Studies in Avian Biology No. 6:511–512, 1981.

SUMMARIZING REMARKS: DATA ANALYSIS

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The papers in this session cover a wide range of the techniques used by ecologists to census populations: spot-mapping (Eagles 1981), home range estimates (Ford and Myers 1981), line transect methods and their relatives (Ramsey and Scott 1981, Burnham et al. 1981, Quinn 1981) as well as techniques used to analyze these data once they are obtained (Sen 1981, Johnson 1981). The number of issues that these papers raise, however, is fewer. I shall consider three of them.

(1) The majority of papers in the symposium end with an estimate of density. Johnson's (1981) paper starts with such estimates. He points to an experience so common to the ecologist: one's experience is often ignored in the estimates of density one obtains and they often seem in conflict with it. Johnson shows that experience need not be ignored—experience of both the past densities and of the current situation can be incorporated into population estimates. Indeed they should be: there is a considerable improvement in the estimates obtained by incorporating prior knowledge. I consider Johnson's (1981) paper particularly innovative because it operates on data at a later stage than most of the techniques discussed elsewhere. It is, thus, an additional, rather than an alternative stage in obtaining populations estimates.

Sen's (1981) paper also addresses population estimates at a late stage—perhaps the last stage—when questions of the significance of population changes are to be answered. As he indicates, an appreciation of the unusual features of population estimates (they are often highly skewed) leads to a transformation of the estimates which greatly improves the power of the statistical tests used on the data. Both Sen (1981) and Johnson (1981) lead to a conclusion that population estimates are not ends in themselves, but are the inputs to subsequent analyses. And how these analyses are performed can be as crucial to the biological conclusions as how the estimates were obtained.

(2) Several of the papers in this session, as well as that of Pollock (1981), in the previous session, are "consumer's guides" to various techniques. They ask: is there a "best buy" among them? The answer is a combination of "yes" and "no." Certainly, some techniques are better than others. Ford and Myers (1981) show that probabilistic estimators of home range are better than the widely used minimum convex polygon (MCP) method. They used a computer-based movement generator that closely describes the space-use patterns of two species. Using this generator to produce simulated home ranges they examined the efficiency of two probabilistic (one parametric, the other not) and the non-probabilistic MCP method. They considered the non-parametric, probabilistic method to be the "best buy."

Similarly Burnham et al. (1981), Quinn (1981), and Ramsey and Scott (1981), evaluate the various forms of line transect techniques. The critical aspect of these studies is the sighting curve—how detection drops off with increasing distance from the observer. Various forms for this function have been suggested. Though each may be suitable in special cases, their inflexibility precludes their widespread use. Burnham et al. (1981) suggest fitting a Fourier series to the data. This approach has flexibility and a number of other desirable attributes required for accurate estimation of density and ease of use. The authors provide a fully documented program, called TRANSECT, which produces estimates in this way.

While line-transects have advantages for sampling small areas frequently, ecologists must often sample more extensively. Ramsey and Scott (1981) attack the problem of variable circular plot designs to this end. They evaluate the possible ways of performing these censusses. Finally, Quinn (1981) considers both the possible forms of the sighting curve, and the complications that arise when animals flock (or school or herd!). In such cases detectability will be a function of group size, and this function must be incorporated into the estimates.

The syntheses that these studies provide should not lead to too simple a view of "best buys." Clearly, some techniques are better than others. But there are still plenty of alternatives, each the best for a limited range of circumstances. The papers on line transect techniques and their modifications are complementary, each describing different field situations and observer needs. There is no global "best buy."

(3) My final comment stems directly from the previous one. If there is no single best line transect method, and, if line transects are but one of several possible census methods, and, moreover, if when I have obtained these estimates they still require additional processing, then my feelings are ones of despair. The necessary com-

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puter programs are scattered over much of one continent, they differ widely in availability and documentation, and I suspect (from previous experience) that getting some of the programs to run on my computer will be anything but trivial. Dr. Rice, in his summary of the session on "Data Analysis," noted that biologists often use such sophisticated routines as principal component analyses and multiple regressions analyses once their data are in hand, but that they seem loath to approach the statistics/statistician at the sampling design stage. I suggest the inaccessibility of many of the techniques discussed in this symposium is the cause. While the techniques remain inaccesible, biologists, particularly those with an inherent fear of mathematics, computers and statistics, will certainly under-use these techniques. My plea is simple and will be unpopular with any programmer. If the statistical techniques are to be used they must be: (1) centrally located; (2) be implemented on a wide range of university systems; and (3) have input requirements and specifications of options that ecologists can easily comprehend. Many ecologists use SAS or SPSS; the package of sampling techniques that appears on these packages first, will whatever its statistical merits, be the one most widely used by biologists.