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SUMMARIZING REMARKS: ENVIRONMENTAL INFLUENCES

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I will make a few comments on the eight individual papers of this session, followed with comments on the role of factors influencing bird counts and the use of counts to estimate bird abundance.

Anderson and Ohmart (1981) report on an extensive study which had a good study design. Data presentation was, however, inadequate and the estimation of density (J. T. Emlen's [1971] method was used) from counts and distances would be improved by using recently developed, comprehensive analysis methods. It would be very informative to present the data as graphs of estimated densities over time with 95% confidence intervals indicated. The data presentation in terms of kurtosis and skewness was uninformative. It was also an incorrect analysis to examine for a normal distribution because the data were first combined over factors such as season or habitat type and for these combined data to follow a normal distribution there would have to be no variation in bird density by season or habitat type. However, the authors' analysis showed that bird densities did vary by season and habitat type. The caveats in their discussion section should be memorized by ornithologists.

The paper by Best (1981) lacks a conceptual basis for relating the data (counts of birds) to the parameter of interest, bird density. The detectability profiles are based only on observed counts, with apparently no attempt made to estimate true density. These seasonal profiles, therefore, reflect a confounding of three factors: bird density, the rate of cue production, and the detectability of the cues. I believe Best is saying that these seasonal profiles are only useful as a qualitative basis for improved study design, in which case the confounding of these factors is not of concern. I agree with this idea, but wonder if such intensive studies are really needed to document what ornithologists probably already know about the optimal timing of bird studies.

Sampling in rugged terrain raises some theoretical problems about what to record for a distance in both line transect or circular plot sampling. Ms. Dawson's paper (1981) appropriately raises this question. I believe the guiding principle should be that we are sampling area (to the bird) in these methods; perhaps, therefore, the distance recorded should follow the contour of the landscape. This matter needs more thought. I find the author's comments regarding correcting distances for slope confusing, and I recommend using the actual line length and distances in the estimation of bird density. Conversion of the estimated density, $\hat{D}$, to total numbers, $\hat{N}$, in the sampled area is the problem. $\hat{N} = \hat{D}A$ should be used, where A is the actual habitat area available rather than the projected map area, A^*, of the study area because $A^* < A$ will hold in rugged terrain. Thus, taking A* from a map, which ignores the relief features of the study area, and using $\hat{N} = \hat{D}A^*$ will give a negatively biased estimate of N.

A typical, small scale, very limited ornithological study was summarized by Grue et al. (1981). Transect counts were done over a four week period in one impacted study plot and one control plot; there was no replication over years or plots. Thus, only very limited conclusions can be validly drawn from this study. Distance data were recorded in seven intervals; this would allow for a considerably more sophisticated data analysis than was done. Again, as is typical in ornithology, estimates of bird abundance are presented without any estimates of precision (i.e., standard errors). The state-of-the-knowledge allows a much better data analysis than is presented. Finally, comparing the number of detections (counts) as birds per 20 ha to the projected densities (estimates of D) as birds per 40 ha is ridiculous.

The paper by Oelke (1981) does not have, and basically does not need, statistical analysis of data. He reminds us of the practical difficulties of access to land (both legal and safety) and of the "big foot" effect, where an intensive study can change the biological community being studied and thereby render the results useless.

Richards (1981) presented the results of a worthwhile investigation and a refreshingly different one, because it is not just counting birds and finding that these counts depend on every conceivable influence. If estimation of the distances to detected birds depends entirely on hearing them, then it is important to understand the nature of this auditory cue. However, if the detection distance can be accurately obtained in some other manner, then the nature of the detection cue, especially attenuation of bird songs, is irrelevant.

There have been too many studies like the two papers of Robbins (1981b) and Skirvin (1981). The resources expended on these studies could be better used on other goals. Admittedly, all sorts

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of factors effect the counts of birds. That is why it is necessary to "correct" these counts to an estimate of absolute density. This can be done using detection distance data from either line transect or circular plot sampling. The time to consider the factors effecting rate of cue production and the probability of detecting a cue is while designing the study. Stated simply, field work should only be done during "acceptable" conditions. The study of Robbins (1981b) is oriented to defining acceptable conditions. However, I maintain that it is pointless to try and precisely quantify such conditions for every species, habitat and season. Only general guidelines are needed, or feasible, and it should be possible for experienced ornithologists to provide such guidelines, in most cases, without further studies.

Judging from his paper, Skirvin (1981) has done a good job of data analysis in many respects, and the reporting of results is informative with the notable exception that no standard errors are given for means or density estimates. Surely these were available; they should be included in the paper. The paper provides a good argument against using counts as indices; the observed counts declined over a four hour morning period. By contrast, the density estimates (counts "adjusted" using detection distances) did not significantly decline during the same time period.

Some general points concerning the use of bird counts to estimate bird abundance that I want to emphasize are:

(1) Using just the count of birds detected (per unit effort) as an index abundance is neither scientifically sound nor reliable. Many papers in this symposium illustrate this fact, in effect, whether the authors so intended or not.
(2) It is necessary to adjust the study counts by the detection probability. Fortunately, this adjustment only requires appropriate detection distance data. The mathematical basis for this computation is now well understood and good estimation methods exist.
(3) Line transect and circular plot (distance) methods should only be used under conditions when the rate of cue production is high and these cues are very detectable. Then there are data analysis methods that eliminate the need for concern about the multitude of factors effecting detection probability. In effect, it becomes unnecessary to worry about all the reasons why birds are not always detected when they are away from the transect center line or the plot center.
(4) From a statistical viewpoint, there is no difference between bird density estimation based on counts and distances from line transect sampling and those based on circular plot sampling. Therefore, the basis for choosing between these two sampling methods is their appropriateness and feasibility in the field.
(5) Trustworthy, predetermined correction factors for counts of each species by habitat, year and observer are impossible to achieve.
(6) Data analysis and reporting of results from ornithological studies needs to be more rigorous. In particular, the precision of results needs to be reported, usually as the standard error of parameter estimates.

In his opening address to this Symposium, Dr. Callaham asked us to determine and compare the state-of-the-practice and the state-of-the-knowledge. There is a large gap between these two in ornithological studies. Specifically, there is approximately a ten year gap between data analysis and field procedures for line transect and circular plot studies. The state-of-the-practice is circa 1970 even though tremendous progress has been made in analysis methods in very recent years. A substantial gap also exists in application of other methodologies, such as capture-recapture and band recovery analysis and in the general level of sophistication of statistical analysis (and sometimes, design) of studies. The knowledge exists; ornithologists need to use it.