# Do Point Counting and Spot Mapping Produce Equivalent Estimates of Bird Densities?

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Our purpose is to evaluate Hamel's (1984) recent comparison of methods to estimate densities of birds. Hamel used data from variable circular-plot counts (Reynolds et al. 1980) and spot mapping (International Bird Census Committee 1970) to estimate densities of bird species in stands of oak-hickory forest in South Carolina Piedmont. Although his study had many strong points, it was marred by some weaknesses. Further, we generally disagree with his primary conclusion that variable circular plots "yielded results comparable with those of [spot mapping] in this study, particularly at the larger spatial scales . . ." (p. 272).

On the positive side, Hamel's study used a reasonably good design. He replicated the study in five forest stands widely distributed in northwestern South Carolina. These were carefully selected to assure that habitats were comparable in vegetative structure and composition. He used two spot-mapping plots in each stand and five counting stations for variable circular plots in each of the spot-mapping plots, plus an additional station randomly located in each stand. His analysis addressed the comparability of results at three scales—plot, stand, and habitat (geographic)—(i.e. pooled results across all stands).

We feel that the study was marred by weaknesses in design, methods, analyses, and inferences. We believe certain of these weaknesses lessen the credibility of Hamel's primary conclusion.

## THE DESIGN

One design weakness was failure to replicate the study at the habitat scale, results from which formed the basis for Hamel's primary conclusion that variable circular plots and spot mapping gave equivalent density estimates. We find it hard to fault him for this, however, because replication at this scale would have been prohibitively costly and time-consuming.

## THE METHODS

*Spot mapping.*—The spot-mapping plots were probably too small (10 ha) to escape the usual positive bias in density estimates that result from overestimating the proportions of boundary territories that fall within plots (see Marchant 1981, Scherner 1981, Verner 1981). Each site was "visited weekly from April to July 1982; each . . . was visited at least eight times" (p. 267). Weekly visits from April to July suggest at least 12 visits to some sites, compared with only 8 to others. Unless Hamel selectively eliminated early visits for some species and late visits for others, depending on differences in the timing of their nesting cycles, the difference in number of visits could bias results between sites visited 8 times and sites visited 12 times. Analysis of data in O'Connor and Marchant (1981) by D. G. Dawson (pers. comm.) showed that density estimates of birds can be markedly influenced by the number of visits to a plot (see fig. 1 *in* Verner 1985, but also see fig. 2 *in* Raphael et al. 1987).

*Variable circular plots.*—We believe that Hamel's counting period of 20 min for variable circular plots was too long, because it risked double-counting of individuals and counting individuals that moved into range of detection during the counting period, both factors contributing to a positive bias in density estimates (e.g. see Granholm 1983).

Probably the most serious flaw in Hamel's methods was his inadequate sample for estimating densities by variable circular plots. These density estimates depend on the form of the detection function of birds with distance from the observer, with data from variable circular plots amenable to analysis by the same algorithms used for line-transect data, appropriately adjusted for area effects associated with circles rather than strips (Burnham et al. 1980). Burnham et al. (1980: 35) stated that "as a practical minimum, studies should be designed to assure that at least 40 total objects ($n > 40$) are detected; it might be preferable . . . to allow the location of at least 60–80 objects." Elsewhere, Burnham et al. (1980: 177) concluded that "Even with sample sizes of 100, one has difficulty inferring the true underlying detection function . . . ." Empirical studies indicate that estimates of bird densities from line-transect data to not stabilize with respect to spot-mapping estimates until sample sizes reach about 100 detections (Verner and Ritter 1988). Only 15 of 55 species detected by Hamel during variable circular-plot counts had 50 or more registrations (pooled across all sites), and 26 species were detected fewer than 15 times. Although Hamel did not report the number of species with a count of 100 or more individuals, we suspect that it was not more than 5. Thus, only ca. 10% of all species were abundant enough to give reasonably precise estimates of the distance detection functions. Indeed, it appears that a detection function was estimated for at least one species with a total count of only 1, as 6 of the 55 species were detected only once, but density estimates were given for 50 species.

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The detection function for each species, based on pooled counts across all sites, was then used to define an effective detection distance (EDD)—the distance within which the detections of a given species are assumed to be 100%. The EDD was then used to estimate the density of that species for each count at each counting station. Whether or not this is a suitable procedure remains to be determined. We are skeptical because it means that a density estimate for a given count would normally be based on detection of few individuals, often only one. Furthermore, we are puzzled by Hamel's explanation of his method in this case (p. 268): "When effective detection distances had been determined for each species, they were used to calculate density estimates for each count by dividing the number of registrations for the species on the count by the area of the circle with radius equal to the effective detection distance." This implies that *all* detections were used, although the method requires use of detections only within the EDD. Including records beyond the EDD would positively bias the density estimate.

### The Analyses

Hamel used four procedures to estimate densities with data from variable circular plots (readers may consult Hamel [1984] and Reynolds et al. [1980] for details). The ANOVA mean procedure gave generally the best results from variable circular plots in comparison with density estimates from spot mapping, and the remainder of our comments are based on that procedure.

