

fairly common in the city, were seen only three times for a total of 6. This is the 18th consecutive count in the area. The identical route was covered each day to limit the variables to temperature and cloud cover. The trees in the area are predominantly White Oak, and the removal of a few more dead Am. Elms was the only physical change.—WOODWARD H. BROWN, 432 Tona-wanda Drive, Des Moines, Iowa, 50312.

56. SUBURBAN NATURE CENTER.—**Location:** El Dorado Nature Center, Long Beach, California. Bounded on the north by Spring Street, south by Willow Street, east by the Long Beach Tree Farm, west by the San Gabriel River. **Size:** 85 acres, rectangular, ½ mile north-south, ¼ mile east-west. **Description of Area:** See AB 25:656 (1971), census no. 39 (Ponds in Irrigated Park). **Weather:** Winters are clement, night temperatures rarely below freezing, usually above 45°F., day temperatures up to 75° but usually around 60°. Rain-fall variable in winter but can be expected in December and January in the form of storms which drop 2-5 in. in several days. This year there was heavy rain during the last week in December and none in January. **Coverage:** Dec. 11; Jan. 5, 12, 19, 25; Feb. 2, 9. Total: 7 trips, all between 8 and 11 a.m., averaging 150 minutes each.

Count: House Finch, 51 (60); Am. Coot, 31 (36); White-crowned Sparrow, 30 (35); Am. Widgeon, 23 (27); Shoveler, 22 (26); Mallard, 16 (19); Canvasback, 13 (15); Ruddy Duck, 13 (15); W. Meadowlark, 12 (14); Am. Goldfinch, 11 (13); Lesser Goldfinch, 10 (12); Pied-billed Grebe, 6 (7); Pintail, 6 (7); Anna's Hummingbird, 6 (7); Red-shafted Flicker, 5 (6); Audubon's Warbler, 5 (6); Song Sparrow, 5 (6); Gadwall, 4 (5); Spotted Dove, 4 (5); Loggerhead Shrike, 4 (5); Yellowthroat, 4 (5); Ring-necked Duck, 3 (4); Cinnamon Teal, 2 (2); Sparrow Hawk, 2 (2); Killdeer, 2 (2); Mourning Dove, 2 (2); Hermit Thrush, 2 (2); Starling, 2 (2); Green Heron, 1 (1); California Quail, 1 (1); Ring-necked Pheasant, 1 (1); Belted Kingfisher, 1 (1); Black Phoebe, 1 (1); Com. Crow, 1 (1); Mockingbird, 1 (1); Robin, 1 (1); Blue-gray Gnatcatcher, 1 (1); Snowy Egret, +; Redhead, +; White-tailed Kite, +; Sharp-shinned Hawk, +; Cooper's Hawk, +; Red-tailed Hawk, +; Red-shouldered Hawk, +; Sora Rail, +; Com. Gallinule, +; Com. Snipe, +; Long-billed Marsh Wren, +; Ruby-crowned Kinglet, +; Orange-crowned Warbler, +; Red-winged Blackbird, +; Rufous-sided Towhee, +; Golden-crowned Sparrow, +; Lincoln's Sparrow, +. **Average Total:** 304 birds (density, 358 per 100 acres).—BARBARA W. MASSEY, 1825 Knoxville Ave., Long Beach, Calif. 90815.

AN APPRAISAL OF THE WINTER BIRD-POPULATION STUDY TECHNIQUE

Chandler S. Robbins*

INTRODUCTION

In the July 1947 issue of *Audubon Field Notes* (1:165-166), the first announcement was made of the National Audubon Society's Winter Bird-Population Study. The stated objective was to determine the number of birds wintering in a measured area of a certain type of habitat, using standardized procedures. Instructions for cooperating in this activity and for reporting results were included in the announcement. Studies were conducted on 20 plots during the winter of 1947-48, and the results were published in the May 1948 issue. Revised instructions appeared in 1950 (*AFN* 4:183-187), and these instructions are still in effect.

