Field Test of the Area-Free Cruise Method

Conducted in May, 2006 by Ken Lucas & Doug Maxey

The "**Area-Free**" **method** is a cruising technique suggested in chapter 14 of "*A Sampler of Inventory Topics***"**, by Dr Kim Iles, http://www.island.net/~kiles/ We recommend that interested persons read the text on the Area-Free method before reading this report.

The Area-Free method measures the total volume of timber in a polygon when the area is not known. There are many practical cases where it is not feasible, due to cost or time, to determine the acreage of a timber stand. Both the usual Variable Plot and Fixed Plot cruise methods require area to calculate volume. The Area-Free method offers a solution to the problem of cruising a stand without having to determine its area, and at the same time it exactly corrects for any edge-effect. The difference from a standard systematic sample is this :

1) You do not measure the stand area, because in essence the number of plots implies an area from the grid size you used. A time savings.

2) You do not worry about edge-effect, since the extra plots outside the tract handle that correctly. A savings and an exact edge-effect solution.

3) You need to visit extra plots – extra effort and time is needed for that.

Our Test : In order to field test the Area-Free method, we selected an 8-sided polygon of timberland, which we knew to be 27.1 acres in size. The boundaries of that unit were clearly flagged and we had earlier determined the exact acreage of the unit by a perimeter traverse. The polygon was prepared as a timber harvest unit on private timberland in the redwood region of northern California. The harvest unit is located on a flat ridge top and is bisected by a seasonal logging road. The acreage of the unit did not include the road right-of-way or a small lake that was typed out. The timber stand was a mix of young growth Redwood & Douglas-fir trees, approximately 70 years old. The question was "could we get an accurate volume without knowing the stand area?"

The landowner required a Variable Plot cruise of the stand. For the control cruise we completed 15 plots on a 4X4 chain systematic grid, and the Area-Free method required another 10 plots outside the area. All the results were compiled with SuperAce, but any compiler could calculate the answer with either method.

Methods used during the cruise :

- We used a combination of laser distance shots and pacing to get the appropriate spacing between plots. We checked our pacing across the length of the unit and determined that the distance traveled was 30' longer than it should have been with 1 degree of angular error in the 1,300 foot length of the unit.

- We cruised the first several plots with a 71.1 BAF and at that point felt that our average tree count per plot might end up being too high, so we switched to a 90 BAF. However, the decision to use the 90 BAF was made before we arrived at our next plot.

- We used a 360 BAF to select about 1 out of every 4 "in" trees for measurement. We measured only one Grand Fir and one Old Growth Redwood tree during the cruise, as these species were rare in the stand. We took the precaution of measuring the first tree "in" with the small BAF for any rare species.

- We did not cruise for hardwood trees or snags. The main species encountered and measured during the cruise were Young growth Redwood and Douglas-fir.

- We created 2 cruise files in the SuperAce compiler: "Area Free" and "Control".

- The "Walkthrough" method was employed for trees near the edge of the stand on the control cruise. See Chapter 14 of "*A Sampler of Inventory Topics*" for this procedure. No correction at the boundary was done for the Area-Free method, since edge-effect is not a problem with that method. We only counted trees we knew to be inside the unit.

- 3 of the plots that fell outside of the unit boundary but counted "in" trees within the unit from those sample points. For the Area-Free cruise, we recorded any trees that fell inside the unit boundary, no matter where the sample point fell. Trees outside the unit boundary were ignored with both methods.

- In the Area-Free cruise we had 7 plots that were outside the unit that were zero-count plots, meaning that no trees *inside* the unit were seen from those plot centers. We would need to visit these plots if we were not absolutely sure that no trees would be seen from these positions.

An imaginary 40 acre square with our cruise unit contained inside it would have 25 sample points (1.6 acres per point). 15 fell inside the unit, 3 outside the unit found at least some trees, and 7 more had a tree count of zero.

- Once the Area-Free" & "control" files were set up in the compiler, we ran the cruise and used the following formulas to calculate the unit volumes:

Control volume / acre * the accurate acreage [1] = control gross volume.

The sampling error for the control cruise was ± 20%, at t=1 (68%) standard error.

Area-Free volume / acre * 40 acres = "Area-Free" gross volume.

Table of Results :

Cruise Project	Per Acre Volume, Gross	Number of Plots in cruise	Assumed Acres	Calculated Volume	Difference
Control	90,525	15	27.10	2,453,228	
Area Free	55,070	25	40.00	2,202,800	**-10.3%**

Summary of Results :

- This difference of -10.3% is due to several reasons.

[1] This accurate area was determined by our perimeter traverse.

1) **Sampling error** – since both of them are estimates, they both have a sampling error, but they should be similar answers since they both used many of the same sample points. The control cruise had 9 trees duplicated by the walkthrough method to adjust for edge-effect, while the Area-free method added 7 trees from outside plots to correct for the edge effect. The zero-count plots would not have an affect on the total volume result.

The second reason for sampling error is how the grid falls over the area. In this case we expected about 17 plots inside the unit (27.1 acres / 1.6 acres per plot) and this is where we expect the larger tree counts to occur. In fact, only 15 plots fell into that 27.1 acre area, which would probably lead to a smaller estimate.

2) **Field Work error** – The Area-Free method *should* have a bit more variability in it because the area was not known. Apparently, this did not amount to much of a difference. The important point is that the results are very similar. There is no theoretical error with the Area-Free method, so the only issue is whether there is any practical error due to field work.

Calculating the volume for the Area-Free method is done under the assumption that you know the area represented by each sample point. In this case, it was 1.6 acres per point. When there is error in the actual grid distance between sample points it will result in a bias. If a cruiser paces long, then this would result in more area per point and fewer points inside the assumed area. The total plot count would therefore be smaller, and the volume lower. If the cruiser short-paces, the reverse bias occurs. **Good distance control for the grid is important to the process**. We therefore recommend the following options for insuring the correct grid spacing and number of plots:

a) Employ a laser distance device and exercise more care when taking compass shots and while moving between plots.

b) Errors may be minimized by employing a tighter plot grid, and more plots would minimize any variability, as with any sampling system.

c) Dr Iles also offered this suggestion: If ground conditions are favorable to the use of GPS, each cruiser could collect some GPS data at the start of his cruise line at a point just outside the stand. After traveling the length of the stand, the cruiser could collect some more GPS data to get the total line length. Then, the cruiser could calculate a correction ratio as follows:

$$(\text{Actual distance} / \text{Assumed distance})^2 = \text{Correction Ratio.}$$

Apply this ratio as an adjustment factor to the cruise volume to correct the for the area per point. With a +30' error in 1,300' (estimating it as 1,270'), the distance between plots was (1,300/1,270) or 1.02362 times what it should have been, the final answer should be corrected by multiplying by $1.02362^2 = 1.0480$, or a +4.8% increase in total volume. This correction would explain some of the difference and leads to a volume of 2,308,098 and is now a -5.9% difference from the control.

When 7 extra plots were added to the control plot on an independent 6X6 chain grid to improve the control volume estimate, the volume changed to 2,305,641 and was virtually identical to the corrected Area-Free result.