We perceived at least four weaknesses in the analyses. First, for spot-mapping estimates Hamel arbitrarily assigned density estimates of 1 pair per 40 ha for species designated as "+" according to the accepted international guidelines, and 0.1 pair per 40 ha for "visitors." Both of these designations necessarily describe species that are uncommon to rare on the mapping plots, so their variable circular-plot counts should be very low as well. As a result, even slight errors in density estimates from spot mapping can result in very large differences in ratios between density estimates from spot mapping and variable circular plots. For example, a "+" species with true density of 0.25 pair per 40 ha on a mapping plot would be only 1.4 times as dense as an estimate of 0.18 pair per 40 ha from variable circular plots, but arbitrarily inflating the spot-mapping estimate to 1.0 pair per 40 ha would make it appear to be 5.6 times as dense. In any case, we do not believe that accurate estimates of the densities of such uncommon species are possible by either spot mapping or variable circular plots, so they should not be included in comparisons of methods.

Second, for data from variable circular plots, Hamel grouped estimated distances to birds into (1) an inner "bull's-eye" with a radius of 30 m, (2) a band extending from 30 to 61 m, (3) another band from 61 to 122 m, or (4) a final band extending from 122 to 310 m. Density was based on a radius set by the EDD, defined in this case as the outer boundary of the band determined by analysis of variance to have a significantly higher density than that in the next band outward. In the latter case, because each counting station was essentially a block in the ANOVA and the counts in each band at a given station constituted a matched set, Hamel should have used a repeated-measures ANOVA. This may have been the case, but he does not mention that technique. Furthermore, because he estimated densities separately for each counting station, Hamel's samples were no doubt very small and included many zeros, which decreased the likelihood that the data were normally distributed. An estimate of the power of his analyses would help readers to assess their suitability.

Third, Hamel's comparison of the methods was based on absolute differences between density estimates. We believe he should have used ratios or percentage differences. Note, for example, that an absolute difference of 1 between density estimates of 19 and 20 pairs per 40 ha is relatively insignificant compared with a difference of 1 between estimates of 1 and 2 pairs per 40 ha.

Finally, Hamel adjusted density estimates from variable circular plots for five "problem species," based on biological knowledge of those species in relation to the variable circular-plot method. For example, "Red-eyed Vireos were the most abundant birds on each census tract. Differences in estimation by variable circular plots and spot mapping were substantial as well, exceeding 10 pairs 40 ha$^{-1}$ at the overall level. When analysis was limited to registrations of singing males only, the difference between estimates from spot mapping and variable circular plots was $\pm 5$ pairs 40 ha$^{-1}$ (ANOVA mean technique). . . ." (Hamel 1984: 272). Although we agree that empirically derived adjustments of this sort can be rationalized biologically when density estimates from spot mapping are available for comparison, such adjustments nonetheless amount to post hoc manipulation of data to make them conform more closely to a preferred model. Statisticians define this as a Type III error. If sufficient replicate studies of this nature suggest standards for adjusting density estimates by variable circular plots for certain species, the practice gains credibility. But we assert that it is not acceptable on a one-time basis for a comparison of density estimates from variable circular plots and spot mapping.

### The Inferences

Hamel's conclusion (p. 272) that variable circular plots "yielded results comparable with those of [spot mapping]. . . , particularly at the larger spatial scales," was based largely on his observation that most absolute differences in density estimates were small. He points out (pp. 269–270) that "After 30 counts, standard errors of mean density for 73% of the species were below 1 pair 40 $ha^{-1}$, while those of all the species were no more than 10 pairs 40 $ha^{-1}$. After 90 counts, the standard errors for 86% of the species were not more than 1 pair 40 $ha^{-1}$, while those of all remaining species were no more than 5 pairs 40 $ha^{-1}$. Thus the maximum length of a 95% confidence interval after 90 counts was 20 pairs 40 $ha^{-1}$, and those of 86% of the species were not longer than 4 pairs 40 $ha^{-1}$." Elsewhere (p. 270) he noted that "At least 60% of the comparisons at the overall level were within $\pm 2$ pairs 40 $ha^{-1}$. . . . After adjusting the ANOVA values for [the problem species] 100% of [estimates from variable circular plots] at the overall level . . . were within $\pm 5$ pairs 40 $ha^{-1}$ of the [spot-mapping] value."

The above observations should be considered relative to the magnitude of density estimates from spot mapping (see Fig. 1). For example, spot-mapping density estimates exceeded 5 pairs per 40 ha for only 6 (12%) of the 50 species on Hamel's list, and spot-mapping estimates for 25 species (50%) were <1 pair per 40 ha. A species so uncommon as to give a density estimate from spot mapping of <1 pair per 40 ha is not likely to be recorded often enough to give a density estimate from variable circular plots in excess of that. In fact, not surprisingly, density estimates by variable circular plots and spot mapping were within 1 pair per 40 ha for 23 of the 25 species with spot-mapping densities <1 pair per 40 ha. But the mean *ratio* of these 25 estimates from the two methods was 8.2 (SD = 11.4) (ratio computed by dividing the smaller estimate into the larger in each case). Moreover, the mean ratio of the more abundant species—the 25 with spot-mapping estimates of 1 or more pairs per 40 ha—was 8.4 (SD = 31.6); deleting the Whip-poor-will from this computation because it was a clear outlier (ratio = 160, Fig. 1) gave a mean ratio of only 2.1 (SD = 1.5). The mean ratio of the cases in which variable circular plots underestimated spot mapping values was 4.5 (SD = 6.4; $n = 33$) (omitting the Whip-poor-will); that of the overestimates was 6.6 (SD = 12.2; $n = 16$).