Now that these winter counts have been conducted for 25 years, it would seem appropriate that some studies be conducted on the effectiveness of the method and thought be given to possible improvements in the procedures used.

The purpose of this paper is to review some of the variables that influence the counts and to dis-

cuss the results of counts taken in two plots under standardized conditions, with special reference to the number of trips required.

STUDY PLOTS

The two plots selected for this appraisal are Numbers 8 and 9 in this issue of *American Birds*. The plots are adjacent to each other along the Middle Patuxent River valley at Columbia, Howard County, situated in the Piedmont of central Maryland. Plot No. 8 is a Hickory—Oak—Ash Floodplain Forest, and Plot No. 9 is an Upland Tulip-tree—Maple—Oak Forest.

Both plots are in fairly mature hardwood forest so that most of the species found in one plot also occur, though in different density, in the other plot. Thus, the relative conspicuousness on morning versus afternoon counts for most species can be studied independently on both plots.

Since the two plots are contiguous, the birds on them are subject to the same weather conditions; thus, any early singing or courtship behavior should begin on both plots at about the same time. Another advantage in having the two plots adjacent to each other is that while censusing one

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plot, additional observations can often be made on the other, giving an opportunity to detect birds that were missed on some or all of the regular trips through each plot.

METHODS

Eight census trips were taken through each plot, along grid lines 250 feet apart. All birds seen or heard were plotted on detailed field maps marked with 5-foot contours. In order to eliminate as many variables as possible, all trips in both plots were made by the same observer, under favorable weather conditions, and during standardized time periods. All trips in a given plot started at the same point and proceeded along the same route.

Weather conditions were standardized as much as possible in that precipitation and high winds were avoided. Wind speeds were less than five miles an hour on seven out of eight coverages in each plot.

Since one objective of the study was to compare morning coverage with afternoon coverage, four trips were taken in each area starting at approximately sunrise and four other trips were taken in each plot in the afternoon, so planned as to end shortly before sunset. Trips in the floodplain plot averaged 3 hours, 40 minutes, and those in the upland plot averaged 2 hours, 31 minutes.

The census period (January 8 through February 10) was carefully chosen so as to avoid any late fall or early spring migration and also to avoid the beginning of the song period. High water, which would have increased the noise factor, was carefully avoided (partly because of the necessity of wading the Middle Patuxent River to get from one side of the floodplain study plot to the other).

PROBLEMS IN ESTIMATING POPULATIONS

It is, of course, impossible to obtain exact counts of birds present at a given time within a heavily forested habitat in midwinter. The daily feeding territories of a great many of the birds take them outside of the study plot for at least part of any day, and some species do a great deal of wandering and are not even associated with a definite territory throughout the winter period. Therefore, birds may be missed on one trip and perhaps counted twice on another trip. Thus, even when the observer, the starting time, the rate of forward progress, the route covered, and the weather are as similar as possible, the bird population within the limits of the study plot is probably never the same from one day to another.

There is also another very important factor to consider. Some species are relatively easy to de-

tect because of large size or loud or frequent calling, whereas other species call comparatively seldom and are secretive in their habits. The observer can learn to adjust for duplication in the case of conspicuous wide-ranging species, but it is less easy to adjust for those relatively silent or secretive species that are infrequently observed.

In the statistical treatment that follows, I have had to assume that the counts obtained each day are reasonably representative of the birds present. I know of specific cases where this was not true, especially in the response of birds to imitation of their calls or "squeaking." White-throated Sparrows responded beautifully on the *first* trip in each plot, but they reacted less and less on subsequent trips. It was impossible to get accurate counts in the dense undergrowth except by attracting the birds into view, so the means based on all trips are known to be too low, perhaps by as much as 30 to 50 per cent.

