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Bird population and habitat surveys in urban areas

Richard M. DeGraaf[a], Aelred D. Geis[b] and Patricia A. Healy[b]
[a]*USDA Forest Service, Northeastern Forest Experiment Station, University of Massachusetts, Amherst, MA 01003, USA*
[b]*Patuxent Wildlife Research Center, US Fish and Wildlife Service, Laurel, MD 20708, USA*

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ABSTRACT

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Breeding bird populations in six habitats in Columbia, MD, were studied to develop procedures suitable for measuring bird use of residential areas and to identify habitat characteristics that define the distribution of various common bird species. A procedure to measure bird use based on 4-min transect counts on plots measuring 91 m × 91 m proved better than point counts. Transect counts reduced many of the problems associated with counting birds in urban areas, such as varying noise and visibility. Eighty percent of observations were recorded in the first 4 min. Habitat measurement procedures were examined also. It was found that a subsample of woody tree and shrub crown volumes made on 0.2 ha was highly correlated with similar measures made on 0.8-ha plots.

INTRODUCTION

People have their most frequent contact with birds around their homes and work areas. Substantial pleasure and educational opportunity is afforded by these observations of wildlife; thus, there is a special need to understand bird populations in such areas. Recent nationwide surveys (US Department of Interior, Fish and Wildlife Service (USDI), 1982) indicate that 79.7 million Americans observe wildlife in residential areas. More than 8 million feed birds, spending more than $1.3 billion on seed-related items (USDI, 1988).

Habitats associated with human dwellings are different from the natural environment in which most bird studies have been made. Bird population changes that occurred during the development of the town of Columbia, MD, were studied from 1966 to 1971 (Geis, 1974). Although dramatic changes occurred as the area urbanized, little information was obtained on the specific habitat factors responsible. Also, it became evident that traditional bird survey methods such as spot mapping, developed for use in rural areas, were unsatisfactory in urban areas owing to noise, limited access and visibility, high proportions of non-territorial bird species, and logistical problems.

The objective of the present study was to develop a bird survey procedure that was suitable for urban areas that permitted an efficient study of the relationships between habitat and bird populations. Preliminary counts yielded striking differences in bird populations in various parts of Columbia. For example, counts in areas of single-family, detached homes and no original trees were so variable that they were segregated into three groups of species representing low, medium, and high bird densities (Geis, 1974). These differences emphasized the importance of a better understanding of the factors in the urban environment that cause differences in bird populations.

To identify a suitable procedure for measuring bird populations, it was necessary to consider problems that tend to be more important in urban areas than in the more natural situations usually studied. These problems include an abundance of non-territorial species such as European starlings and house sparrows (scientific names are given in Table 1), varying amounts of noise that create biases in techniques requiring auditory cues, and striking differences in visibility among neighborhoods caused by varying densities of housing and vegetation. In urban areas the presence of roads, lawns, and wires causes a non-random bird distribution which complicates transect methods based on observation distances (Emlen, 1974). Also, there was need to relate the bird counts specifically to habitat measurements on defined areas. If all birds heard singing are counted, reference areas are poorly defined: birds with loud songs relate to much larger areas than do species that sing or call more softly.

A sampling procedure was needed to obtain an index of bird use of each sample plot. Several problems needed resolution: whether the counts should be made from a single point or along a transect and whether a fixed or variable plot size (defined by some measurement of the distance birds could be seen) should be used. Point counts are essentially transect counts conducted at zero speed (Burnham et al., 1981); furthermore, the assumptions that apply to one apply to the other (Verner, 1985). If a fixed plot size were used, what should the size of the plot be? Goldstein et al. (1986) reported that total woody vegetation crown volume, measured on 1-ha plots, accounted for about 50% of the variation in suburban breeding bird species richness. It would be useful to know if such habitat features could be reliably represented on smaller plots for efficient sampling of urban habitats where dwelling densities are high.

