P-3-P LIMITING DISTANCE SELECTION STUDY

Cruising research conducted by Ken Lucas and Len Nielson in the Redwood Region of Northern California
Theory suggested by Dr. Kim Iles
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STUDY GOAL: Reduce the sampling error on variable plot cruises of highly variable Redwood timber stands by **increasing the cruise intensity** over the area standard of one plot per acre, **without significantly increasing the field time** (and expense) required to cruise the stands. The improved cruise procedure must be able to be effectively executed by less experienced, seasonal timber cruisers, as well as experienced cruisers.

THEORY: **Dr. Iles** has suggested that basal area per acre could be more variable than V-BAR, which is tree volume / basal area. We agree with this idea and feel that more effort should be shifted toward capturing basal area variability in redwood stands, rather than V-BAR variability.

Since we are striving to develop more accurate cruises for the same or less cost, we must achieve an optimal balance of our field cruise measurements. The standard field cruise time must be budgeted to gain the optimum balance between more plots and full tree measures. The "**STAR_BAR.xls**" Excel program in Dr. Iles book, "**A Sampler of Inventory Topics**", is very effective at doing general measurement balancing in the planning phase of a cruise.

In this study, we wanted to look at the possibility of reducing the number of plots recommended by the various runs through "**STAR_BAR.xls**" even further, while still achieving an acceptable level of accuracy for these Redwood stands. We decided to make a detailed evaluation of the time required for the various cruise measurements and try to find ways to cut some corners, using the advanced equipment and software available to us. **Saving some time by not doing unneeded measurements would allow us to spend it increasing the plot intensity.**

REQUIRED CRUISE MEASUREMENTS:

Our existing cruise procedure specifies that we do limiting distance checks on every plot that we encounter borderline "in/out" trees on and that we average 1.5 full tree measures on every plot. We've already adopted an alternative method to the usual method of measuring every tree "in" on the plots, by using one of the large BAFs offered by the Relaskop, such as 250, to select which "in" trees to do the full measurements on. This "Big BAF" selection method is a major time-saver in of itself. Still, using our existing procedure, it normally requires approximately 25-35 minutes to complete a plot, including the walk between plots. Cruise measurements include-

1. Limiting distance measure checks on trees that appear "borderline in/out" when sighted with a relaskop. Conventional cruising thought makes the claim that this is the single most important measurement in a variable plot cruise; that accurately determining "in/out" trees have a great affect on capturing the variability of basal area per acre, which, in turn affects the V-BAR, from which the volume per acre is calculated. Doing the limiting distance checks in clumpy, brushy Redwood stands can consume as much, or more of the field time budget as the full tree measures. One or

more of these checks are often required on every plot. These checks probably take up 33% of our plot time.

2. Determining tree DBH, using either a diameter tape or Biltmore stick.
DBH is an important measurement, since the cruise compiler we use, SuperAce, can extrapolate a volume for a DBH-only data entry; in contrast to entering only a tree count, for which the program will not calculate a volume per acre. Standard procedure is to make this measurement for all of the trees on every plot, except the occasional hard-to-access tree, for which the DBH is simply estimated. Getting the tree DBHs probably take up 12% of our plot time.

3. Full tree measure, including- form factor, bole height, and sort & defect by log position. Full tree measures are a series of important measurement, as they allow the cruise compiler to calculate the volume for all of the DBH-only tree entries. Also, these measurements provide log product data, important to the client. The usual procedure is to average 1.5 full tree measures per plot, using the "Big BAF" selection method. These full tree measures consume the largest part of the field time budget, they probably account for up to 40% of our plot time.

4. Accessing the plots. Moving the distance between plots (3 chains, if doing a one plot per acre intensity) consumes a significant amount of the field time budget. Moving between plots probably takes up 15% of our plot time. We'd like to recover some of the use of this wasted travel time by stopping more often to do plots.

OUR SPECIFIC PROPOSALS:

1. Do limiting distance checks on only those plots selected by a **3-P weighted random sample** selection program installed on a small handheld data collector, such as a palm pilot, Trimble Recon, or like device.
2. Reduce, as much as possible, the amount of full tree measures done in the cruise.