RESULTS

Time of Day

Since one of the objectives of Winter Bird-Population Studies is to make comparisons between different habitats, then the average totals should reflect the average use throughout the day rather than the highest count that could be obtained for each species if the counts were made at the most suitable time of day for that particular species. If some trips are taken in the morning and some in the afternoon, and if a species were equally conspicuous in both morning and afternoon, the mean population for that species would be the average between the morning and the afternoon counts. Since many species are more conspicuous in the early morning hours than they are in mid-afternoon, however, a knowledge of the habits or relative conspicuousness of the species may be important to the investigator who is trying to decide whether a lower count in the afternoon means a lower population or simply less activity on the part of the species.

In order to compare morning and afternoon counts, I ran an analysis of variance for each species, comparing the four morning trips in each plot with the four afternoon trips. Since the plots are of unequal size (45.5 acres for the floodplain and 29.6 acres for the upland), I multiplied all upland counts by a correction factor (1.54) so differences in density between the two plots also could be detected. The average of the total number of birds recorded (for all species combined) was significantly higher (at the 99% level of probability) in the morning than in the afternoon. The total individuals recorded in the floodplain plot were 20% higher in the morning than in the afternoon, and in the upland, 47% higher in the morn-

ing than in the afternoon. Although almost all species averaged higher on the morning counts, there were only two species that showed *significantly* higher counts in the morning than in the afternoon: Blue Jay and Evening Grosbeak. Only two species, the Golden-crowned Kinglet and Slate-colored Junco, were consistently more conspicuous in the afternoon than in the morning in both plots. We may assume that for most species the afternoon counts are less accurate than the morning counts and that a better measure of the actual number of birds present may be obtained by using only the morning counts to compute the average.

Following the above assumption, Table 1 was constructed to compare the population density (birds per 100 acres) computed in the traditional manner (the mean of all counts, morning and afternoon) with that computed on the basis of morning counts only, for those species that were recorded in greater numbers in the morning in *both* plots (or greater in one plot and equal in the other). If the afternoon average was greater in either or both plots, the original figures were retained. To maintain greater accuracy, no rounding of numbers was done until after the density had been computed.

Total Species

The total number of species recorded on a Winter Bird-Population Study is closely related to the number of trips the observer takes in the study

plot. In fact, after 4 or 5 trips have been conducted, the investigator can plot the cumulative species totals on semi-logarithmic paper (so the points will fall approximately along a straight line) and make a good estimate as to the number of additional species that are likely to be found as a result of any given number of additional trips. These predictions hold, of course, only as long as census conditions remain stable; the arrival of spring migrants will invalidate both the predictions and the census results.

In each of the two plots under discussion, all but one of the species recorded in 8 trips had been found on one or more of the first 4 trips. This suggests that in deciduous woodland about 20 minutes of field work *per acre* spread over four trips is the minimum required to find nearly all of the species (97% in these two plots) that would be observed in twice that amount of time.

The cumulative number of species found (y) approximates a parabolic curve of the form $y = a + b\sqrt{x}$ where x is the number of trips and a and b are constants that must be computed separately for each study by solving simultaneous equations (one for the first trip and one for the last). This formula gives a closer estimate than the logarithmic plot mentioned above, and will enable the investigator to determine how productive any given number of additional trips will be. An even better approximation can be obtained by using $y = a + b\sqrt[4]{x}$.

Table 1. Densities (birds per 100 acres) as a Function of Time of Day

	Floodplain Forest		Upland Forest	
	Mean of all 8 trips	Mean of 4 morning trips	Mean of all 8 trips	Mean of 4 morning trips
Myrtle Warbler	119	124	20	35
Carolina Chickadee	35	38	27	30
Cardinal	37	42	17	20
Evening Grosbeak	24	42	3	4
Yellow-shafted Flicker	15	17	3	4
Purple Finch	9	10	7	9
Yellow-bellied Sapsucker	7	10	+	1
Blue Jay	7	9	3	5
Carolina Wren	4	4	7	8
Ruby-crowned Kinglet	4	7	0	0
Common Crow	2	2	3	4
Robin	2	3	0	0
Eastern Bluebird	2	3	0	0
Total, 13 species above	267	311	90	120
Total, other species, unchanged	164	164	69	69
Total, all species	431	475	159	189
Increase in population estimate		10.2%		18.9%