TABLE 1

Scientific names of birds occurring in Columbia, MD, 1973

Mourning dove (*Zenaida macroura*)
Downy woodpecker (*Picoides pubescens*)
Eastern wood-pewee (*Contopus virens*)
Barn swallow (*Hirundo rustica*)
Blue jay (*Cyanocitta cristata*)
Carolina chickadee (*Parus carolinensis*)
Carolina wren (*Thryothorus ludovicianus*)
Wood thrush (*Hylocichla mustelina*)
American robin (*Turdus migratorius*)
Northern mockingbird (*Mimus polyglottos*)
European starling (*Sturnus vulgaris*)
Red-eyed vireo (*Vireo olivaceus*)
Northern cardinal (*Cardinalis cardinalis*)
Chipping sparrow (*Spizella passerina*)
Song sparrow (*Melospiza melodia*)
Common grackle (*Quiscalus quiscula*)
Brown-headed cowbird (*Molothrus ater*)
Northern oriole (*Icterus galbula*)
House sparrow (*Passer domesticus*)

From American Ornithologists' Union (1983).

STUDY AREA AND METHODS

The variation in habitats found in the new city of Columbia, built in the late 1960s, made it an excellent place to study the effect of urban habitat on bird populations. Columbia consists of different kinds of neighborhoods, but within each neighborhood, building design, construction characteristics, and past land-use histories were similar. Thus, cluster sampling could be conducted efficiently in contiguous plots of similar habitat. Six study areas were identified representing large differences in the density of development and the amount of woody vegetation.

Areas A and F were the most "natural" of the study areas, much of the original deciduous forest remained on the lots. Deciduous trees and shrubs were more mature in these two study areas than in the others in Columbia; coniferous trees were almost completely absent. Coniferous shrubs had been planted by homeowners. The major difference between these two study areas was in building design. Area A contained homes with "unboxed" eaves, whereas eaves in Area F were boxed.

Areas B and D consisted of detached homes built in open fields. No natural vegetation remained. The major difference between these two areas was also in building structure. Some of the homes in Area B had widely louvered vents in their exterior attic walls whereas homes in Area D did not.

Area C was located in a townhouse complex. Most woody plants were coniferous; a few original deciduous trees remained along streams. These townhouses were constructed with unboxed eaves.

Area E was located in two apartment complexes, and had the highest number of dwellings. Shrubs were few; a few original deciduous trees had been retained. Building structure included unboxed eaves and lattice work covering air conditioning units.

During the period 2 June to 3 July 1973, we employed two separate urban bird survey procedures. To facilitate these surveys, six observation points and six 91-m transect segments were located in the centers of roads through each of the residential developments. Ten 5-min counts were made between 05:00 and 08:00 h on clear, calm mornings. Counts from transect lines observation points, located 91 m apart at the center of each 91 m segment, were paired on the same day.

Aerial photographs (1970) were obtained at a scale of 1 cm = 10 m for each of the study neighborhoods. The sample-plot boundaries, observation points, and transect lines were marked on them. Clear acetate was placed over each photograph and the location of each bird observation marked on it with a number. The relationship of the observation point or transect line to the number permitted the observation distance to be measured later. We measured observation distances from points and right-angle distances from transect lines. For each bird observation, data were recorded on the location of each bird, habitat use, the minute of detection within the 5-min observation period, and whether detected by song or by sight. The 5-min observation interval was used because of the time required to record the many detailed observations made during this survey.

Habitat measurements were made during August 1975 by obtaining a complete measure of the amount of each habitat variable on each 0.8 ha square plot following the procedure of Thomas et al. (1977). Variables also were measured on a circular 0.2 ha subplot located in the center of each plot in order to compare the complete inventory with data collected on a portion of the bird survey areas. Habitat variables included deciduous and coniferous tree and shrub volumes, calculated from field measures described by Mawson et al. (1976).

RESULTS AND DISCUSSION

Bird surveys

The maximum distance at which birds usually can be seen or heard is an important consideration in defining the size of sample plots. Observation distances recorded from points and transect lines during the spring of 1973 are summarized in Fig. 1. The relatively few birds seen at more than 91 m from points in the streets were not recorded. Ninety-four percent of the observations were made within 64 m of a survey point; 76.8% within 43 m. In the study-plot technique involving transect lines, only 6.9% of the bird observations were at distances greater than 46 m from the center line of the plot. The data suggest that relatively few

