3609	14	15	722
16	14.32	957.9					
16	14.32	957.9					
16	7.16	455.1					
16	14.32	957.9	50.14	3329	16	10	666
18	11.32	947.1					
18	11.32	947.1	22.64	1894	18	5	379
Saw						**47**	**2408**
Total						**183**	**4300**

Final Stand and Stock Table: (the tree and volume sums are the same as those from the basic cruise computations.)

Table 1. Pine stand and stock (cubic feet to 3 inch top, ob) table from BAF 10 cruise on the 40 acre Smith tract in Oktibbeha County, Mississippi.

dbh (in.)	Trees (per acre)	Cu. Ft (per acre)	Trees (40 ac)	Cu. Ft (40 ac)
6	61	483	2,445	19,308
8	34	477	1,375	19,077
10	40	932	1,613	37,298
Pulp	**136**	**1,892**	**5,433**	**75,683**
12	18	641	713	25,656
14	15	722	599	28,869
16	10	666	401	26,630
18	5	379	181	15,153
Saw	**47**	**2,408**	**1,894**	**96,309**
Total	**183**	**4,300**	**7,327**	**171,992**

Comparison of Per Acre Computations from Fixed-Area and Prism Cruises

Fixed-area (strip segments, fixed-radius plots) - constant for all dbh classes; ppf

$$PACF\ (ac) = \frac{1}{plotsize,ac}$$

Prism or point cruise - computed separately for each dbh class; a function of tree size; pps

$$PACF = \frac{1}{plot\ size} = \frac{BAF}{ba_{dbh_i}}$$

The PACF is the only variable that is different between fixed-are and prism or point cruises.
The plot radius/boundary or the BAF angle selects the sample tree with probability proportional to frequency (ppf) or probability proportional to size (pps). Once the appropriate PACF is applied to the tally trees, the computation of trees and volumes on a per acre basis and stand & stock tables are the same for both inventory methods.

Trees per acre = $\sum$ [PACF * (tally trees in dbh_i)] ÷ (no. plots/points)

Volume per acre = $\sum$ [PACF * (tally trees in dbh_i) * (volume per tree in dbh_i)] ÷ (no. plots/points)