THE STRADDLER PLOT PROBLEM AND IMPLICATIONS FOR FIA SURVEY DESIGN

by

Alan R. Ek and Thomas E. Burk

Staff Paper Series No. 103

DEPARTMENT OF FOREST RESOURCES

College of Natural Resources
and
Minnesota Agricultural Experiment Station
University of Minnesota
St. Paul, Minnesota

For more information about the Department of Forest Resources and its teaching, research and outreach programs contact the department head at:

Department of Forest Resources
University of Minnesota
115 Green Hall
1530 North Cleveland Avenue
St. Paul, MN 55108 Ph: 612-624-3400; Fax: 612-625-5212

THE STRADDLER PLOT PROBLEM AND IMPLICATIONS FOR FIA SURVEY DESIGN[1]

by

Alan R. Ek and Thomas E. Burk

April, 1995

Staff Paper Series No. 103

---

[1] Panel comments presented at "The great straddler plot debate" Technical Workshop. USDA Forest Service, Fort Collins, CO. January 29, 1991. Research supported by the College of Natural Resources and Minnesota Agricultural Experiment Station, St. Paul, MN. Published as paper number 21,810 of the Minnesota Agricultural Experiment Station.

The authors are professors, Department of Forest Resources, University of Minnesota.

Introduction:

Plots that straddle two or more forest type-size-density classes, land use classes or other stand conditions have long posed a problem in forest survey design. Here we address all these situations as a confusion of forest type information. The charge for our participation, as we interpreted it, was to examine the papers prepared on the subject and consider the implications with respect to statistical, analytical and practical considerations and suggest solutions. The specific subject is procedure for handling Forest Inventory and Analysis (FIA) ten-point cluster plots.

Specifically, the concept of randomization in sampling (not just in cluster sampling theory) is violated by moving the plot or points. The move is likely to affect results in several ways:

- bias in estimates both overall and within types,
- bias in estimation of variation and sampling error, and
- confusion of long term monitoring.

Bias within types would be minimal, except that forest edge and stand edge conditions (species, form, size class, density and spatial pattern) are often different from those in the interior of stands. This is well documented. Some moving algorithms would also seem to concentrate points along edges. The resulting bias is probably small in most cases, but survey adequacy and interpretation will still be in question. Our understanding is also that plots which are moved might, in fact, be moved again at some later remeasurement. That might be compounding the problem.

Solutions:

We would like to be helpful in suggesting solutions, but we not sure there is much opportunity if we must stay with the existing ten-point clusters or plots of this kind. The number of points and area covered exacerbates the confrontation with edges. In other words, the current ten-point cluster causes more problems than it solves—in fact, were not sure it solved any problems (more on that later). We recommend replacing this plot with an alternative plot design. We see three possible solutions:

1. use a smaller plot or cluster that is less likely to fall across edges or straddle stand boundaries (this is a partial solution),
2. with one point or a fixed radius plot, one need only take a half plot in peripheral zones (say within a plot radius of the edge) or simply omit the points that fall beyond the edge and expand the rest of the plot accordingly (e.g., use the Mirage method), and
3. take each point where it falls and label it as to stand or cover type.

Solutions 2 and 3 have a solid statistical basis, are fairly easy to implement and are easy to understand. The problem is that the inferences are different for (2) versus (3). In the first case the inferences are clearest for types. In the second, they are clearest for the entire forest.

Another solution, like (1) above, is the Scandinavian one of very large clusters and moderate to small-sized plots. In that case, the points could be treated as falling in separate types if necessary.

In considering these plot design options, it appears to us that the objective of FIA efforts may not be well defined given today's interests. The specification of overall survey unit volumes as an objective is clear. However, today's users and FIA units appear to be placing a higher priority on estimates by forest type, etc. There is no question that areas and stand conditions can be distorted by the creation of artificial mixed stands if plot locations do not consider boundaries. If type estimation is to be the primary interest (and we think it should), then the design should perhaps change. For example, if you want to get estimates by type, then you need to be able to identify these types and sample them. The designs in use now do not do that. If you want an overall forest estimate, letting the plots fall randomly (or systematically) seems best. If you cannot define and identify the strata well it seems that the advantages of stratified sampling would be greatly diminished. In other words, treatment of straddler plots may be asking the wrong question. If type estimates are a primary objective, then rethinking the survey design seems appropriate—e.g., map out large clusters and then place plots in the mapped areas of the delineated cover types. This is a major change, but the Alaska FIA and several research projects point in that direction.

If the data are to be used as *model input* one could argue that movement is appropriate as most models will require or assume homogeneous units. This is especially true of biologically based models like the ones used to predict scenarios for uncertain futures. Some individual tree models are an exception. If the data are to be used to *calibrate models,* we suppose you could argue either way. However, it is our experience that you will get fairly crude models if you let things mix artifically—we have enough natural variability already.