*Relation Between Number of Trips
and Accuracy of Population Estimate*

The Winter Bird-Population Study Instructions call for taking "at least 6 census trips (preferably more)." Many observers take only 6, but a few take a dozen or more. One of the purposes of the present study was to examine the day-to-day variability in the counts and see whether the recommended minimum of 6 trips is realistic.

In Table 2 are listed all species with a mean count of 5 or more individuals in one or both plots. The cumulative means for 1 trip through 7 trips have been compared with the mean obtained from all 8 trips, and the percentage departures from this mean are given in the last 7 columns of the table. As soon as the departure has decreased to (and remained below) 5 percent, the figures are presented in italics.

By the fifth trip most species had stabilized to within 10 percent of their final value, the principal exception being the Myrtle Warbler, which showed a very sharp decline in the upland study plot near the end of the counting period when the supply of berries became exhausted. About two-thirds of the species in Table 2 were within 5 percent of their final count after 7 trips. The principal exception was the Slate-colored Junco, which

traveled in flocks and was entirely absent from the plot on some days. For species with fairly stable populations of 5 or more individuals, it would seem that 8 trips would give very satisfactory results.

But if results for the next 9 species are examined—those species represented by 2 to 5 individuals—only 5 of them had settled down to a variability of less than 5 percent by the 7th trip. Thus, 8 trips would be the very minimum for getting a close approximation of the (minimum) average population of species represented by 2 to 5 individuals.

With an average of less than 2 individuals of a species, the percentage variability is of necessity quite high unless the number of trips is so high as to be impractical.

CONCLUSION

The present Winter Bird-Population Study method, when used in dense deciduous woodland, tends to provide an under-estimate of the wintering bird population, even under ideal weather conditions. This results from: (1) inability to see all birds that are present; (2) changes in conspicuousness of the birds as the day progresses; (3) reduction of response to imitation or "squeaking" after repeated exposure; and (4) a greater chance of missing a bird than of counting it twice.

Table 2. Increase in Accuracy of Estimate as Number of Trips Increases¹

	8-trip Mean	Percentage Departure from 8-trip Mean						
		1 trip	2 trips	3 trips	4 trips	5 trips	6 trips	7 trips
<i>Floodplain (45.5 acres)</i>								
Myrtle Warbler	53.5	- 2	+15	0	- 3	- 2	+ 3	+ 3
Downy Woodpecker	18.0	- 55	-22	-12	-10	- 5	- 2	+ 2
White-throated Sparrow	17.5	- 26	+ 9	- 1	0	+ 2	+ 6	0
Cardinal	17.0	- 43	+ 9	- 7	+18	+12	+11	+ 7
Carolina Chickadee	15.5	- 48	-29	-16	- 8	- 5	- 2	- 4
Slate-colored Junco	11.4	+ 93	- 4	+64	+23	+ 7	-11	-20
Evening Grosbeak	11.1	- 91	-10	-40	+ 4	- 1	+25	+11
Yellow-shafted Flicker	6.9	+ 1	+30	+11	+16	+ 4	+ 6	+ 8
Tufted Titmouse	6.4	- 38	- 45	- 1	+ 2	- 9	- 9	- 2
Red-bellied Woodpecker	5.9	- 32	+ 2	- 9	+ 2	+ 6	+ 5	+ 2
Total Individuals	194.00	- 21	0	+ 1	+ 3	+ 1	+ 3	+ 1
<i>Upland (29.6 acres)</i>								
Carolina Chickadee	8.3	- 4	+ 2	- 8	- 4	- 8	- 8	- 2
Myrtle Warbler	6.1	- 51	+130	+75	+80	+44	+34	+15
White-throated Sparrow	6.0	+133	+ 50	+22	+ 4	-13	-11	- 5
Cardinal	5.4	- 7	- 17	-26	- 7	- 7	- 4	- 2
Total Individuals	48.75	+ 1	+ 29	+12	+14	+ 2	+ 1	0

¹ Italicized figures indicate that departure from the 8-trip mean has dropped to 5 percent or less; no statistical significance is implied.

