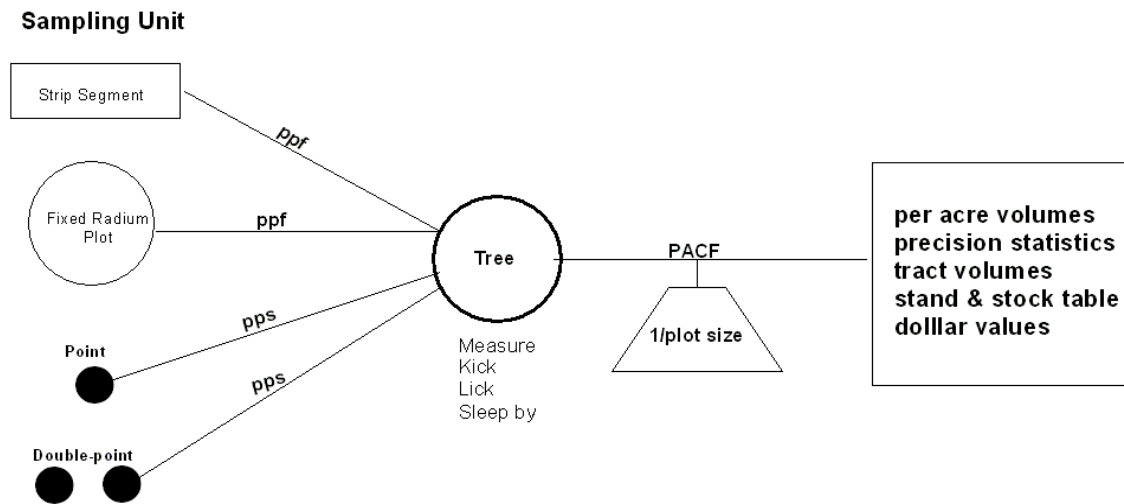


FO-2213 Forest Measurement
Topic 12: Inventories with Sample Strips or Plots

Forest Inventory Procedures



Sample Procedure:

1. Select the sample tree,
2. with probability proportional to frequency (PPF) or to size (PPS)
3. Measure tree attributes (dbh, height, form, volume, etc.),
4. Expand tree volume to per acre basis with Per Acre Conversion Factor (PACF).

1 Chain = 66 feet = 100 links
10 chains² = 1 acre

Chapter 10
Fixed Area Sampling Units

Each sampling unit has a fixed area and shape; i.e. 0.1 acre circular plot, 1 x 2 chain (rectangular) strip segment, 0.2 acre circular plot, 1 x 5 chain strip segment.

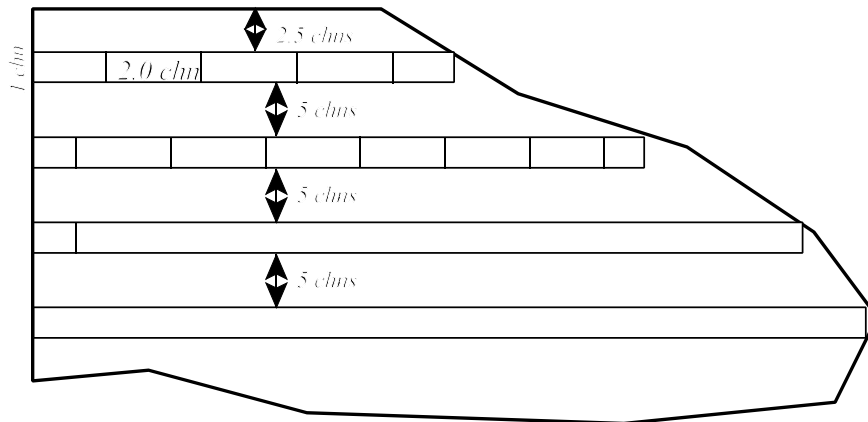
So, a circular plot or a rectangular strip segment of the same size have the same sampling probability; i.e. sampling with probability proportional to frequency of distribution.

Strip Cruise with Segments: (segments allow the computation of precision statistics)

Strip Design: A rectangular strip is W chain wide, spaced every L chains, thus theoretical intensity = $W/L = 1/5 = 20\%$ for 1 x 5 chain segments. First strip is one-half the line spacing interval; thus 2.5 chains for a 5 chain spacing.