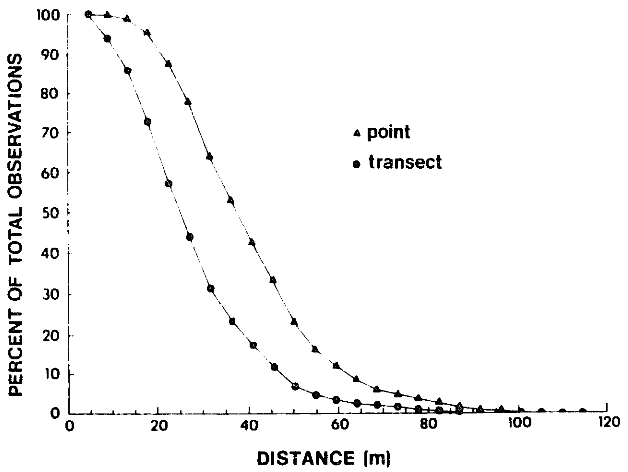

Fig. 1. Accumulative percentage of total observations recorded at various distances from observation points or transect lines.

birds were recorded at distances of more than 46 m from the midpoints of the roads running through centers of sample plots.

Table 2 summarizes the differences among species in their observed distances from observation points or the perpendicular distances from transect lines. The general pattern of these differences essentially was the same, regardless of sampling method. Species such as starlings that tend to use exposed perches, often on the tops of buildings, were observed at relatively long distances, while birds such as American robins and Carolina chickadees that use natural habitat were observed at relatively short distances. In both point and transect surveys, as shown by the observed distances for total species, the observation distances are strongly skewed (Fig. 1), making the estimates of standard deviation questionable.

With either method, the shortest observation distances were obtained by both methods in the apartment areas (Table 3). There was, however, some inconsistency in other neighborhoods, possibly because of the differences

TABLE 2

Average observed distances (m) of birds seen from observation points and average right-angle distances from transects in Columbia, MD, bird survey, June 1973

Species	From an observation point			From transect lines		
	n	$\bar{x}$ distance	SD	n	$\bar{x}$ distance	SD
Barn swallow	36	35.9	16.0	38	18.3	6.3
Blue jay	69	40.6	19.7	53	21.9	13.5
Carolina chickadee	20	27.5	11.6	21	19.3	11.5
Tufted titmouse	42	37.7	11.9	40	25.4	13.3
Mockingbird	79	37.9	18.9	82	26.2	18.1
American robin	143	34.9	13.9	100	13.[illegible]	20.8
Wood thrush	21	36.8	13.8			
Starling	765	39.4	17.0	782	27.8	16.0
House sparrow	763	30.3	14.0	714	18.3	11.9
Common grackle	87	46.2	14.8	90	28.3	17.1
Brown-headed cowbird	56	32.1	19.8	51	18.5	14.4
Cardinal	33	33.1	11.9	40	24.3	16.0
Chipping sparrow	56	40.3	17.4	43	24.9	14.2
Song sparrow	31	39.9	19.1	42	24.6	15.5
Other species	154	39.5	18.6	162	24.7	13.0
All species	2355	36.0	16.6	2258	23.4	14.8

TABLE 3

Average bird observation distances (m) in Columbia, MD, study areas, June 1973

Habitat	From observation points			Right-angle distance from transect lines		
	$\bar{x}$	SE	95% CI	$\bar{x}$	SE	95% CI
Detached homes, original trees						
Area A	37.68	0.80	36.11–39.25	21.14	0.69	19.77–22.51
Area F	37.65	1.09	35.50–39.80	24.30	0.90	22.52–26.08
Detached homes, no original trees						
Area B	37.83	0.90	36.05–39.60	23.01	1.13	20.78–25.24
Area D	37.00	1.06	34.91–39.08	31.02	0.87	29.30–32.74
Townhouses						
Area C	36.29	0.71	34.89–37.69	23.76	0.56	22.64–24.88
Apartments						
Area E	31.89	0.65	30.60–33.18	20.35	0.56	19.24–21.46

in the way the measurements were taken: observations from the transect were made at right angles even though the true distance at which the bird was noted may have been greater. Similar differences among periods within the season (Table 4) were shown by both methods. For example, sharp declines were recorded in starling counts between early June and late June–early July. After the young fledged, starlings which nested in holes in buildings left the study areas, perhaps to feed in more rural situations.

