AN OBSERVER-SPECIFIC, FULL-SEASON, STRIP-MAP METHOD FOR CENSUSING SONGBIRD COMMUNITIES

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ABSTRACT.—In this paper I describe and demonstrate a strip-map census method designed to provide a complete record of the composition and density of a temperate-zone breeding bird community through a period covering the peaks of breeding activity of all resident species and individuals. A route transecting the area of interest is laid out, flanked on each side by an unmarked strip of a width equal to the distance at which birds can be detected (the detection-threshold distance). All birds detected during uniform listening periods on frequent, closely scheduled, early morning traverses of the route are recorded with appropriate symbols at the moment of detection on simple line maps of the route. Because species differ in the distance at which their calls and songs can be heard and observers differ in their hearing acuity, each observer has an observer-specific strip width for each species. These strip widths are determined directly from the distribution of all detection points on the census maps at the end of the season. Multiplied by the length of the strip, they give the area of the strip for each species.

The accumulations of detection-point clusters on summary maps for each species are interpreted as the territories of individual birds. Densities within the study area or segments of it are determined by dividing the number of equivalent territories (Σ wholes plus fractions) within the species-detection strip by the area of the strip. Song frequencies are determined for each individual territory holder by multiplying the proportion of listening periods during which the bird was heard by the proportion of that bird's territory that fell within the species' detectability strip.

The method provides a continuous record, divisible into segments of any desired length, of the density, song activity, and distribution of individuals of each species through its breeding season. The detection-threshold distance and song-frequency values obtained can be used as species-specific conversion factors for translating simple detection counts to bird densities. *Received 3 October 1983, accepted 9 March 1984.*

FACING an increasing demand for quantitative data on songbird populations for scientific and applied ecological studies (Ralph and Scott 1981, Dawson and Verner in press), ornithologists have depended heavily on two relatively inefficient and unreliable census methods: short-term spot mapping (Kendeigh 1944, Anon. 1969) and converted detection counts (Emlen 1971, Shields 1979, Reynolds et al. 1980). With spot-mapping, as standardized for general application (Anon. 1969), one attempts to plot the home ranges of all singing males on small but representative plots during a brief segment of the breeding season when most resident birds are stably localized and vocally conspicuous. With detection counts, one attempts to record all visible or audible birds along a transect route or at a series of observation stations; such counts can, if desired, be converted to density values (birds per unit of area) by applying areal denominators and indices of cue-production frequency.

The usefulness of spot mapping is limited primarily by the small area that can be covered by an observer in a reasonable period of time (Svensson 1978), the variation among species and individuals in the period of breeding activity within which censuses should be concentrated (Best 1981), and the subjectivity of procedures used in interpreting clusters of song-detection points as individual breeding territories (Svensson 1974, Best 1975, Oelke 1981). The usefulness of the generally more efficient detection-count method is limited primarily by problems of obtaining reliable values for areas of detectability (areas covered by the observers' hearing and vision) (DeJong and Emlen in prep.) and for rates of cue production (songs, calls, etc.) (Emlen 1977, Christman in press).

In this paper I describe a strip-map method that resembles the conventional spot-mapping method but differs in: (a) replacing the usual short-duration census period (designed to minimize the confusion of constantly changing individual activity and distribution patterns) with a continuous, season-long operation, and (b) replacing the usual, arbitrarily bounded, quadrangular plot with an elongate strip or series of strips of widths equal to twice the observer's detectability range for each bird species. For direct censusing, this method is obviously more time-consuming than spot-mapping; its advantages lie in the opportunity it provides for tracing changes in densities, composition, and individual distributions through the season and the greater completeness that results from frequent, regularly scheduled traverses of the area. It fills a need recognized by Best (1981) for combining intensive coverage with a temporal spread that includes the widely differing optimal periods of song activity of all species and individuals resident in the census area. In addition, it generates species-specific values for detection-threshold distances (and hence areas of detectability) and for cue-production rates, the two functions required for converting transect or point counts to population densities.

The Method

The primary objective of a strip-map census is to provide a complete record of the composition and density of the bird community within a selected tract of uniform or mixed habitat through a breeding season.