Use the time saved through these "short cuts" to complete additional plots while moving on the grid only between the primary plots.

SPECIAL TOOLS. These tools are absolutely required to achieve the time-savings critical to accomplishing the goal of this study:

1. The **SuperAce (ACE)** cruise compiler, marketed by **Atterbury Consultants**,
2. A 3-P program, such as the one written in Excel by Len Nielson.

The 3-P program file only serves 2 functions-

1) To make a weighted random selection. We feel that the higher tree count plots are the ones where a cruiser is most likely to miss or add trees to a variable plot count. It is necessary, therefore, for the selection program to make both a random and weighted selection, so that the higher count plots will have a higher probability of being selected.

2) To record the plots actually selected for sampling during the cruise.

The program is used during the cruise by entering a DBH for each "in" tree on the plot; the program then calculates the basal area of each tree, sums the basal area for the plot, and does a 3-P selection. For this test we specified in the program that we wanted a 33% sample of the plots. Since the program selects samples in a random fashion, we ended up with 15 of the 30 plots, a 50% sample, selected in this run. Some of these samples could have been held as “reserve” plots, in the event we felt the initial adjustment ratio to be too high.

3. A handheld data collector, such as the **Trimble Recon** we used, to install and run the 3-P program on. We are not aware of a 3-P program that will run on the CMT data collector.

5. A ratio adjustment calculation spreadsheet written in Excel.

6. A CMT data collector, loaded with the timber cruise data collection program, **SuperEasy**, marketed by Atterbury Consultants.

7. An **Impulse 200 laser hypsometer**, marketed by LaserTech. This tool is absolutely critical for saving time by both permitting the accurate distances required for limiting distance checks and getting tree heights.

TEST PROCEDURE. We selected a 4-acre young-growth redwood stand, for which a 100% cruise inventory had been previously completed on, to use as our study stand, because it would serve as an accurate base control. We had one experienced cruiser, Ken Lucas, complete 30 plots in the stand on a 1 chain spacing grid. Completing the 30 plots required 6.25 hours. A 15-plot cruise in the Redwoods, employing the existing cruise procedures, normally takes about 6 hours for one man to complete.

In the field:

1. Once on plot, each tree in the immediate vicinity was examined through a relaskop and an estimate made by Ken if the tree was “in” or “out” on the plot. Borderline “in/out” trees were noted, but not checked, at this point.

2. A full measure was done on the tree closest to plot center, including taping the DBH with a diameter tape to the nearest one inch. We opted not to use the “Big BAF” selection method for this study in order to determine if we could reduce the number of full tree measures without decreasing the cruise accuracy.

3. All other trees estimated “in” on plot had their DBHs measured with a Biltmore stick or just estimated by Ken. Ken used this opportunity of walking out to measure the DBHs to scan the area for hidden “in” trees; it’s important to make every effort to classify trees “in” or “out” prior to entering the DBHs into the 3-P program. All full measure data and DBHs were entered into the SuperEasy cruise collection program on the CMT.

4. The measured DBHs of each “in” tree were then entered into the 3-P selection program on the Trimble Recon. If the plot was selected by the program, Ken did limiting distance checks on all earlier determined “borderline” trees. The 3-P program is a “live” program, with the sample selections changing every time a “+” is entered into the “plot completed” column; so it’s necessary to note which plots were selected for sampling in the “plots selected” column.

