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SUMMARIZING REMARKS: COMPARISON OF METHODS

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The evolution of censusing methodology involves continual refinement of techniques. The comparison of different census methods outlined in this session, to my mind makes this the most valuable session of the symposium. When different techniques were compared here, the results showed that density estimates varied depending upon which method was tested. However, deeper probing into each paper reveals similar themes which wind through the session. These may allow us to tie together some of the fundamental censusing problems which are being encountered today. In this summary I will present thoughts and suggestions on the biological ramifications of the methods and ideas presented in this session: first will be an analysis of the logistical comparisons; and second, some biological implications that have been made apparent by these comparisons.

The best available density estimate for a population is obtained when all the birds in an area are banded. In decreasing accuracy this method is followed by the spot mapping technique, the circular plot method, line transect counts, and least effective—the guess. But all of the sampling methods that were compared in this session invariably underestimated total population numbers. It was also pointed out that bird density estimates were greatly modified by the type of habitat in which the census was made. As Anderson and Ohmart (1981a) showed, open vegetation types lend themselves better to the line transect technique. If Edwards et al. (1981) had expanded the area of their line transects (as suggested by one of the questioners), they also would have found this to be true. For a general rule of thumb, line transects are best used in open areas such as savannah or scrub, whereas the circular plot method seems to be more applicable to closed canopy forests. This is particularly true for tropical areas where there is either a very high canopy or a dense understory.

There was unanimous agreement among all the participants that it is logistically more expedient to use the line transect technique. The circular plot and mapping methods take longer; and this problem is magnified when there is behavioral modification of cues, such as a decrease in vocalization rates over a short time period. A way around this problem might be to replicate circular plots with multiple teams. But a cautionary note—there is a disturbance factor when one person follows closely behind another on a transect (Scott and Ramsey 1981a, Scott et al. 1981b).

It was fairly well agreed upon that, regardless of technique, the more intensive the effort, the greater the number of species counted. The participants also agreed that replications are needed, particularly when using the line transect method. As Jolly suggests, in most situations three replications of a transect should be an absolute minimum. Perhaps the use of an index, as pointed out in Franzreb (1981b), where preliminary censuses are run to determine that point after which new species are no longer encountered, might be useful. This information could then be used to determine the number of replications needed for future census work in that particular habitat. All of the techniques used were adequate to determine densities of common and vociferous species, but silent and/or rare birds were always badly underestimated. The technique that proved best able to deal with the rare species problem was the circular plot.

The final major problem brought out in this session was that of swamping. In an avifauna in which a few species are very abundant, the common birds will mask the presence of silent and/or rare species. This proves especially true for areas such as tropical forest habitat, where there may easily be 250 species to be included in the census (Karr 1981). One suggestion made in regard to the Christmas Bird Count might be applied to this problem—that the census be stepped-down to a simpler level by using only presence-absence data. Or, in an effort to increase the reliability of density estimates, censuses might be broken down into separate species groups based on abundance or possibly guilds (Franzreb 1981b, Scott and Ramsey 1981a). Possible divisions of a population to be sampled include: vociferous versus non-vociferous species, foraging guilds, horizontal vegetation strata, or distinct vegetation types. In summary of this first section, know what objectives you want to accomplish before going out, and be aware of what logistics need to be taken into account to accomplish those objectives.

The second section of this summary will deal with the biological implications made during the comparison of papers presented in this session. These studies have all shown that in order to decrease sampling problems one must intimately

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know the ecosystem to be sampled. This includes awareness of the vegetation structure and the responses of each species to be counted to the biotic and abiotic parameters of the habitat. In short, know the animals you will be censusing. Some of the biological problems brought up during this session follow:

Song cycles.—Eighty to 90% of the detections during a count period are from aural cues (Ramsey and Scott 1981a, Cyr 1981), yet very little background work has been done to incorporate variances of vocalizations into censusing methodology. One needs to be aware of daily and annual song cycles of the birds that will be counted. Much of this information is available in the literature and can be put to good use (e.g., Thorpe 1961, Hinde 1969, Armstrong 1963). Dawson (1981a) showed that singing rates of birds in New Zealand are fairly uniform throughout the day, whereas Anderson and Ohmart (1981a) found a decided early morning vocalization peak. A predawn chorus may pose a censusing problem in certain areas, and in colder climates birds may not vocalize until later in the day. Differences in vocalization patterns must be taken into account if the census results are to be meaningful.

Breeding patterns.—Hildén (1981) and Svensson (1981) pointed out that the initiation of the breeding season is quite variable between years, particularly at higher latitudes. The number of cues recorded during a count period will be greatly modified by the stage of the breeding cycle during the census. Therefore, if the objective is to compare censuses between years, there must be some flexibility in the initiation date of the census. Some point in the breeding cycle should be selected that will enable censuses to be repeated at the same "biological time" year after year, such as an interval after the arrival of a certain species or after the first nest is found.

Banded birds.—The elegant comparison of census techniques done by DeSante (1981) was made possible only because he had a banded population of birds to work with. In conducting comparative censuses, advantage should be taken of situations, such as the one at Point Reyes Bird Observatory, where banded populations of birds are present. This is one of the most expedient ways in which to refine censusing techniques.

Cavity-nesting birds.—There are some real problems with the censusing techniques which are currently available to us when attempting to determine accurate numbers of cavity-nesting birds. Hildén (1981), Svennsson (1981) and Järvinen and Väisänen (1981) all showed discrepancies between the numbers of European Starlings (*Sturnus vulgaris*) counted in nest boxes versus those recorded on line-transect censuses over a period of years. Population estimates derived from nest box data revealed a dramatic decrease in Starling numbers, whereas no declining trend was found from the line-transect census results. It is possible that the Starlings are utilizing different nesting locations, or perhaps there is presently a high proportion of nonbreeding birds in the population. In any event, this problem might be inherent to cavity-nesting species, and censuses dealing with them should take into account this potential problem.

Nonbreeding birds.—Large groups of nonbreeding birds can contribute a bias to census results. Males without mates (which have not yet obtained a mate or have lost a mate) will vocalize more than breeding males (Nolan 1978). The number of "floaters" in a population is usually ignored, but in certain areas these birds can make up a significant portion of the population being counted (Smith 1978). Karr (1981) has suggested that large numbers of floating birds exist in tropical forests, Recher (1977) has documented numerous floating birds in Australia, and my own experience in Hawaii has shown that many individuals sighted within an area are floaters (van Riper 1978, 1980). However, as DeSante (1981) found at Point Reyes, some areas do not have large percentages of floating birds in the population. Before censusing an area, it must be determined if a floating population is present, how large it is, and to what degree it might bias the census results.

In summary, each censusing method has its weaknesses and limitations. Researchers should be aware of the limitations before applying a technique to a censusing problem. The area to be censused should be carefully surveyed *prior* to embarking on a study. This preliminary information should then be analyzed so that the censusing method best suited logistically to the area can be chosen. In addition, the species which are to be censused should be researched to determine if any biological or behavioral variances will modify the cues to be recorded during the count periods. The study should be planned to minimize logistical and biological variances. The papers presented at this symposium and the discussion arising from their comparison should better enable workers to use the censusing tools now available to scientists in the field.