There was essentially no change in observed species composition associated with the length of the observation interval. The greatest number of observations generally were made during the first minute. About 30% of the birds were recorded during the first minute of the counting period for both survey methods. The numbers of birds counted from points in successive minutes, as percentages of the total were 30.7, 15.5, 15.2, 18.3, and 20.3; from transects, percentages were 30.0, 15.2, 16.4, 17.7, and 20.7. In both surveys, slightly higher counts were recorded during the last minute than during the second, third, or fourth, possibly because of an unconscious tendency of the observer to accumulate observations mentally and enter them at the last minute. However, in

TABLE 4

Mean number of birds …corded in sequential coverages, Columbia, MD, June 1973

Species	Date	Point		Transect	
		Mean	95% *ci*	Mean	95% *ci*
All birds other than house sparrows and starlings	2, 4–5 June	[illegible]	1.2–2.4	2.3	1.7–2.9
	6–8 June	1.9	[illegible]–2.6	2.0	1.4–2.6
	9–10, 12 June	2.2	1.5–[illegible]	3.1	2.2–4.1
	13–15 June	2.4	1.5–3.2	[illegible]	[illegible]–4.3
	16–17, 20 June	2.2	1.6–2.9	2.3	1.7–2.9
	23–25 June	1.6	1.0–2.3	2.2	[illegible]–2.8
	26–27, 29 June	2.1	1.3–2.9	1.9	1.2–2.7
	30 June, 2–3 July	2.6	1.5–3.7	2.4	1.7–3.2
House sparrows	2, 4–5 June	2.0	1.[illegible]–3.0	2.9	1.5–4.3
	6–8 June	2.2	1.2–3.2	2.4	1.3–3.4
	9–10, 12 June	2.0	1.0–3.0	2.6	1.6–3.5
	13–15 June	2.5	1.1–3.9	2.0	0.9–3.0
	16–17, 20 June	2.0	0.9–3.2	2.0	0.8–3.3
	23–25 June	2.2	1.1–3.2	2.9	1.2–4.5
	26–27, 29 June	2.7	1.3–4.0	2.3	1.1–3.4
	30 June, 2–3 July	2.7	1.2–4.1	2.3	1.1–3.5
Starlings	2, 4–5 June	2.9	1.4–4.4	3.9	2.5–5.4
	6–8 June	3.0	1.7–4.4	2.6	1.6–3.7
	9–10, 12 June	1.6	0.9–2.3	2.4	1.4–3.4
	13–15 June	1.8	1.0–2.5	2.2	1.1–3.3
	16–17, 20 June	1.9	1.1–2.8	2.6	1.4–3.8
	23–25 June	1.2	0.4–2.1	2.6	1.5–3.7
	30 June, 2–3 July	1.3	0.6–2.0	1.1	0.6–1.6
Total birds	2, 4–5 June	6.7	4.8–8.7	9.2	7.1–11.2
	6–8 June	7.2	5.5–8.8	7.0	5.6–8.4
	9–10, 12 June	5.9	4.6–7.2	8.1	6.5–9.6
	13–15 June	6.6	4.9–8.4	7.4	6.0–8.9
	16–17, 20 June	6.2	4.7–7.7	7.0	5.4–8.6
	23–25 June	5.0	3.6–6.4	7.6	5.5–9.8
	26–27, 29 June	6.0	4.2–7.8	6.2	4.6–7.9
	30 June, 2–3 July	6.6	4.8–8.3	5.8	4.5–7.2

both cases, the fifth minute accounted for only 20% of the observations. We found that birds on a 91 m plot could be surveyed effectively during a 4 min period. Similar information could be obtained from a shorter observation period, but counts during shorter time periods seemed hurried. With 4-min intervals, as many as 25–30 sample plots could be thoroughly, yet comfortably, surveyed in a morning.

The various bird species were engaged in quite different activities when recorded. Table 5 summarizes the proportion of the observations of each species that was recorded as a result of the bird having been heard singing or calling, seen flying into or away from the plot, on the ground or perching in vegetation, or on buildings or other structures such as fences. For red-eyed vireos, 91.7% were detected solely from their vocalizations while less than 5% of the barn swallows, mockingbirds, starlings, house sparrows, and common grackles were so detected. In those instances where the attention of the observer was attracted to a bird by its song or call and the bird subsequently seen, it was recorded as seen and the location (ground, vegetation) noted. These data clearly demonstrate the importance of a survey procedure that uses both auditory and visual detections because a high percentage of some observations are based solely on vocalization. Recording of birds detected solely by sound was especially important for red-eyed vireos, wood pewees, tufted titmice, Carolina wrens, wood thrushes, and Northern cardinals. The ratio of birds observed in vegetation to those on buildings reflects the different habitat characteristics of the various species. More barn swallows, chipping sparrows, and mockingbirds were seen perching on buildings than in vegetation. This also was true, as anticipated, of starlings and house sparrows.