A long narrow strip provides a better sample (lower variance) of an area of patchy vegetation than a rectangular plot or series of plots of the same area (Grieg-Smith 1964) and is more easily and efficiently traversed, especially if the strip can be designed as a circuit returning the observer to the starting point. The observer traverses the strip daily or as often as weather conditions permit, following a fixed route along the center of the strip, and recording every bird detected by sight or sound. The length of the strip will generally be determined by the length of the period of avian vocal activity and the observer's rate of progress along the route. The width of the strip is simply the distance at which singing birds are detected on either side of the route—the detection-threshold distance (based on an all-or-none detection model as distinct from an effective-distance model) (Emlen and DeJong 1981, DeJong and Emlen in prep.). Because species differ in the distance at which they can be heard, strip widths, and hence strip areas (strip widths × strip length), will be different for each species. They may also vary from observer to observer, although audiometric data (Davis and Silverman 1960) and field studies (Emlen and DeJong 1981) indicate that individual differences are slight between observers with "full normal hearing." Observers with deficient hearing, including most people over 40 yr of age (Ramsay and Scott 1981), will inevitably have narrower strip widths, especially for species with high-pitched, thin songs (Mayfield 1966). The counts of such observers will be reduced proportionately, however, and their calculated density values will therefore be unaffected. An observer with moderately reduced hearing acuity, although acquiring less information per hour of work, actually enjoys a technical advantage in having fewer concurrently singing birds to decipher at congested listening stations and shorter distances over which to locate detection points. The sampled area is reduced, but the calculated density values are as valid as those of a young observer with maximum acuity and greater areal coverage.

Listening stations are established at fixed intervals along the route, and a closely standardized schedule is followed on each traverse, the observer alternating periods of intensive listening at the stations with slow attentive walking between them. Observers record all bird detections made at and between the stations directly on prepared outline maps by using appropriate symbols to indicate the species and type of cue detected (songs, calls, sightings). The outline maps (a fresh copy used for each traverse) indicate the position of each listening station in relation to turns or curves in the trail and to prominent landmarks (e.g. artificial markers, buildings, large trees, etc.). The preparation of detailed scale maps of the entire area, often a time-consuming operation in plot censuses, is unnecessary, but locating detection points on the outline map requires that distances, compass angles, and turns along the route be depicted to scale, a requirement readily satisfied by preparing the outline maps from good aerial photos. A tally sheet with rows for each resident species and columns for each station on the strip should be carried with the map for recording minute-to-minute progress along the route, for cross-checking with the map at the end of the traverse, and as a form on which to summarize the days's record.

Collated at convenient intervals (e.g. a week or 10 days), the data from these daily maps and tally sheets provide the material for a series of summary maps and tables that collectively trace the changes in local distribution and activity of each resident bird through the breeding season. Clusters of detection points on the summary maps for each period provide the basis for outlining individual home ranges or territories, just as they do in conventional spot-map censuses. The series of consecutive maps, in addition to providing a temporal dimension for the record, add considerable credibility to the subjective procedures necessary for interpreting detection-point clusters as individual territories by increasing sample sizes and revealing occasional adjustments in territory shape or position.

The linear form of the strip map facilitates the plotting of detection points in the field. A bird's position along the route is determined by counting steps from the nearest listening station to the point where the bird's position, whether at trailside or distant, is perpendicular to the census trail. The distance from the trail (inevitably approximate if the bird is not seen) is determined by noting the changing detection angle from the trail's alignment as one advances from station to station and/or by comparing detection angles from two or more successive stations. Distance estimating, always a risky practice (DeJong and Emlen in prep.), plays only a minor part in the location of detection points. Turns in the trail and loopbacks forming parallel trail segments are helpful in pinpointing detection points, although one must always be aware that birds may change perches between successive detections. Detection vectors to all birds are drawn and labelled with a species symbol at each station, clearly distinguishing and locating the relative position of simultaneous singers (different individuals) (see Fig. 1). Additional detection vectors at successive stations allow for triangulation on each bird's position if the bird is still in approximately the same place.

