COMPARISON OF VARIABLE STRIP TRANSECT AND SPOT-MAP METHODS FOR CENSUSING AVIAN POPULATIONS IN A MIXED-CONIFEROUS FOREST

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Avian density information is necessary to estimate population size and community composition. As a result, various techniques have been developed to derive density values (see Kendeigh 1944 and Emlen 1971 for a review of methods). For the spot-map method (Williams 1936), a common sampling procedure, one determines the number of territories of each species in the study plot and derives breeding pair density. Emlen (1971) employed a new sampling technique that involves lateral distance from the transect line of each bird observed and a coefficient of detectability for each bird species. I report here my investigation of the advantages and disadvantages of the spot-map and the variable strip transect methods.

METHODS

My study was conducted on the Willow Creek watershed, a mixed-coniferous forest (131.2 ha) approximately 80 km south of Springerville, in the Apache-Sitgreaves National Forest, White Mountains, Arizona (elevation 2667–2805 m). Vegetation was mixed-conifer in which Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and southwest white pine (*P. strobiformis*) were dominant tree species. Other trees species included alpine fir (*Abies lasiocarpa*), white fir (*A. concolor*), blue spruce (*Picea pungens*), and Engelmann spruce (*P. engelmanni*). A deciduous species, quaking aspen (*Populus tremuloides*), was also present. Using the plotless point-quarter method (Cottam and Curtis 1956), and sampling 400 trees, I calculated total tree density as 626.2/ha.

Climatological data furnished by the U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Tempe, Arizona, indicated that annual precipitation for the Willow Creek watershed averaged 76.3 cm for the past 14 years. Temperature data for May through August 1973, collected from an area 8.1 km from Willow Creek and at an elevation of 2592 m, indicated a mean daily maximum of 23.3°C and mean daily minimum of 3.3°C.

For the variable strip method a transect line 1.6 km long was censused. With each observation I recorded the lateral distance from the transect line, species, sex of bird (if possible), whether the bird was singing if it was a territorial male, and age (fledgling vs. adult). A coefficient of detectability (CD) was derived for each species. The CD represents the proportion of the population which an observer can detect while running the transect; it varies with species and habitat. Densities and CD values are determined by counting the number of individuals found in strips on both sides of the transect from the base to the point of inflection on the distribution curve of the results. Since detectability varies with distance from the transect line, the area in the strips when multiplied by the appropriate value will yield the expected number to be found within 125.6 m on both sides of the transect line. For example, if the maximum number of birds occurred in the 15.2 m strips on each side of the transect line, this number when multiplied by 8.24 will give the total number expected. A more detailed description of this sampling procedure may be found in Emlen (1971).

Emlen (1971) suggested that data be tabulated separately for singing males and all other observations. Data for singing males are then multiplied by two. I used whichever density value (singing male $\times$ 2 vs. all other observations) was higher.

Censuses were started ½ hr after sunrise and completed within 2 hr. I began 4 June and ended 5 August 1973. The transect line was censused each day for three consecutive days in the first week of June, July, and August. A mean of the nine counts was used to arrive at a final density figure.

For the spot-map method I established a grid pattern using plastic flags placed at 25 m intervals along 9 lines, each 390 m long. Lines were spaced 50 m apart. Flags were labelled with a number corresponding to the transect line and a letter indicating the distance traveled from the beginning of the line. The grid pattern encompassed 15.5 ha, the same area sampled with the transect method.

The location of each observation was marked on a map of the grid pattern and coded to signify a singing male, non-singing male, female, fledgling, or nest. Territories were then delineated for each species. The number of territories multiplied by two gave the number of breeding birds per 15.5 ha.

Censusing began 4 June and ended 9 August 1973. I sampled for up to three hours beginning ½ hour after sunrise, which corresponds to the highest avian activity period. Each line in the study plot was followed six times per month, providing essentially equal coverage for the entire area. For most birds, territorial defense declined or was non-existent in August, making the spot-map method unreliable. Therefore, an average of the June and July values was used to determine densities from the spot-map data.

RESULTS

Avian densities are given in table 1. Using either method, the Yellow-rumped Warbler was the most abundant species. Density estimates differed significantly ($P < 0.01$, Chi-square test) between the two methods, the spot-map method yielding higher densities for all species except the Broad-tailed Hummingbird, Common Flicker, Red-breasted Nuthatch, Pygmy Nuthatch, and Gray-headed Junco. I estimated the total density to be 1589 birds per 100 ha by the spot-map technique and 1145 per 100 ha by the variable strip transect method.