Neighborhoods with substantial vegetation had much higher percentages of their counts based on vocalizations alone. Areas C and E had only 1% and 2%, respectively, of bird observations based on vocalizations while area F with original trees had 33% of its total observations based solely on vocalization (Table 3). Knowledge of bird call notes and songs is extremely important. Counts made during June 1975 by four different observers were compared. Three observers were experienced counters and had previously worked on bird surveys; the fourth was relatively inexperienced. The counts of the first three were essentially identical; the fourth obtained counts that were significantly higher in four areas, comparable in the townhouse study areas, and much lower in the apartment complex. The inexperienced counter also showed inconsistencies in species identification. These findings indicate that reasonably experienced counters

TABLE 5

Activities (%) of species in Columbia, MD, during June 1973 bird surveys

Species	Voice[1]	Flying	Location				Total (%)	Sample size
			Ground	Vegetation	Building	Structure		
Mourning dove	6.7	6.7	23.3	56.7	6.7	0.0	100.1	30
Downy woodpecker	16.7	8.3	0.0	75.0	0.0	0.0	100.0	24
Eastern wood-pewee	61.5	3.8	0.0	34.6	0.0	0.0	99.9	26
Barn shallow	0.0	8.1	0.0	35.1	56.8	0.0	100.0	74
Blue jay	7.4	12.3	7.4	67.2	4.1	1.6	100.0	122
Carolina chickadee	29.3	2.4	0.0	63.4	4.9	0.0	100.0	41
Tufted titmouse	54.9	1.2	0.0	43.9	0.0	0.0	100.0	82
Carolina wren	47.8	0.0	8.7	30.4	13.0	0.0	99.9	23
Mockingbird	3.1	5.6	12.4	20.5	58.4	0.0	100.0	161
Robin	8.2	5.3	25.5	49.4	11.5	0.0	99.9	243
Wood thrush	65.8	13.2	5.3	13.2	2.6	0.0	100.1	38
Starling	0.4	5.5	25.9	23.3	44.1	0.8	100.0	1547
Red-eyed vireo	91.7	0.0	0.0	8.3	0.0	0.0	100.0	36
House sparrow	1.5	3.6	22.2	24.1	46.9	1.7	100.0	1477
Northern oriole	21.2	0.0	0.0	78.8	0.0	0.0	100.0	33
Common grackle	0.6	3.4	57.1	34.5	1.1	3.4	100.1	177
Brown-headed cowbird	18.7	15.9	18.7	41.1	5.6	0.0	100.0	107
Cardinal	38.4	13.7	6.8	38.4	2.7	0.0	100.0	73
Chipping sparrow	28.3	6.1	14.1	24.2	27.3	0.0	100.0	99
Song sparrow	31.5	0.0	15.1	42.5	9.6	1.4	100.1	73
Other species	36.2	3.1	3.1	51.2	6.3	0.0	99.9	127
All species	7.9	5.1	21.3	29.9	34.8	1.0	100.0	4613

tend to make consistent counts and are not subject to substantial differences, as reported by Carney and Petrides (1957). It is important that care be taken in screening personnel for such studies.

We used the method of Thomas et al. (1977) and found that it consistently yielded estimates of plot sizes that were smaller than our effective plot size. Lucid (1974) also concluded that the use of variable plot sizes under urban conditions would add more variability than would be eliminated. Square study plots of 91 m × 91 m and centered on streets, were a practical division because only 6.9% of all possible observations were more than 46 m from the center of the street transect line. This plot size also has a practical advantage because it corresponds to the narrow ends of blocks in many cities.

There was little difference between the counts made while walking along a transect and those made from a single point. We noted, however, that counts made from points were rarely actually made from an absolutely fixed point. Observers tended to move about to some extent to improve their view of birds. Furthermore, all observers believed that birds could be seen more effectively if they moved along the transect line during the observation period. Moving through the plot made it possible to locate an unseen singing bird by triangulation and so determine whether it was within the sample area. There also was an increase in efficiency associated with walking a transect; the end of a plot was at the edge of the next, eliminating moving from point to point when counts could not be made.