Repetition of these procedures at frequent (essentially daily) intervals confirms the persistence of particular birds in particular areas along the route and facilitates the recognition of point clusters as territories on the periodically collated summary maps. It also provides for increasing precision in determining the maximum distance at which individual birds can be detected—the detection-threshold distance that determines the boundary of the census strip for each species. Furthermore, if we assume that territories tend to be circular in shape, territories only partially included within the strip can be distinguished from fully-included territories and the extent of their inclusion estimated by the position and shape of the cluster of detection points within the strip.

A Field Test of the Method

Procedures.—I selected an area in the University of Wisconsin Arboretum, Madison, Wisconsin, to test the feasibility and effectiveness of the strip-map method. The strip, 4.5 km in length and following established paths and roadways, formed a roughly triangular circuit (Fig. 1). Listening stations were established at 150-m (160 steps) intervals, ten on each of the three equal segments (A, B, and C) of the circuit. I timed my progress along the route to allow 4 min of listening at each station and 2 min of walking (with listening) between stations, for a total of 1 h for each 1.5-km segment and 3 h for the entire circuit. Early morning counts were started within 10 min of local sunrise, and the sequence of segments was rotated from day to day so that each was equally represented in the record in the first, second, and third post-sunrise hours. Six of these morning traverses were run each week (one exception) between late May and mid-August 1982. I also ran a few late-morning and afternoon traverses to provide additional data on diel song-frequency patterns and a few late-August and September traverses during which I used squeak lures (pishing sounds) to check for the persistence of vocally quiet, territorial residents late in the season.

All detections were recorded on the outline maps and tally forms as described in the method section above. Singing-bird locations were indicated with capital letters, calls and sightings with lower-case letters (Fig. 1). I used dashed lines to connect my position at the moment of detection with that of the bird. An erasable pencil was used to permit on-the-spot corrections as needed. The tally forms listed all