Unless we interpreted things incorrectly, the Schreuder et al. results prepared for this meeting on "random" versus "nonrotated" designs suggest something is basically wrong with what some units are doing even before straddling is considered. The differences there are sometimes as big as those between rotated and nonrotated designs. We need more insight on that.

Related to this, we have not seen much work on the efficiency of ten-point clusters (or for that matter, five-point clusters). We found one independent study by Nyyssonen and Kilkki (1965) where they compared ten-point clusters with some fixed- and variable-radius plots for sampling stands. They found the ten-point clusters did not fare well unless you had to estimate areas also, although differences were not large. This suggests that if ten point clusters are not effective within stands, then why use them, especially when they pose problems for straddling. They recommend using many small plots.

We do not think a solution exists given the way the charge has been stated. Anytime you let subjectivity enter the implementation of a design you are asking for problems. If you let people move plots you will get subjectivity no matter how detailed the rules are. Current practice of moving points or rotation involves subjectivity and also lacks a theoretical basis. The result is confusion, especially for change estimation and that is clearly undesirable. The fact that some FIA units handle the moving differently only makes the confusion worse.

Besides the above suggestions, we emphasize the need for simplicity and scientific credibility. Surveys are increasingly pressed to produce results and within FIA units probably more people are skilled at "doing" the surveys than people who fully understand the design. This increases the potential for inadvertent design changes that compromise objectives or analyses that are contrary to the design.

Current designs are also less well adapted to the expertise or understanding of growing traditional and scientific user communities and the scientific and practical questions they would like to address. The sooner the survey moves back to fixed radius plots and simple stratification, the more credible and useful it will be. As it is now, the 37.5 BAF provides growth information emphasizing larger trees. Even with that, procedure for estimating growth components is confusing and inconsistent at best. Further, with 10 to 15-year measurement cycles, what we really need are improvements in the reliability of information for small trees. For example, we have worked with the Minnesota Department of Natural Resources to augment the current FIA design by placing a 1/15th acre plot at point 1. With that, we expect to obtain much better information on small tree growth once these plots are remeasured.

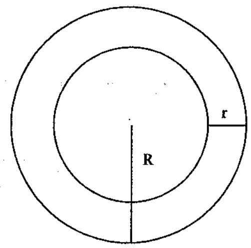
Addenda to this paper elaborate on the nature of the straddler plot problem and solutions. We hope these suggestions (and digressions) help. The task ahead for FIA will be a challenge, but resolution of problems like this will have many benefits.

Literature Cited:

Nyyssonen, A., and P. Kilkki. 1965. Sampling a stand in forest survey. *Acta Forestalia Fennica* 79(4):1-20.

Addendum 1: Probability of Boundary overlap for an area of size A using a plot of size a.

1) Assume the area of interest and sample plot are circular:



2) Then if plot falls in the outer zone of width r, you have boundary overlap:

$$1 - P = \frac{\pi(R-r)^2}{\pi R^2}$$

$$= \frac{(\sqrt{A\ 43560/\pi} - \sqrt{a\ 43560/\pi})^2}{A\ 43560/\pi}$$

$$= \frac{(\sqrt{A} - \sqrt{a})^2}{A} \longrightarrow P = 1 - \frac{(\sqrt{A} - \sqrt{a})^2}{A}$$

	For a = 1 ac	For a = .1 ac
A	P	P
20	.40	.14
40	.29	.10
80	.21	.07

4) With ten plots and simple random sampling, the probability of no boundary overlap = $.9^{10}$ = .35!

Similar results can be developed for areas and plots of other shapes. The conclusion is that the probably of boundary overlap is large.

Addendum 2: Suggested solution to straddler plot problem.

Choose a cluster plot design such that:

1. there are few plots or points, say 2 to 5 per cluster
2. use small fixed-radius plots (1/20 to 1/5 acre in size)
3. disperse plots in the cluster so they are at least three to five chains apart
4. analyze plots in the cluster as the type they indicate (say by sorting trees on plot by algorithm) or fall in (say with field classification). Choice of analysis dependent on size of plot and utility. This requires keeping records by plot within cluster.
5. use the mirage method or peripheral zone method for plots that truly cross type boundaries. It may also be possible to maintain records by tree, but you will still want to retain a record of the distance from the plot center to the type boundary, for blowup purposes.

These steps will:

- improve area estimation precision
- reduce subjectivity and/or bias
- improve precision within types and across forests
- aid simplicity, utility and credibility for users
- facilitate post-stratification in analysis