The limiting distance checks included determining the distance to the face of the tree to the nearest tenth of an inch, taping the DBH of the tree to the nearest tenth of an inch, and doing the calculation:

Maximum horizontal distance allowed = DBH * Plot Radius Factor

If there was a tree count discrepancy after making the limiting distance checks, the DBHs were added or subtracted from the data file in the CMT only. The data file in the Trimble Recon was **not corrected following the limiting distance checks.** The 3-P program file only serves 2 functions:

1. To make a weighted random sample.
2. To record the plots actually selected for sampling.

Back in the office:

1. Download the CMT SuperEasy cruise and Trimble 3-P data files into a desktop pc, also loaded with the adjustment ratio calculation spreadsheet.
2. Edit the mistakes out of the main Ace cruise file.
3. Run and print out copies of the Ace plot tree, plot tree volume, statistics, and species volume lists. **The plot tree list is the hardcopy record of the field data.**
4. Using the 3-P spreadsheet downloaded from the Trimble Recon or other data collector:
   1) Note and write down the numbers of all plots selected for limiting distance **samples** on a piece of paper.
   2) Refer to the 3-P spreadsheet:
   Compare the ACE file plot tree list to the 3-P spreadsheet, listing the DBHs, to determine which tree DBHs need to be added or subtracted from the ACE plot tree list. Remember, the main Ace file plot tree list includes the sample plots where the tree count discrepancies were corrected on the sample plots in the field; it will be necessary to change these corrections to calculate an adjustment ratio later. For any plots on the spreadsheet that do not have the same tree count as the plot tree list write down the plot number and DBH of the trees that will have to be added or subtracted later from the main Ace cruise file on a piece of paper. This becomes the "tree correction list".
5. Select the sample plots in the main Ace cruise file; the ones that had limiting distance checks done for them. Copy only these plots into a separate Ace file named "correct".
6. Run and print out the plot tree list-volume report for the "correct" file.
7. Copy all of the plots from the "correct" file into a new ACE file named "uncorrect".
8. **Add or subtract the tree DBHs in the tree edit mode of the "uncorrect" file as directed by correction list made earlier.**
9. Run & print out the plot tree list- volume reports for the "uncorrect" file.
10. Open the adjustment ratio calc spreadsheet and enter the following data:
    1) Referring to the plot tree list-volume reports for both the "correct" and "uncorrect" files- enter the plot Net Volume (Bd-Ft) per Acre by plot for both the uncorrected and corrected sample plots.
    2) Referring to the main Ace file plot tree list-volumes report - enter the plot Net Volume (Bd-Ft) per Acre for the **estimate** plots only.
11. The adjustment ratio calc spreadsheet should follow the calculation procedure-
    1) The adjustment ratio =
    Correct volume per sample plot / uncorrect volume per sample plot
    3) Average the adjustment ratios for all of the sample plots.
    4) Calculate the Average, SD, CV, and SE of the adjustment ratio. The SE of the ratio should be lower than 5% to insure that enough limiting distance samples were taken. If the SE is still too high, more plots will have to be sampled.

    5) Adjusted volume per plot =
    Average adjustment ratio * the estimate volume per plot
    6) Then calculate the final adjusted average volume per acre:
    average all of the volumes per plot, including the corrected sample plots and the adjusted estimate plots.

14. Refer to the main Ace cruise file species volume report to obtain the accurate species composition percent. To determine the volumes by species per acre or for the stand:

(Species composition percent / 100) * the adjusted average volume

15. Refer to the main Ace file statistics report to evaluate the net volume SE to verify that enough plots were taken.

OUR EXPERIMENT RESULTS:

To determine the most optimum blend of cruise measurements, we need to examine these results to determine the accuracy "thresholds"; which are cruise measurement combinations where the error of the cruise verses the base control volume per acre and/or the SE reaches an unacceptable level. These "thresholds" tell us how far we can push our shortcuts and maintain a "comfort level" with the cruise accuracy.

We have confidence in the base control stand, because:

1. Each tree was marked immediately after it was counted and measured.
2. Len carefully measured the acreage by traversing the unit.
3. The DBH of each tree was taped or checked with a Biltmore stick and the heights were all measured with an impulse hypsometer.
4. The CV of this stand was calculated to be 63%; this is just a little under the 67% CV that we often see in our cruises of Redwood stands in this area. This can, therefore, be considered a typical CV for timber stands in this area.