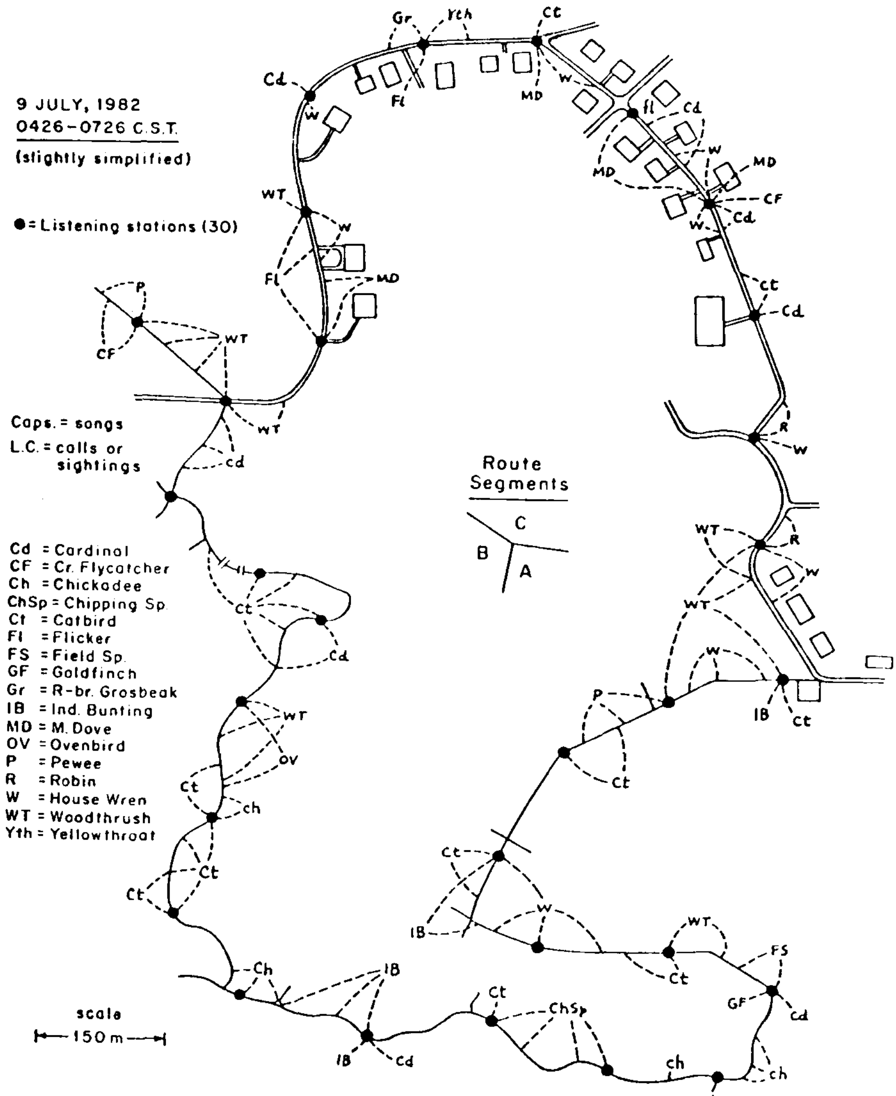

Fig. 1. Sample strip-map count: birds detected along the University of Wisconsin Arboretum strip-map circuit on 9 July 1982. Dashed lines indicate detection vectors from observer positions to calling (l.c.) or singing (caps) birds.

regularly encountered resident species down the left margin and provided 34 columns for recording observations at the 30 listening stations plus segment subtotals and totals. A detection was indicated by drawing a small circle (song) or dot (call or sighting) in the center of the appropriate species/station square on the form; short, medium, or long spurs from this circle or dot indicated the direction and distance (close, medium, or distant) of the detection point(s).

At the end of the season, I prepared two summary maps for each species, one for the 4 weeks of June, the other for the 4 weeks of July. Because of confusion created by transient migrants and local drifters, I used my May and August data only as they provided useful supplementary information. Using colored numbers (the color identifying the week; the number, the day within the week), I transferred all detection indicators from the daily traverse maps to these summary maps for analysis. With

TABLE 1. Density, seasonal trends, and territory size of birds resident in the University of Wisconsin Arboretum census area in June and July 1982, as determined by the observer-specific strip-map method.

Species	Strip size		Number of territories located[c]	Density (territory equivalents per km²)[d]								Total number of detections[e]		Territory size[f] (ha)
	Width[a] (m)	Area[b] (ha)		June (weeks) 1st	2nd	3rd	4th	July (weeks) 1st	2nd	3rd	4th	Within	Between	
Mourning Dove (*Zenaida macroura*)	200	90	14	9.5	10.7	11.6	13.6	13.6	13.3	13.3	12.1	162	3	1.8
Red-bellied Woodpecker (*Melanerpes carolinus*)	120	54	10	15.0	15.0	15.0	15.0	16.9	16.9	16.9	16.9	103	6	1.6
Downy Woodpecker (*Picoides pubescens*)	120	54	(?)[g]	—	—	—	—	—	—	—	—	—	—	—
Northern Flicker (*Colaptes auratus*)	240	108	6	1.9	3.3	4.3	4.3	4.3	4.3	4.3	4.3	54	5	1.6
Eastern Wood-Pewee (*Contopus virens*)	140	63	5	4.9	4.9	5.9	5.9	5.9	5.9	5.9	5.9	66	2	1.8
Great Crested Flycatcher (*Myiarchus crinitus*)	200	90	16	13.9	13.9	13.9	13.0	11.0	10.1	10.1	8.1	157	12	2.0
Eastern Kingbird (*Tyrannus tyrannus*)	120	54	1	1.0	1.0	1.0	1.0	1.0	0	0	0	15	0	2.5
Blue Jay (*Cyanocitta cristata*)	160	72	35?[g]	—	—	—	—	—	—	—	—	318	102	0.9
Black-capped Chickadee (*Parus atricapillus*)	80	36	15	10.8	12.5	12.5	12.5	12.5	12.5	12.5	12.5	146	0	3.5
Tufted Titmouse (*Parus bicolor*)	300	135	3	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	19	2	5.0?
White-breasted Nuthatch (*Sitta carolinensis*)	120	54	12	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	124	0	3.0
House Wren (*Troglodytes aedon*)	140	63	33	26.3	26.0	28.4	25.0	23.5	23.5	25.4	20.5	455	13	0.8
Blue-gray Gnatcatcher (*Polioptila caerulea*)	(?)[h]	(?)	1	—	—	—	—	—	—	—	—	—	—	—
Wood Thrush (*Hylocichla mustelina*)	300	135	17	9.9	9.9	10.4	9.8	9.8	10.5	10.5	9.8	325	11	1.3
American Robin (*Turdus migratorius*)	140	63	14	16.2	16.2	16.2	16.2	16.5	16.3	18.3	18.3	252	47	2.2
Gray Catbird (*Dumetella carolinensis*)	140	63	36	42.7	42.7	39.5	38.3	32.9	32.1	31.6	28.4	484	7	1.0
Brown Thrasher (*Toxostoma rufum*)	200	90	9	7.6	7.6	8.1	8.1	8.1	8.1	7.6	7.6	32	0	1.4
White-eyed Vireo (*Vireo griseus*)	(?)[h]	(?)	1	—	—	—	—	—	—	—	—	—	—	—
Red-eyed Vireo (*Vireo olivaceus*)	200	90	0	0	0	0	0	0	0	0	0	0	17	—
Blue-winged Warbler (*Vermivora pinus*)	(?)[h]	(?)	1	1.0	1.0	0	0	0	0	0	0	12	0	—
Ovenbird (*Seiurus aurocapillus*)	300	135	3	1.9	1.9	1.9	1.3	1.3	1.3	0.5	0.4	37	15	3.0