The time of day bias could be controlled by either reporting separate estimates for different times of the day, or, when the difference is known to be a result of missing birds that are continually present (rather than birds that feed outside the study plot during part of the day), by computing the population from only those trips taken at the optimum time of day. This latter procedure seems preferable. In the present study, it increased the accuracy by 10 percent in one plot and 19 percent in the other. Unfortunately, there does not seem to be any way to apply a mathematical correction to the other biases.

A minimum of 6 trips was quite ample to record nearly all of the *species* that were resident in the study plot, but additional trips continued to detect irregular visitors and wide-ranging species such as hawks and owls.

Although the *total* population estimate was not improved appreciably after the 6th trip, mean population densities for all but the commonest species still had not stabilized after 8 trips. Thus, to obtain valid population estimates on an individual *species* basis, at least 8 or 10 trips would be required.

It is recommended that similar studies be conducted in other habitats, in both large and small plots, and in other parts of the continent, preferably based on 10 or 12 trips rather than 8 trips per plot. On the basis of such studies, sound recommendations can be made for improving the Winter Bird-Population Study instructions.

Going Places

Following is a partial listing of birding and wildlife tours scheduled for the months of August–November, 1972. It has been compiled from information supplied by tour sponsors, and *American Birds* is not accountable for any subsequent changes in plans or prices. Prices are usually the base prices quoted; there are usually minor additional costs. Tour sponsors are listed by key initials; full names and addresses, to which all inquiries should be addressed, will be found at the end of the listings. Tours scheduled for December–February will be published in the October issue of *American Birds*. Deadline for information is September 1, 1972.

AUGUST

- 1 and alternate days through Oct. 20, Nov. 9, 23.—East Africa Wing Safaris. 21 days. Birds, wildlife. Leaders, local experts. \$1680 plus air fare. LT.
- 1—East Africa. 21 days. Birds, wildlife. Leader not announced. \$1620 incl. air fare from Toronto. FON.
- 2—Southeastern Arizona. 10 days. Birds, natural history. Leaders, Chris Leahy and Chuck Roth. \$445 from Tucson. MAS.

BIRDING TOURS TO EXCITING PLACES



Small groups. Kindred spirits. Tour director ornithologist Annette C. Koon and local experts. Write for details.

ROADRUNNER NATURE TOURS, BOX 945, GAINESVILLE, TEXAS 76240

CANADIAN ROCKIES. OLYMPIC PENINSULA. 15 DAYS. AUG. 19 — SEPT. 3. Mt. Rainier, Lake Louise, Jasper, Vancouver, Puget Sound, and the fabulous Olympic Peninsula. \$800.

AUSTRALIA. 5 WEEKS OF FANTASTIC BIRDING. SEPT. 23 — OCT. 28. Brisbane, Darwin, Arnhemland, Katherine and the interior. Perth, Kerri Forests. South Coast. Alice Springs, Ayers Rock. Great Barrier Reef. Sydney, and more. \$2650 from San Francisco.

NEW ZEALAND. 3 WEEKS EXTENSION OF ABOVE TOUR. OCT. 28 — NOV. 18. Both islands, best birding areas, spectacular scenery. \$1695.

CHRISTMAS IN MEXICO. 11 DAYS. DEC. 23 — JAN. 2. Central highlands, Mexico City. Popo, Taxco, Patzcuaro, Urapan, Guadalajara. \$650.