A consideration in confining the sample plots to 91 m × 91 m was to lessen the potential bias associated with differences in noise from traffic, people, and points among areas. Recording singing birds no more than 46 m from

TABLE 6

Correlation coefficients (r) between tree and shrub volumes measured on 0.8 and 0.2 ha plots, Columbia, MD, June 1973

Habitat variable	r	P	Habitat variable	r	P
Conif. canopy vol. 3.1–6 m (m^3)	0.14	0.4292	Decid. canopy vol. 3.1–6 m (m^3)	0.66	0.0001
Conif. canopy vol. 6.1–9 m (m^3)	0.00	1.0000	Decid. canopy vol. 6.1–9 m (m^3)	0.67	0.0001
Total decid. shrub vol. (m^3)	0.43	0.0093	Decid. canopy vol. 9.1–12 m (m^3)	0.72	0.0001
Decid. shrub vol. 1–3 m (m^3)	0.18	0.2935	Decid. canopy vol. 12.1–15 m (m^3)	0.79	0.0001
Decid. shrub vol. 3.1–6 m (m^3)	0.48	0.0028	Decid. canopy vol. 15.1–18 m (m^3)	0.67	0.0006
Total conif. shrub vol. (m^3)	0.00	1.0000	Decid. canopy vol. 18.1–21 m (m^3)	0.54	0.00006
Conif. shrub vol. 1–3 m (m^3)	0.44	0.0066	Decid. canopy vol. 21.1–24 m (m^3)	0.25	0.1377
Conif. shrub vol. 3.1–6 m (m^3)	0.54	0.0007	Decid. canopy vol. 24.1–27 m (m^3)	0.00	1.0000
Conif. shrub vol. 6.1–9 m (m^3)	0.10	0.5733	Total conif. canopy vol. (m^3)	0.83	0.0001
Total decid. canopy vol. (m^3)	0.72	0.0001	Conif. canopy vol. 1–3 m (m^3)	0.86	0.0001
Decid. canopy vol. 1–3 m (m^3)	0.73	0.0001			

See Thomas et al. (1977) for a full description of variables and measurements.

the plot center line greatly reduced negative bias that would be expected in noisy plots. Thus, we decided to conduct counts during 4-min intervals in 91 m × 91 m blocks.

Our second objective was to evaluate the comparability of urban habitat data collected from the entire bird sampling areas vs. data collected from only a portion of it. Habitat data for this comparison were collected over the entire 0.8 ha plot and on a 0.2 ha subplot in the center of each plot and concentric with the bird survey point.

Pearson correlation coefficients were determined for each variable measured on both the habitat surveys. Approximately two-thirds of the variables show significant ($P<0.01$) correlations between the 0.8 and the 0.2 ha data, actual values are not extremely high (Table 6). Also, stepwise linear discriminant-function analyses were used to classify plots into six habitats using each data set. In all but one instance, the 0.2 ha data produced results which were as good or better than the 0.8 ha data, as indicated by the proportion of the plots correctly classified. Using the 0.2 ha data set, all discriminations were significant after only three steps. The number of plots classified correctly by functions derived from the 0.8 ha plots vs. the 0.2 ha plots differed by 5 at the most, with a mean difference of only 1.8.

These results indicate that habitat data collected on 0.2 ha plots generally provided a fair representation of the habitat on the entire 0.8 ha bird sampling areas in which they were centrally located. However, without further field study, it is uncertain what effect subsampling would have on the ability to predict bird presence or abundance. Obviously, this will vary with the homogeneity of the area, just as ability to predict from habitat data collected on the entire area will vary, among other factors, with adjacent habitat.

This study indicates that bird use of sample plots during the breeding season can be measured satisfactorily by establishing plots of 91 m × 91 m, centered on existing roads, and surveying birds on these plots during a 4 min period between 15 min before and $2\frac{1}{2}$ h after sunrise. Birds seen and heard singing on the plot are recorded. Procedures for measuring habitat in urban areas were not as thoroughly investigated as bird-use survey methods. However, data collected indicate that a subsampling procedure can be substituted for a complete measurement of habitat.

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