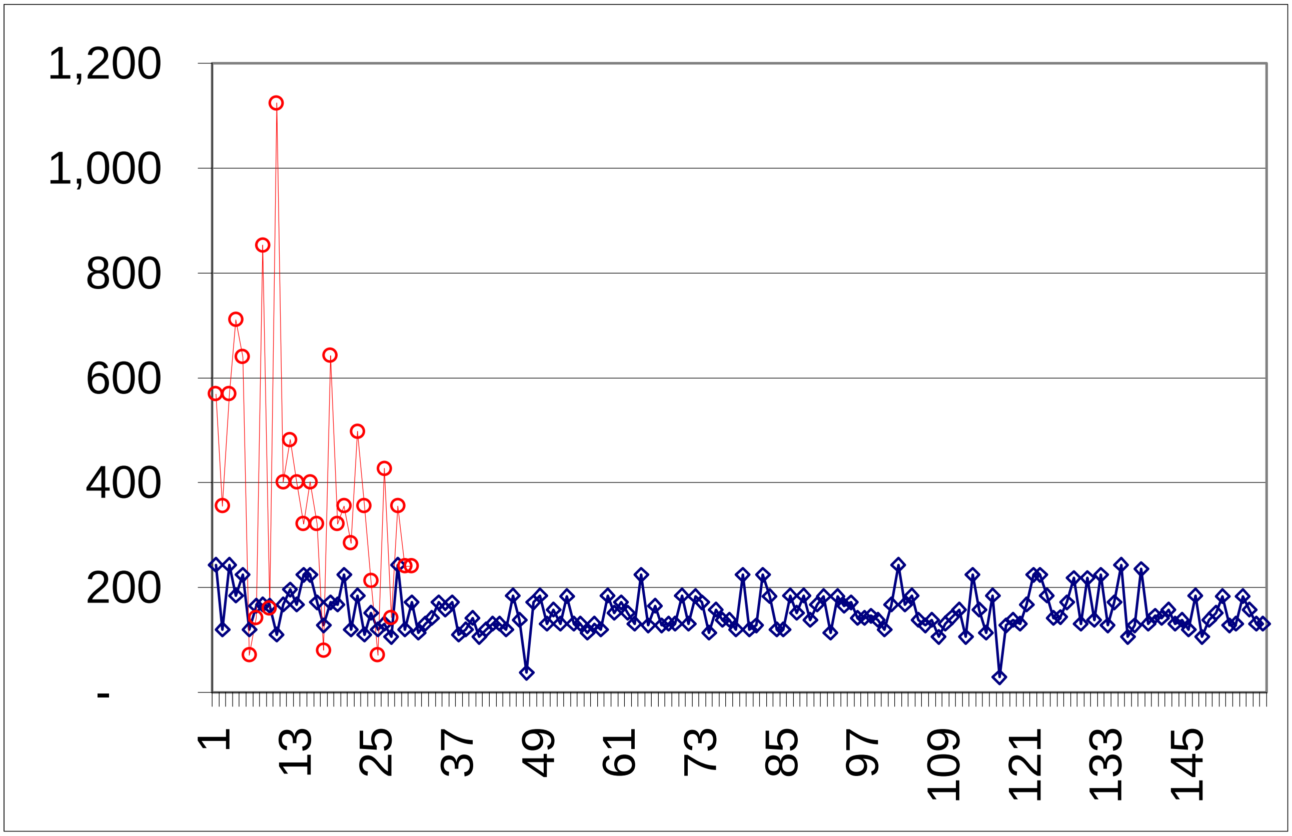
Dr. Iles calculated the individual and combined statistics of the two cruise components for the 30 plots; basal area (count trees) and V-BAR (full tree measures). The combined standard error was calculated using "Bruce's equation. The combined SE is 11.1%. Notice something interesting when we break out the individual SEs:

V-BAR Standard Error= 2%

Basal Area Standard Error= 9%

The basal area is clearly contributing way more error to the cruise than the V-BAR (full tree measurements).