Strip segments are, for example, 2 x 1 chain; thus each segment is $2 \times 1/10 = 1/5$ acre. Each strip segment is treated as a rectangular 0.2 acre plot. Half the strip width can be used as a different plot size; i.e. 0.1 acre for a specific product.

The plot is “wrapped around” at the end of a line if the segment length is not reached; i.e. if the end of the strip has 1 chain then the other chain length is tallied on the next strip.



Acres in strips = total length of strip x strip width ÷ 10 chns²/acre

Actual cruise intensity = (acres in strips ÷ tract acres) 100%

Per Acre Conversion Factor (PACF)

Each tree tallied on a strip segment represents (is expanded) to a per acre basis by the factor:

$$\text{PACF for segment strip} = 1/\text{plot size}$$

thus if the strip segment is 0.2 acres then the PACF = $1/0.2 = 5$

The PACF for a non-segmented strip cruise is:

$$\begin{aligned} \text{PACF for non-segmented strip} &= (\text{Length} \times \text{Width})/10 = \text{acres} \\ \text{Per acre volume} &= (\text{volume tallied} \div \text{acres in strips}) \end{aligned}$$

Tree and Volume Computations: (per acre basis)

For a segment strip cruise, each plot tally is expanded to a per acre basis, summed for all the segments, and divided by the number of segments to compute the mean number of trees and volume on per acre basis.

$$trees_i^{th} dbh = \frac{\sum (PACF(trees_{seg\ i}))}{no.\ of\ segments} \qquad trees / acre = \sum trees_i^{th} dbh$$

$$volume_i^{th} dbh = \frac{\sum (PACF(trees_{seg\ i})(volume\ per\ tree))}{no.\ of\ segments} \qquad volume / acre = \sum volume\ i^{th} dbh$$

$$per\ acre\ (anything) = \frac{items\ tallied\ (anything)}{acres\ in\ tally}$$

Statistical Computations: (per acre basis)

Let X_i = the volume per unit measured (per segment, per plot, per acre, etc.), then use standard statistical computations.

$$s^2 = \frac{\left[\sum_{i=1}^n x_i^2 - \bar{x} \sum_{i=1}^n x_i \right]}{(n - 1)}$$

$$s_{\bar{x}} = \sqrt{\frac{s^2}{n} \left(1 - \frac{n}{N}\right)}$$

$$s_{\bar{x}} = \sqrt{\frac{s^2}{n} \left(1 - \frac{n}{N}\right)}$$

$$\bar{x} \pm (t_{\alpha, n-1}) s_{\bar{x}}$$

$$SE\% = \left(\frac{t_{\alpha, n-1} s_{\bar{x}}}{\bar{x}} \right) 100\%$$

$$CV\% = \left(\frac{s}{\bar{x}} \right) (100)$$

Sample Size: the value of N determines finite vs. infinite population size

$$n = \frac{1}{\frac{1}{N} + \left(\frac{AE\%}{t CV\%} \right)^2} \quad \text{where } N = \left(\frac{A}{ps} \right)$$

Sample Strip Cruise Computations:

Cruise specs = 1 x 2 chain segments, pulpwood on the right half of each segment, sawtimber on the full strip width; thus pulpwood on 0.1 ac and sawtimber on 0.2 ac plots.