TABLE 1. Continued.

Species	Strip size: Width[a] (m)	Strip size: Area[b] (ha)	Number of territories located[c]	Density (territory equivalents per km²)[d]: June (weeks) 1st	June 2nd	June 3rd	June 4th	July (weeks) 1st	July 2nd	July 3rd	July 4th	Total number of detections[e]: Within	Between	Territory size[f] (ha)
Common Yellowthroat (*Geothlypis trichas*)	180	81	9	5.7	5.7	5.7	5.7	5.7	3.6	2.3	2.3	44	2	0.7
Scarlet Tanager (*Piranga olivacea*)	200	90	3	2.3	2.3	1.5	1.5	1.5	1.5	0.7	0.7	17	3	2.5
Northern Cardinal (*Cardinalis cardinalis*)	280	126	27	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	460	10	3.0
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	200	90	8	6.4	6.4	8.4	8.4	8.4	6.2	4.0	0	55	21	0.8
Indigo Bunting (*Passerina cyanea*)	200	90	9	6.7	6.7	6.7	5.8	5.2	5.2	3.6	3.0	88	5	1.3
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	200	90	2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	31	4	1.5
Field Sparrow (*Spizella pusilla*)	160	72	4	3.8	3.8	3.8	3.8	4.4	4.4	4.4	4.4	43	0	0.8
Song Sparrow (*Melospiza melodia*)	140	63	6	2.2	2.2	2.2	3.5	3.5	3.5	3.5	3.5	21	0	1.3
Brown-headed Cowbird (*Molothrus ater*)	(?)	(?)	(?)[g]	—	—	—	—	—	—	—	—	—	—	—
Northern Oriole (*Icterus galbula*)	200	90	2	2.2	2.2	2.2	2.2	2.2	0	0	0	10	4	1.8
American Goldfinch (*Carduelis tristis*)	200	90	1	0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	28	29	2.3

[a] Observer's detection-threshold distance times 2.
[b] Strip width × strip length (4,500 m).
[c] Number of territories (represented wholly or fractionally) located within the strip.
[d] Sum of territories (total of fractions and wholes) per km² for each of 8 weeks—June and July.
[e] Number of detections recorded (a) within and (b) between the detection-point clusters (territories) during the 45 traverses.
[f] Mean area of detection-point clusters (territories).
[g] Clustering of detection points too loose to indicate clearly the location of localized (territorial) resident birds. Indications of clustering, presumably near nests, prompted a guess of ca. 35 home areas for the Blue Jay.
[h] Data were insufficient to provide a useful estimate of the detection-strip widths.

relatively few exceptions, these detection indicators fell neatly into clusters, which, when encircled, delineated the home ranges (territories) of each resident male. Territories so delineated rarely overlapped except in incidents of boundary infractions accompanied by overt aggression. Some between-territory and boundary-area detections were unassignable, but I could assign many to a territory with considerable confidence by examining the concurrent local distribution patterns for all neighboring males as revealed by the color symbols on the summary maps.