Dr. Iles then thought it would be helpful to graph the two components. This graph displays the experiment's **basal area variability (red)** and **V-BAR variability** (blue):



Notice the extreme “peaks” and “valleys” on the red graph (the different basal areas, or tree counts, graphed for all 30 plots). Major variability from plot to plot. Now notice how relatively stable the blue graph (the average V-BAR of each plot). We could draw two conclusions from this graph:

1. We need to take a lot of plots in these THP units in order to lower the basal area sampling error, and thus the overall sampling error.
2. We could take less full tree measures on each plot, if necessary to save time, since the V-BAR does not appear to be that variable.

This study allowed us to calculate a Net V-BAR/Height ratio that could be used in a calculation to make an estimate of net volume per plot for entry into a P-3-P program:
Tree Net V-Bar= Bole Height * 1.59
Average plot V-BAR= Average all of the net V-BARs on the plot
Estimated Volume= (Tree Count * BAF) * Ave V-BAR for trees on that plot

The tree counts did not balance on 3 plots out of the 15 in the test cruise that limiting distance check samples were done on. The mistakes included-
1. added a 19” tree. This tree was behind another tree in a clump and no clear view of it was available.
2. missed a 13” tree. There was a clear view of the tree from plot center, but the tree was not cylindrical shaped and the side facing the plot appeared smaller in the relaskop.

3. missed a 19" tree. This tree was at the back of a clump, with a very poor view from anywhere near plot center; it was even difficult getting a straight horizontal distance measure during the sampling effort.

Our formulas for calculating the volume error potentially introduced into the cruise by the net miscount of one tree:

Correct Tree Count(156) / Net Incorrect Tree Count(155) = 1.0065% Less than 1% potential volume per acre error. The following calculations are used to determine the incorrect tree count error vs. the base control volume:

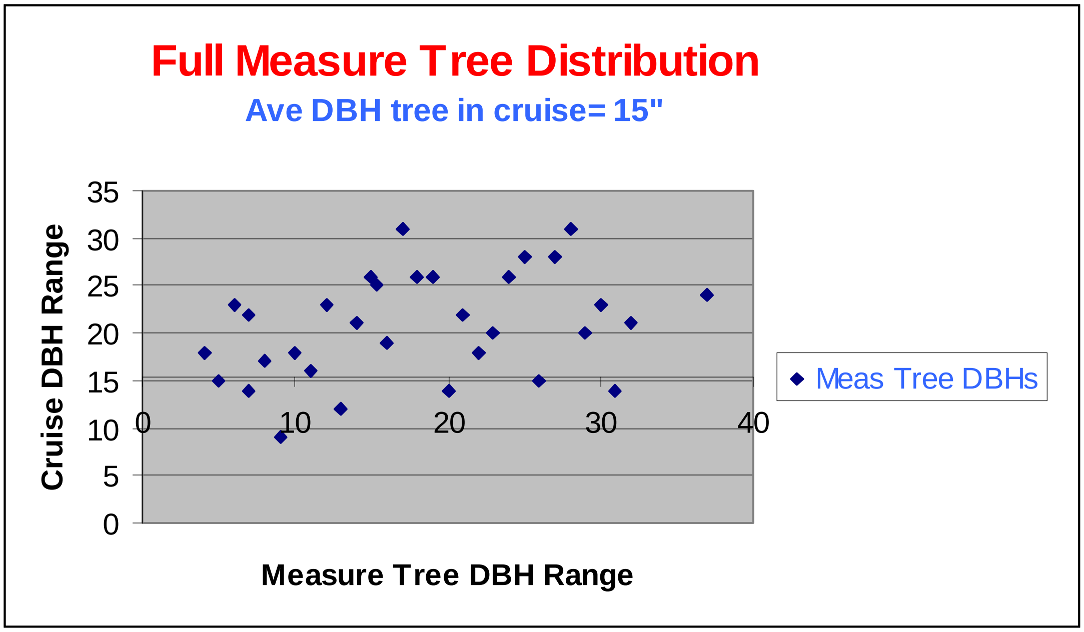
Plot Spacing (66')^2 / 43,560 = 0.1 acres per plot

Net one missed tree * BAF used (80.3) * Ave V-BAR of a 19" DBH(141) * acres per plot (0.1) = 1,132 bd-ft total tract volume error

1,132 bd-ft is 0.4% of the base control tract volume. So, doing limiting distance checks on only half the plots at this high sample intensity appears to have contributed only a very small amount of error.