Tract size = 40 acres

Volume equation = $CV_3 = 3.6058 + 0.0026014(D^2H)$

Seg#	Prod	dbh	height	no.	PACF	Tree/ac	Vol/Tree	Vol/ac	Vol/Plot
1	Pulp	6	45	2	10.0	20.0	7.8	156	
		8	65	1	10.0	10.0	14.4	144	
		10	75	2	10.0	20.0	23.1	462	763
Sawt	12	85	2	5.0	10.0	35.4	354		
	14	90	1	5.0	5.0	49.5	247		
	16	95	2	5.0	10.0	66.9	669	1271	
2	Pulp	6	50	1	10.0	10.0	8.3	83	
		8	70	2	10.0	20.0	15.3	305	388
		12	90	2	5.0	10.0	37.3	373	
Sawt	14	85	2	5.0	10.0	46.9	469		
	18	95	2	5.0	10.0	83.7	837	1679	
	3	Pulp	6	45	1	10.0	10.0	7.8	78
8	65		1	10.0	10.0	14.4	144		
10	75		3	10.0	30.0	23.1	693	916	
Sawtr	12	85	1	5.0	5.0	35.4	177		
	14	90	2	5.0	10.0	49.5	495		
	16	95	2	5.0	10.0	66.9	669	1341	
4	Pulp	6	45	2	10.0	20.0	7.8	156	
		10	75	3	10.0	30.0	23.1	693	850
		14	85	2	5.0	10.0	46.9	469	
Sawt	16	90	1	5.0	5.0	63.5	318		
	18	95	2	5.0	10.0	83.7	837	1624	
	5	Pulp	8	50	2	10.0	20.0	11.9	239
10	75		3	10.0	30.0	23.1	693	932	
12	85		2	5.0	10.0	35.4	354		
Sawt	14	90	1	5.0	5.0	49.5	247		
	16	95	2	5.0	10.0	66.9	669	1271	

Segment Volumes and Statistical Computations:

Segment	Pulp	Saw	Total		Pulp ²	Saw ²	Total ²
1	763	1271	2034		582174	1614578	4135789
2	388	1679	2068		150610	2820450	4274574
3	916	1341	2257		838994	1798008	5093435
4	850	1624	2474		722314	2637150	6119789
5	932	1271	2203		868800	1614578	4852129
total	3849	7186	11035	sum	3162892	10484763	24475717
PerAcre	770	1437	2207				
				CSS	199871.3	158283.5	123202.2
				s²	49967.82	39570.88	30800.55
				s	223.53	198.92	175.50
				s_{xbar}	99.34	87.84	77.50
				t	2.776	2.776	2.776
				se%	35.8%	17.0%	9.7%
				cv%	29.0%	13.8%	8.0%

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

dbh	trees	volume			dbh	Trees/ac	Vol/ac
6	20	156.4					
6	10	82.9					
6	10	78.2					
6	20	156.4	60	474	6	12	95
8	10	144.3					
8	20	305.2					
8	10	144.3					
8	20	238.6	60	832	8	12	166
10	20	462.3					
10	30	693.5					
10	30	693.5					
10	30	693.5	110	2543	10	22	509
Pulp						46	770
12	10	354.5					
12	10	373.2					
12	5	177.2					
12	10	354.5	35	1259	12	7	252
14	5	247.5					
14	10	469.5					
14	10	494.9					
14	10	469.5					
14	5	247.5	40	1929	14	8	386
16	10	668.7					
16	10	668.7					
16	5	317.7					
16	10	668.7	35	2324	16	7	465
18	10	836.8					
18	10	836.8	20	1674	18	4	335
Saw						26	1437
Total						72	2207

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

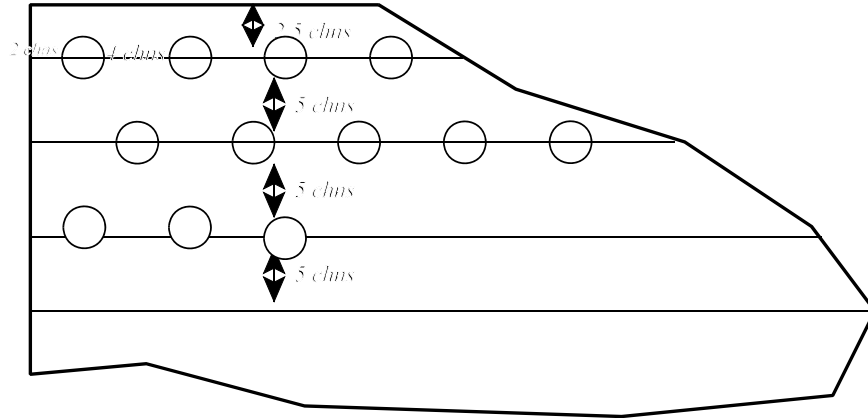
Table 1. Pine stand and stock (cubic feet to 3 inch top, ob) table from 0.2 acre segmented strip cruise on the 40 acre Smith tract in Oktibbeha County, Mississippi.

dbh (in.)	Trees (per acre)	Cubic Ft (per acre)	Trees (40 ac)	Cubic Ft (40 ac)
6	12	95	480	3,791
8	12	166	480	6,659
10	22	509	880	20,342
Pulp	46	770	1,840	30,792
12	7	252	280	10,075
14	8	386	320	15,430
16	7	465	280	18,591
18	4	335	160	13,388
Saw	26	1,437	1,040	57,485
Total	72	2,207	2,880	88,277

Fixed-Radium, Circular Plots:

Cruise Design: fixed-radius, circular plots are spaced P-chains apart on lines that are L-chains apart and cross the topography at approximately 90° angles.

