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INTRODUCTORY REMARKS: SAMPLING DESIGN

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Probably no aspect of the study of avian ecology has shown so marked an increase in interest in recent years as the counting of birds. Accompanying this increase has been a growing awareness among field researchers that bird counting is a distressingly imprecise science. Variances in count data are extraordinarily high, partly because birds are so mobile and partly because so many different effects can bias the counts. The literature documents many of these sources of bias and addresses the question of how to design experiments to control bias and thereby reduce the variance in count data.

Sources of bias can be grouped conveniently into four categories: (1) *observer effects* include experience, acuity, and alertness, as well as number of observers; (2) *bird species effects* include species detectability, species density, timing of breeding, social or breeding system, and flocking habits; (3) *site selection effects* include the site selection procedure (random, stratified random, regular, or selective), site separation, number of sites, vegetation density, vegetation homogeneity, plot size or transect length, and terrain; and (4) *sampling schedule effects* include the season, time of day, duration of a single sampling period, duration of the overall sampling period, number of counts per site, the frequency of sampling, and weather constraints. Some of these effects are easily controlled by experimental design or modes of analysis, but others are not so easily controlled and offer a real challenge.

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This session includes several papers and poster presentations. Most participants deal with transect or point counting methods for sampling bird communities, though some attention is given here to the mapping method, and one paper provides a useful overview of the capture-recapture method. Among these presentations, I have found data relating to experimental design for control of 15 of the 23 sources of bias I have categorized, but applications tend to be restricted to one sampling method. It is a fair assessment to say that we only scratch the surface of the many questions in experimental design.

Taken together in all their permutations, the many sources of bias listed, and others unlisted produce real world conditions that so far have defied our abilities to count accurately all species comprising avian communities thus far sampled. Our ingenuity in experimental design will undoubtedly go a long way toward improving this unhappy situation. We can certainly generate count data with low variances, and we may then draw conclusions within prescribed limits of confidence. However, low variances do not necessarily indicate accurate data. They can also result from a sampling design that controls only the magnitude of the effect of a given biasing factor, without eliminating the bias. Therefore, we will always err in the same direction, and within acceptable limits of variation, but still we will always err. The trick, if we insist on accurate counts of all species in a community, will be to determine for all species and habitats the directions and magnitudes of those errors. I see this as the essence of the bird counter's challenge.