Here's the effect of missing a tree on a **plot intensity of 1 per acre:**
One missed tree * BAF (80.3) * Ave V-BAR of a 19" DBH (141) * Acres per Plot (1) = **11,322 bd-ft or 4.4% of the total tract cruise volume.**
Tighter plot spacing appears to greatly reduce the effect of missing trees on cruise accuracy.

Rather than use the conventional procedure of taking full tree measures on all those trees found "in" on plot by the Big BAF, we used a protocol of measuring only the closest tree to plot center and one each of the rare species encountered during the cruise. We felt it was important to get a more even distribution of measured trees throughout the stand. Using this alternate method of selecting full tree measures, we wanted to insure that we were getting enough full tree measures of the larger DBH-size trees; which contribute more to the volume of the cruise than the smaller trees. The average size tree in this cruise was a 15.3" DBH. The volume per acre distribution is 22% for trees with DBHs of 15" or under and 78% for trees larger than 15" DBH. The following graph confirms that we did measure a greater percentage of larger diameter trees:



The following tests are things we tried in our effort to find the best blend of cruise measurements and time. The "error" in the tables refers the amount of volume that the test method is off of the base control volume. The first 6 tests reflect what the experienced cruiser was able to achieve, **without making any adjustments to the volume per acre -**

Test 1. The unadjusted volume per acre achieved by the experienced cruiser doing 30 plots, with limiting distance checks on 15 of them and one full tree measure on each plot (total 30). **30 cruise plots, 15 limiting distance check plots, & 30 full tree measures**				
Method	Net Vol. per Acre	Error	SE	Time
Test 1	63,744 BF	Less than 1%	11.2%	6.75 Hr.s
Base Control	63,837 BF	N/A	N/A	65 Hr.s

The questions we have after reviewing this test:

- How was the cruiser able to achieve such a small error without making any adjustment to the volume?
- Do we even need to consider using a sample adjustment method at all?

Some points on these questions:

- We used a unusually high plot intensity for this experiment, allowing more effective capture of the basal variability; which contributes the most error to a cruise.
- Note the 11.2% SE achieved. This means that we are only 68% sure that the actual volume is within +/- 7,100 bd-ft of the calculated cruise volume; which, in this case, it is; but normally we would not have a base control volume to confirm our accuracy. Please note later in this section, that the ratio SEs of the adjusted volumes show a lot tighter variance range.
- The cruiser required a 3-P program to select the 15 plots to do the

limiting distance checks on.

- This test does not confirm how less experienced, or less conscientious cruisers would do.

Test 2. The unadjusted volume per acre achieved by the experienced cruiser doing only half (15, randomly selected) of the specified number of plots (30), with limiting distance checks on only half of these plots (7) and a full tree measure on each plot(15)
15 cruise plots, 7 limiting distance check plots, & 15 full tree measures

Method	Net Vol. Per Acre	Error	SE	Time
Test 2	63,342	Less than 1%	14.3%	3.4 Hr.s
Base Control	63,837	N/A	N/A	65 Hr.s

The 14% SE achieved in this test is common for these 15-plot THP unit cruises, using the existing PL cruise procedure. We are uncomfortable with an SE that high, since we are only 68% sure that the true volume could fall anywhere within the range 54,284-72,400 bd-ft per acre.