DISCUSSION

Both censusing techniques have advantages and disadvantages. With the variable strip method, one person can sample large areas easily. According to Emlen (1971) only 3 replications are needed, whereas 10 are recommended for the spot-map method. Variations in detectability among species and between sexes are taken into account to a certain extent. Once CD values have been established, a similar habitat can be quickly censused. Also, all birds, both breeding and nonbreeding, are censused (including fledglings).

However, there are problems with the variable strip method. Males involved in territorial advertisement become less conspicuous as the breeding

TABLE 1. A comparison of avian densities (number per 100 ha) in a mixed-conifer forest using the variable strip transect and spot-map censusing techniques.[a]

Species	Transect	Spot-map
Turkey Vulture, *Cathartes aura*	0	6.8
Great Horned Owl, *Bubo virginianus*	3.4	13.2
Flammulated Owl, *Otus flammeolus*	0	26.4
Broad-tailed Hummingbird, *Selasphorus platycercus*	14.7	13.2
Common Flicker, *Colaptes auratus*	32.8	26.3
Yellow-bellied Sapsucker, *Sphyrapicus varius*	6.7	26.3
Williamson's Sapsucker, *S. thyroideus*	0	6.8
Hairy Woodpecker, *Dendrocopos villosus*	15.8	29.5
Downy Woodpecker, *D. pubescens*	4.5	13.2
Northern Three-toed Woodpecker, *Picoides tridactylus*	3.4	6.8
Dusky Flycatcher, *Empidonax oberholseri*	4.6	6.6
Western Flycatcher, *E. difficilis*	106.9	118.4
Violet-green Swallow, *Tachycineta thalassina*	0	6.6
Steller's Jay, *Cyanocitta stelleri*	19.3	39.5
Clark's Nutcracker, *Nucifraga columbiana*	3.4	P
Mountain Chickadee, *Parus gambeli*	105.6	111.8
White-breasted Nuthatch, *Sitta carolinensis*	4.5	6.6
Red-breasted Nuthatch, *S. canadensis*	9.0	6.6
Pygmy Nuthatch, *S. pygmaea*	16.4	6.6
Brown Creeper, *Certhia familiaris*	64.6	98.7
House Wren, *Troglodytes aedon*	0	65.8
Hermit Thrush, *Catharus guttatus*	98.5	177.6
Golden-crowned Kinglet, *Regulus satrapa*	49.8	65.8
Ruby-crowned Kinglet, *R. calendula*	171.2	177.6
Warbling Vireo, *Vireo gilvus*	30.6	52.6
Orange-crowned Warbler, *Vermivora celata*	2.2	6.6
Yellow-rumped Warbler, *Dendroica coronata*	259.9	329.0
Red-faced Warbler, *Cardellina rubrifrons*	20.4	26.3
Western Tanager, *Piranga ludoviciana*	2.2	19.2
Pine Siskin, *Spinus pinus*	7.9	19.8
Gray-headed Junco, *Junco caniceps*	86.2	79.0
TOTAL	1145	1589

[a] A "P" indicates that the species was present.

season progresses. Males of some species become less vocal once the females begin incubating or the young hatch. It is difficult to distinguish such a non-singing territorial male from any other male who may wander through the area. Conspicuousness of females also declines beginning with incubation. Shyness of some species such as the Hermit Thrush makes it extremely difficult to detect them even at close range. These factors may make it difficult to arrive at a reliable CD and may substantially affect the overall population estimate. The calculation of the densities is another problem. The CD depends upon the distance of each bird from the transect line and the absolute detectability of the bird. I assumed that all birds were detected within the strips on either side of the transect line bounded by the point of inflection in the distribution curve. In an area with fairly dense vegetation, this assumption may not be valid. If not, the total density value will be less than the actual number. This may account for the lower densities estimated using the variable strip transect count versus the spot-map method. Thus, the data from the former should be multiplied by a basal detectability value (see Emlen 1971). However, this conversion factor will be only as accurate as the results derived from another sampling method.

Emlen (1971) noted several other problems with the variable strip transect method. Identification skill of the observer, observation conditions such as weather, and misjudgment of distance are further sources of error. Also, with only three trips through the study area, a species may be missed, as was the case with the House Wren in my study.

Emlen (1971) recommended comparing data for singing males $\times$ 2 with results obtained from all other observations and adopting the higher value. I suggest that one rely on the highest number of observations in one of three categories (singing male data $\times$ 2, all other observations, or total observations). In some cases there may be a high number of "all observations other than singing male" but after singing male data are multiplied by 2, the latter may be greater. However, if the singing male data are instead added to all other observations, the resultant value may be the highest. Also, multiplying the territorial singing male data by 2 may underestimate the population size since the non-singing, territorial males are not included. Furthermore, if all observations are considered, including singing and nonsinging territorial males, the population may still be underestimated since females may be under-represented because of nesting activities.