For each species I summarized the breeding-season histories of all territory residents in charts with rows for each territory and columns (with six subcolumns) for each 6-day (or 3-day) week of the season. Each recorded occurrence was entered as a small circle (song) or dot (call or sighting) to form a row of symbols delimiting the period of residence and of song activity for the bird. On the assumption that a brief interval without recorded detections was more likely due to a period of relative vocal inactivity than to a temporary absence from the home tertitory, I considered that up to 10 consecutive blank spaces in a row did not reflect a break in a bird's record of residency if this gap was bracketed by three or more symbols indicating presence at each end or by two or more responses to squeak lures after the last week of July. Summed vertically, the dots and circles in the columns of these charts reveal the number of territorial males present on the census area and an index of song frequency for each week of the 2-month season. The record of these charts is summarized in Table 1 (densities) and Table 2 (song frequencies) for each species.

Results.—The width of the census strip as determined by my personal detection-threshold distances on either side of the traverse route ranged from 80 (40 + 40) m for the Black-capped Chickadee (see Table 1 for scientific names) to 300 (150 + 150) m for the Wood Thrush, Ovenbird, and Tufted Titmouse (Table 1). The area of the census strip (4,500 m length times these species-specific strip widths) ranged from 36 to 135 ha. The number of territories (detection clusters) intercepted along the route ranged from one for the Eastern Kingbird, Blue-gray Gnatcatcher, White-eyed Vireo, Blue-winged Warbler, and American Goldfinch to 36 for the Gray Catbird. The average size of these territories as rounded off by eye on the June and July summary maps ranged from 0.7 ha for the Common Yellowthroat to 3.0 for the Ovenbird, Northern Cardinal, and White-breasted Nuthatch, and possibly 5.0 for the Tufted Titmouse (only one full territory). The number of mapped detections on which territory locations and sizes were based ranged from 10 for the Northern Oriole (one full territory) to 484 for the Gray Catbird (36 territories). Detections lying outside territory boundaries as drawn comprised only 9.0% of all detections, but outnumbered intraterritorial detections for the American Goldfinch (29:28), a wide-ranging forager, and constituted the entire tally of 17 for the Red-eyed Vireo, a common summer resident over much of the Madison region but apparently not present as a breeding bird in the strip-census area.

The study produced no evidence of nonbreeding residents (cf. Stewart and Aldrich 1951, Smith 1978) except for the Red-eyed Vireos, and the irregularity of their records in space and time suggests drifters rather than localized residents. The scarcity of between-cluster detections (Table 1) and the stability of the clusters from week to week suggest that the great majority of at least the vocalizing birds on the census area were territorially established. The occasional nonlocalized intruder was readily recognized as such by its day-to-day movements into and between established territories and the frequent clashes it elicited from resident males. This, of course, does not mean that all the territorial males were breeding or even paired. It is also conceivable that nonvocalizing individuals were present and completely overlooked through the season.

The density of territorial males, based on the sum of all full and partial territories within the census strip, varied from week to week in most species, reaching seasonal peaks of from 1.0 (Eastern Kingbird and Blue-winged Warbler) to 42.7 (Gray Catbird) per km^2 (Table 1). The summed community totals were highest in the third week of June (233.4) and lowest in the last week of July (193.4). (These totals exclude seven species for which data were inadequate or too irregular to permit territory delineation.) In line with predictions of the observer-specific concept of strip censuses and reflecting the wider strip widths covered, a younger colleague (M. J. DeJong), who could detect some species at up to twice the distance I detected them, recorded nearly twice as many birds in two test runs over the same route.

The song frequency for each species varied

TABLE 2. Seasonal trends in song frequency (percentage of 4-min, early morning visits to currently active territories during which the resident male sang at least once) for 17 species with weekly sample sizes (territory visits) ≥20. Values in parenthesis are the number of territory visits (number of currently active territories and/or fractional territories within the detectability strip times the number of census days in the week).