Test 3. The unadjusted volume per acre achieved by the experienced cruiser doing 30 plots, with limiting distance checks on just 33% (10) of the plots and full tree measures on all of them.
30 cruise plots, 10 limiting distance check plots, & 30 full tree measures

Method	Net Vol. Per Acre	Error	SE	Time
Test 3	63,447	Less than 1%	11.2%	6.2 Hr.s
Base Control	63,837	N/A	N/A	65 Hr.s

Test 4. The unadjusted volume per acre achieved by the experienced cruiser doing 30 plots, with 33% (10) limiting distance samples and full tree measures on 83% (25, randomly selected) of the plots.
30 cruise plots, 10 limiting distance check plots, & 25 full tree measures

Method	Net Vol. per Acre	Error	SE	Time
Test 4	60,839	-4.7%	11.5%	5.8
Base Control	63,837	N/A	N/A	65 Hr.s

Test 5. The unadjusted volume per acre achieved by the experienced cruiser doing 30 plots, with 33% (10) limiting distance samples and full tree measures on 66% (20, randomly selected) of the plots.
30 cruise plots, 10 limiting distance check plots, & 20 full tree measures

Method	Net Vol. per Acre	Error	SE	Time
Test 5	66,761	+4.6%	11.6%	5.4 Hr.s
Base Control	63,837	N/A	N/A	65 Hr.s

Test 6. The unadjusted volume per acre achieved by the experienced cruiser doing 30 plots, with 33% (10) limiting distance samples and full tree measures on 50% (15, randomly selected) of the plots. **30 cruise plots, 10 limiting distance check plots, & 15 full tree measures**				
Method	Net Vol. per Acre	Error	SE	Time
Test 6	39,476	-38.2%	9.5%	4.9 Hr.s
Base Control	63,837	N/A	N/A	65 Hr.s

We've crossed an accuracy threshold on this test method. Taking one full tree measure on every other plot only will give us unacceptable accuracy.

Test 6. The unadjusted volume per acre achieved by the experienced cruiser doing 30 plots, with no limiting distance check and full tree measures on every plot. **30 cruise plots, no limiting distance check plots, & 30 full tree measures**				
Method	Net Vol. Per Acre	Error	SE	Time
Cruiser	63,430	Less than 1%	11.3%	5
Base Control	63,837	N/A	N/A	65 Hr.s

After reviewing this test and noting earlier that the basal area of the miscounted trees represented less than 1% of the total basal area cruised, we can, therefore, suggest that experienced cruisers could do less limiting distance checks in these PL THP cruises, without reducing the accuracy an excessive amount. However, cruisers should still have the flexibility to do limiting distance checks in situations where they can not get a clear view of the "borderline" tree, even after moving well off plot center.

Since it is statistically more efficient to sample for adjustment ratios than to sample for measurements, we wanted to employ a 3-P program to select plots to sample; so that we could obtain adjustment ratios. Correct plot volumes / estimated plot volumes. We calculate that it is 50 times more efficient to do statistics for the ratios in these tests than to do statistics on the measurements directly. In other words, the adjustment ratios are far less variable than the sample volumes, allowing us to have more confidence in our ratio-adjusted volume figures.

The following 5 tests were made with ratio adjustments to the plots that had no limiting distance checks done on them (the estimate plots):

Test 7. The proposed P-3-P limiting distance sample method, without any shortcuts. **30 cruise plots, 15 limiting distance check plots, & 30 full tree measures**				
Method	Net Vol. per Acre	Error	Ratio SE	Time
Test 7	60,486	-5.2%	1.5%	7.75 Hr.s
Base Control	63,837 BF	N/A	N/A	65 Hr.s

A ratio SE of 1.5% means that we are 95% sure that the actual volume per acre should fall within the range 59,304-63,123 bd-ft

Test 8. The proposed P-3-P limiting distance sample method, with a reduction of the number of samples to 33% of the total plots taken(10).

30 cruise plots, 10 limiting distance check plots, & 30 full tree measures

Method	Net Vol / Acre	Error	Ratio SE	Time
Test 8	59,891	-6.2%	1.6%	7.75 Hr.s
Base Control	63,837 BF	N/A	N/A	65 Hr.s

With this ratio SE of 1.6%, we are 95% sure that the actual volume will be within +/- 2,010 bd-ft of the adjusted volume per acre.

