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SUMMARIZING REMARKS: ESTIMATING BIRDS PER UNIT AREA

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Evelyn Bull (1981) presented a very interesting discussion on the estimation of indirect measures of abundance for birds. I have no quibble with her rather thorough coverage of the many indices that have been suggested in the literature. However, the paper does not recognize that methods have been suggested in the literature for obtaining not only relative, but absolute measures of abundance (indeed, one method has been suggested specifically for birds). Three instances of attempts made to estimate absolute population densities are: the use of aural information requiring estimates of both the number of calls and the calling rate per time period. This development is exemplified by Gates and Smith (1972) for Mourning Doves (*Zenaida macroura*). A second example is the use of pellet group counts to estimate the size of deer and elk populations. The third example is the estimation of absolute hare populations from tracks in the snow (Hayashi et al. 1966). Both the latter two methods could be adapted to birds, e.g., tracks in the dust for some species. It almost goes without saying that the assumptions for absolute densities from indirect measures are even more stringent than for direct measures (see, for example, Gates and Smith 1972).

Capture-mark-recapture methodology has been widely used in small mammals and fisheries. Here Nichols et al. (1981) examine its uses in estimating avian populations. The paper is lengthy, comprehensive and comprehensible. I highly recommend reading it in its entirety. I do note that the paper does not deal specifically with density even though this is a density session. A minor quibble with the paper is that the relative advantages of mark-recapture methodology vis-a-vis other sampling methods are not discussed. This would permit ornithologists and other potential users of the methodology to make more rational decisions. For example, compared to the line transect method, the mark-recapture method will be much more time consuming, (i.e. expensive), birds must be handled (except for specialized situations such as Hewitt's (1963) Red-winged Blackbird procedure), but the final results may be achieved with better precision.

As I understand the paper by Oelke (1981), it is concerned with the controversy of whether bird density should be determined by territorial mapping, obtained by observing bird behavior, or by discovering the nests of nesting birds. Without a clearer understanding of what the controversy is all about, I will not enter the fray.

The manuscript by Franzreb (1981) has to do with an empirical evaluation of the strip vs. the line transect methods of sampling. I observe there is a great deal of variation in the use of sampling terminology; not only here at the conference, but in the literature as well. I should like to make a very strong appeal to this Symposium that standardized terminology be adopted in transect sampling as well as other areas suggested by the Symposium organizers. I make a strong plea for adopting the standardized terminology set forth by Eberhardt (1978). In his terminology "variable-strip transect" and "fixed-width transect" simply become the *line* and *strip transects,* respectively.

Franzreb's (1981) Figure 1 and Table 1 appear to demonstrate direct violations of the assumptions underlying line or strip transect methodology given by the author. The theoretical curve of right angle flushing distances must be non-increasing. In Figure 1 there is clear-cut evidence by any standard of an increase in the number of birds sighted at a right angle distance away from the line. I do not believe the author addresses the question of whether the "excess" of birds at 30 m is due to birds moving out from the line in areas in which they are subsequently seen or is due to birds making themselves more inconspicuous on the line. (The behavior is undoubtedly species dependent.) For those species that move away from the observer, and are subsequently seen along with all other birds at that distance, a method that appears to have merit is the *spline* method. The spline method is specifically designed for situations in which all birds are observed at some unknown distance from the transect at which point the sightings begin to fall-off. The spline procedure fits by least squares a horizontal straight line intersecting the ordinate ($Y = \hat{f}(0)$) with a quadratic curve approximating the downward trend of the observations in the right tail. Because the intersection point of the horizontal line and the quadratic curves are assumed unknown, either non-linear least squares or some special spline technique must be used to solve the equations and hence to estimate density. The method is outlined in Gates (1980). The advantages to the spline pro-

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cedure, where it is appropriate, appear to be considerable. Least squares, rather than a subjective estimation of the "point of inflection," determines $\hat{f}(0)$ and the right angle distance to the left of which it is assumed all birds are seen. The spline method would appear to be an attractive method of analysis for data gathered by the J. T. Emlen (1971) procedure.

If, however, the paucity of observations near the transect is due to birds becoming less conspicuous, rather than moving, the situation appears to be very difficult.

In conclusion, I heartily agree with Franzreb's (1981) recommendation of recording each bird's distance as accurately as possible, but possibly for different reasons. If distances are recorded rather than intervals, analysis of the resulting data sets is vastly more flexible. One can then subsequently group the data and use spline or Emlen procedures or use one of the robust estimation procedures mentioned by Burnham et al. 1980:125–127.