In addition, if avian densities vary annually, during years of high densities, territories may be compressed and territorial males more vocal, thus increasing their detectability. Hence, a new CD would have to be calculated. Furthermore, CD values may vary seasonally.

As for the spot-map method, one advantage is that if territorial males are accurately counted, the num-

ber of breeding birds can be reasonably predicted, but this is not easily done. On the other hand, in interpreting spot-maps it is useful to know territory size. However, for many birds territory size is not well-known and varies with many circumstances such as habitat, breeding bird density, and individual differences in aggressiveness (Schoener 1968). This is not usually a problem for species with low densities since territories may be more widely spaced. With high density species, however, such as the Yellow-rumped Warbler and Ruby-crowned Kinglet in Willow Creek, it was difficult to delimit one territory from all adjacent ones. If territory size is underestimated, population density will be too high. This may account, in part, for the discrepancy in density estimates for some species when comparing the variable strip transect to spot-map results.

Kendeigh (1944) criticized the use of singing males to indicate number of breeding pairs since a considerable proportion of them may be unmated. For example, he found that 9% of the singing male House Wrens were unpaired. Variation in degree and strength of vocalizations occurs among species. The spot-map method does not distingush between paired and unpaired birds and does not consider variation in adults or territories during the raising of second broods (Kendeigh 1944).

Mapping territories is time consuming and requires at least three readings through the study area per month; Kendeigh (1944) indicated that five per breeding season were necessary. In addition, certain members of the population are not counted, such as the non-breeding adults and the fledglings. Toward the end of the breeding season territories begin to break down and accuracy of spot-mapping declines rapidly. One big drawback to spot-mapping is that it is applicable only when birds are reproducing. For most species, this is the only time that singing occurs and territories are maintained.

The method used should depend upon the circumstances. In situations where dense vegetation may hamper detectability, resulting in underestimation of population size, the spot-map method may be more accurate. Availability of personnel may be a consideration because the transect method requires less time and fewer observers to census a given amount of habitat. I thank John T. Emlen and Robert D. Ohmart for helpful suggestions on improving the manuscript. I am grateful to the U. S. Forest Service for supplying the funds for the field research (16-382-CA).

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A LOCAL OCCURRENCE OF AVIAN POX IN THE HOUSE FINCH

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Avian Pox is a viral infection of birds characterized outwardly by proliferative, warty lesions commonly on legs, feet, eyelids, and at the base of the bill (Karstad, *in* Davis et al., Infections and parasitic diseases of wild birds, Iowa State Univ. Press, 1971). Infections of the mouth and upper respiratory tract are also known but less easy to identify, at least in wild birds. Although firm figures on mortality rates in nature are unknown, Karstad maintained that pox in wild birds is a mild disease where lesions eventually heal and abnormally proliferated epithelium sloughs off. Large lesions that completely occlude the eyes or are subject to injury, bacterial infection, and hemorrhage are more conducive to death in the host.

Although pox has been reported in 24 species of Fringillidae (Kirmse, Div. Zoonoses and Wildl. Dis., Ontario Vet. College, Publ. No. 49, 1967; Savage and Dick, Condor 71:71, 1969), the only record we know of for occurrence in the House Finch (*Carpodacus mexicanus*) is that of Warner (Condor 70:101, 1969) for introduced populations on Kauai in the Hawaiian Archipelago.

House Finches are commonly observed at garden feeders in and around the Santa Barbara area, and occasional birds with tumors or suspected lesions on the head or legs have been seen from time to time in past years (W. Abbott, pers. comm. and others). However, in the winter of 1972–73 a particularly heavy outbreak occurred and an unusually high number of sight records of deformed birds was received. In response to inquiries by one of us (GH), approximately 40 cases were reported by bird watchers from Atascadero to Huntington Park, California. It is impossible to compare this figure to what might take place in a "normal" year as no systematic attempts to record the occurrence of suspected pox-induced lesions and tumors have been made. However, through personal communication, we obtained a clear impression that there was a great increase in the occurrence of deformed birds seen in the wild.

During December 1972 and January 1973, mist nets and traps were set up near the Santa Barbara Museum of Natural History to capture live House Finches. Of 24 males captured and maintained in captivity, 5 had observable pox lesions (fig. 1) and died within a few weeks of being kept in captivity; 2 died from unknown causes. Of 18 females captured, 2 died with observable lesions and 5 died from unknown causes. Thus, of the total number of House Finches captured, 17% died with pox lesions. No birds with observable lesions recovered. The high incidence of mortality may have been due in part to the added stress of being in captivity. However, some birds were