These results do not suggest that density estimates from variable circular plots were equivalent to those obtained from spot mapping, as Hamel concluded (e.g. pp. 266, 272). At best, ratios of density estimates from the two methods for common and uncommon species suggest that they are more equivalent for common species. In fact, the ratio between density estimates declined with increasing density estimates from spot mapping (Spearman's rho = $-0.60$, $P < 0.01$). Similar results were found in a comparison of line-transect data with spot-mapping data in oak-pine woodlands of California (Verner and Ritter 1988).

Finally, Hamel's (pp. 269–270) assessment of standard error in estimates of species richness with different numbers of counts was optimistic, because he lacked an independent data set. He included replicate

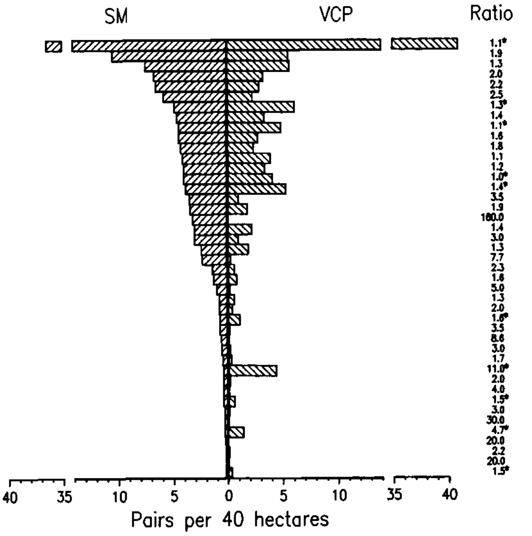


Fig. 1. Comparison of density estimates by spot mapping (SM) and variable circular-plot (VCP) methods (ANOVA mean), with the ratio of the higher estimate to the lower estimate. Overestimates by variable circular plots in relation to spot mapping are indicated by an asterisk. Only species with a density estimate by spot mapping of at least 0.2 pairs per 40 ha are shown here.

counts from the same points. The extent to which this underestimated true standard error cannot be determined from the data given.

## Other Comments

If variable circular plots eventually prove to be reliable for density estimation, it will be only after *extensive* and *intensive* comparative studies of color-banded birds on mapping plots, such that standardized adjustments can be developed for each species in each habitat. In that regard, Hamel took a step in the right direction by using his knowledge of the biology of certain "problem species" to reduce the differences between their density estimates from spot-mapping and variable circular plots.

Hamel probably overestimated the efficiency of variable circular plots for measuring bird species richness. Still we agree that they are more efficient than spot mapping for that purpose. However, users of point counts to sample assemblages of breeding birds should be mindful of the fact that they can include species that do not breed on the study area (transients and visitors from different, neighboring habitats). This is not true of spot mapping. A true assessment of the relative efficiency of the two methods depends on a thorough knowledge of all species known to breed on a study plot. In a long-term study of breeding species in oak-pine woodlands in California (Verner and Ritter 1985), 38 eight-min point counts (total time (including walking between counting stations) = 7.8 h/plot) gave 99.7% of the bird species known ever to nest on the two plots. Spot-mapping estimates required ca. 52 h/plot of field time to generate the same list of breeding species. Even this is not an ideal comparison, however, because one could not be certain from point counting whether or not "usual" breeders detected on a site actually bred there that particular year.

We share Hamel's opinion that point counting is probably the first method of choice for monitoring trends in bird populations, especially over moderate to large geographic scales, but on the condition that no attempt is made to use the data for between-species comparisons of densities or relative abundance. The problem is that many practitioners continue to use data from variable circular plots for these purposes.

Although we disagree with many of Hamel's conclusions, we nonetheless laud the intent of his study. It seems to us that the greatest gain in our efforts to estimate bird abundance will come from empirical tests of existing methods, not in the development of numerous new, untested methods and variations of old methods. The difference in interpretation of results evidenced by Hamel's study and those of DeSante (1981, 1986) (and our Commentary) indicates a need for many more such tests. For example, we need to know about the comparability of results between bird species, bird densities, habitats, seasons, and years. We need empirical evidence on the assumption (e.g. Hamel 1984: 272) that point counting is preferable to spot mapping in small patches of habitat. And, as Svensson (1981) pointed out, we need to know for a variety of field conditions whether different methods give comparable measures of trends for different species. To achieve all this, team efforts promise to be especially productive, as in the example of Tiainen et al. (1980).

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