Test 9. The proposed P-3-P limiting distance sample method, with a reduction of the number of samples to 17% of the total plots taken(5)-

30 cruise plots, 5 limiting distance check plots, & 30 full tree measures

Method	Net Vol. per Acre	Error	Ratio SE	Time
Ratio Adjust.	57,779	-9.5%	2.1%	7.2 Hr.s
Base Control	63,837	N/A	N/A	65 Hr.s

Test 10. The proposed P-3-P limiting distance sample method, with samples on half the plots (15) and full tree measures taken on 66% (20) of the plots.

30 cruise plots, 15 limiting distance check plots, & 20 full tree measures

Method	Net Vol. per Acre	Error	Ratio SE	Time
Ratio Adjust.	60,662	-5.0%	1.6%	7 Hr.s
Base Control	63,837	N/A	N/A	65 Hr.s

Test 11. The proposed P-3-P limiting distance sample method, with samples on half the plots (15) and full tree measures taken only on 50% (15) of the plots.

30 cruise plots, 15 limiting distance check plots, & 15 full tree measures

Method	Net Vol. per Acre	Error	Ratio SE	Time
Ratio Adjust.	48,643	-23.8%	2.2%	6.5 Hr.s
Base Control	63,837	N/A	N/A	65 Hr.s

We have crossed an accuracy "threshold" with this method. A 23.8% error is excessive.

For this next test, we wanted to see the effects on accuracy if we deliberately introduced serious basal area error into the cruise to simulate an inexperienced or unconscientious cruiser getting sloppy doing his tree counts. We changed the tree count on every third plot in the Ace cruise file. On 66% of the artificial miscount plots we deleted a tree and on the remaining 33% of the miscount plots we added a tree.

Test 12. Introduction of tree miscount of 33% of the plots.

30 cruise plots, with 10 plots that have missing or added trees

Method	Net Vol. per Acre	Error	Ratio SE	Time
Test 12	62,057	-2.8%	11.4	3.75 Hr.s
Base Control	63,837	N/A	N/A	65 Hr.s

Surprisingly, introducing tree count error appears to have had a noticeable, but not a major, adverse effect on the volume. We think the volume error is being significantly mitigated by the close spacing of the plots; bear in mind that we did 30 plots in a 4-acre area.

Summary points:

- **The cruiser was able to complete double the amount of plots in the same amount of time;** this was accomplished by doing less limiting distance checks and taking only 1 full tree measure on every plot. This study proved that cruise time can be budgeted to allow doing the additional plots required to capture the basal area variability.
- The cruise basal area figure, gained from making tree counts, is far more variable than V-BAR figure, gained from making full tree measures. More effort should be made in cruises to reduce basal area error by doing more plots.
- Selecting the closest tree to plot center to make a full tree measure on does not seem to result in an unacceptable DBH measure distribution; it does, however, allow a more even distribution of measure trees throughout the cruise. Also, it's generally quicker for the cruiser to take a bole height on the closest tree. After discussing this issue more with Dr Iles, we would recommend selecting the single full measure tree on plot by an equally weighted random selection, such as rolling a dice, after all of the "in" trees are determined. For instance, if there are 5 trees on the plot roll a 6-sided dice: on a 1-5 make full measurements on the corresponding tree, if a 6 is rolled: re-roll.
- Tighter plot spacing significantly mitigates the effect of tree count error.
- **Our recommendations for an adjusted cruise protocol:**
  1. Use a 3-P program set to select approximately **25% of the plots** to do limiting distance checks on to sample the tree counts. **Do not do any limiting distance checks on plots not selected by the 3-P program,** even if there are border line "in" trees totally screened by other trees or brush.
  2. Do only 1 full measure tree per plot, including any rare species. Consideration could even be given to skipping the full tree measure on every third plot, if more than 30 plots will be done in a given stand.
  3. Use a plot spacing of **1 chain** for stands you estimate to be unusually variable. Use a standard plot spacing of **1.5 chains** for all other stands. If you feel that these specified plot spacings will require too much time to implement, open up the spacing between grid lines.

Useful website links:

http://www.tsiwood.com/

http://www.forestig.com/

http://www.atterbury.com/

http://www.island.net/~kiles/