First plot on each line is ½ the plot spacing and first line is ½ the line spacing. The last plot on an individual line is only installed if the entire plot falls inside the boundary.



Plot radius = $[(\text{plot size, ac} * 43,560) \div \Pi]^{0.5}$ from Area = Πr^2 , area = size * 43,560
for 1/5 acre = $0.2 * 43,560 = 9,712$ sq. ft per plot $\div \Pi = (2,773 \text{ sq. ft})^{0.5} = 52.66$ ft

Theoretical sampling intensity = $(\text{plot size, ac}) \div [(P \times L)/10 \text{ chn}^2/\text{ac}] \times 100\%$
Example: $0.2 \text{ ac} / (4 \times 5 / 10) = 0.2 \text{ ac} / 2 \text{ ac} = 0.10 \times 100\% = 10\%$

Acres in plots = (number of plots) x (plot size, acres)

Actual cruise intensity = $[(\text{acres in plots}) \div \text{tract acres}] \times 100\%$
= $[(\text{no. of plots} \times \text{plot size}) \div \text{tract acres}] \times 100\%$

Per Acre Conversion Factor (PACF)

Each tree tallied on a fixed-radius plot represents (is expanded) to a per acre basis by the factor:

PACF for fixed-radius plot = $1/\text{plot size}$
thus if the plot size is 0.2 acres then the PACF = $1/0.2 = 5$

Tree and Volume Computations: (per acre basis)

For a segment strip cruise, each plot tally is expanded to a per acre basis, summed for all the segments, and divided by the number of segments to compute the mean number of trees and volume on per acre basis.

$$trees_i^{th} dbh = \frac{\sum (PACF(trees_{plot\ i}))}{no. of\ plots} \qquad trees / acre = \sum trees_i^{th} dbh$$

$$volume_i^{th} dbh = \frac{\sum (PACF(trees_{plot\ i})(volume\ per\ tree))}{no. of\ plots} \qquad volume / acre = \sum volume\ i^{th} dbh$$

$$per\ acre\ (anything) = \frac{items\ tallied\ (anything)}{acres\ in\ tally}$$

Statistical Computations: (per acre basis)

X_i = plot or per acre volume

Same as for strip cruise.

Sample Size: the value of N determines finite vs. infinite population size

$$n = \frac{1}{\frac{1}{N} + \left(\frac{AE\%}{t\ CV\%}\right)^2} \qquad \text{where } N = \left(\frac{A}{ps}\right)$$

Sample Plot Cruise Computations:

Exactly the same as the computations for the strip cruise, previously shown. Since the rectangular strip segments were 0.2 acres for sawtimber and 0.1 acres for pulpwood, the fixed radius plot could also have a 0.2 ac circular plot for sawtimber and the right-half of the circular plot (i.e. 0.1) used for pulpwood.

Strips vs. Plots

Strips or strip segments sample the variation in timber conditions more thoroughly than do systematically spaced circular plots. Usually a relatively large segment size (e.g. 0.5 ac) will dramatically improve the precision statistics on a cruise over circular plots of 0.2 acre.

Strips contain more boundary length per sampling unit (i.e. segment) than do circular plots and usually require a 2or 3 person team to tally and maintain the strip boundaries. The plot boundary on a fixed-radius plot is easy to check with a DME and 1-person can easily conduct a plot cruise.

Rule of Thumb for Plot/Segment Size

Choose a plot/segment size that will yield 6-15 trees per plot/segment. Plots that sample less than 6 trees will have the within-plot variation mask the between-plot variation. The 15-tree upper number is a logistical count variable; i.e. you loose or mis-tally trees when there are large numbers on a plot.