	June (weeks)				July (weeks)				
Species[a]	1st	2nd	3rd	4th	1st	2nd	3rd	4th	$\bar{x} \pm 1$ SD
Mourning Dove	23 (52)	14 (29)	22 (62)	29 (73)	36 (73)	35 (72)	39 (72)	39 (66)	29.23 ± 9.20
Northern Flicker	8 (13)	0 (11)	15 (28)	22 (28)	40 (28)	25 (28)	44 (28)	4 (28)	19.25 ± 16.17
Eastern Wood-Pewee	11 (19)	32 (9)	23 (22)	45 (22)	36 (22)	59 (22)	50 (22)	63 (22)	39.88 ± 17.83
Great Crested Flycatcher	61 (75)	45 (38)	33 (75)	21 (70)	19 (59)	27 (55)	12 (55)	19 (44)	29.63 ± 16.26
Black-capped Chickadee	17 (23)	44 (14)	40 (27)	7 (27)	19 (27)	4 (27)	0 (27)	0 (27)	16.38 ± 17.34
House Wren	60 (100)	67 (50)	61 (107)	72 (95)	71 (89)	69 (89)	64 (96)	47 (77)	63.88 ± 8.11
American Robin	16 (61)	13 (31)	26 (61)	23 (61)	24 (62)	12 (68)	25 (68)	7 (68)	18.25 ± 7.18
Brown Thrasher	12 (41)	10 (20)	5 (44)	9 (44)	2 (44)	5 (44)	3 (41)	3 (41)	6.13 ± 3.72
Gray Catbird	49 (161)	43 (81)	43 (150)	54 (145)	48 (124)	50 (122)	46 (119)	10 (107)	42.88 ± 13.38
Wood Thrush	34 (80)	45 (40)	41 (84)	46 (80)	52 (80)	56 (85)	76 (85)	62 (79)	51.50 ± 13.20
Ovenbird	45 (16)	39 (8)	51 (16)	56 (11)	37 (11)	46 (11)	61 (7)	0 (6)	41.88 ± 18.75
Common Yellowthroat	15 (28)	29 (14)	7 (28)	22 (28)	36 (28)	40 (17)	26 (11)	53 (11)	28.5 ± 14.55
Northern Cardinal	53 (122)	36 (70)	42 (122)	44 (122)	37 (122)	42 (122)	60 (122)	43 (122)	44.63 ± 8.07
Rose-breasted Grosbeak	9 (35)	29 (17)	35 (46)	33 (46)	13 (46)	6 (34)	19 (22)	0 (0)	18.00 ± 13.15
Indigo Bunting	22 (36)	33 (18)	28 (36)	58 (31)	43 (28)	32 (28)	42 (19)	19 (16)	34.63 ± 12.69
Rufous-sided Towhee	67 (12)	50 (6)	42 (12)	17 (12)	42 (12)	17 (12)	0 (12)	42 (12)	34.63 ± 21.61
Field Sparrow	43 (16)	49 (8)	62 (16)	19 (16)	10 (19)	21 (19)	16 (19)	21 (19)	30.13 ± 18.64
Total community[b]	501	466	486	446	447	429	404	326	
Percentage of 1st week total	100	93	97	89	89	86	81	65	

[a] For full names see Table 1.

[b] Total of song detections for all singing species (including those with small sample sizes).

TABLE 3. Diel changes in singing activity (number of birds that sang per 100 4-min listening sessions) for nine well-represented species and the total community of the University of Wisconsin Arboretum census strip.

Species	Early morning hours[a] 1st (450)[c]	2nd (450)[c]	3rd (450)[c]	Hours through the day (post-sunrise)[b] 1–3 (180)[c]	4–7½ (60)[c]	7½–12 (30)[c]	13–15 (60)[c]
Mourning Dove	20.0	16.2	12.4	14.4	5.0	3.3	15.0
Eastern Wood-Pewee	5.8	3.8	3.8	3.9	1.7	0	3.3
Great Crested Flycatcher	18.0	19.3	9.1	6.1	0	0	3.3
House Wren	38.4	36.2	33.8	33.3	25.0	13.3	10.0
American Robin	7.3	7.8	8.9	8.3	6.7	10.0	6.7
Wood Thrush	38.7	31.6	28.0	44.4	23.3	43.3	45.0
Gray Catbird	40.4	35.8	35.1	32.2	25.0	6.7	16.7
Northern Cardinal	47.6	43.1	32.7	46.1	15.0	26.7	25.0
Indigo Bunting	7.6	8.4	7.8	7.2	3.3	10.0	1.7
Total—nine species	223.8	202.2	171.6	196.1	105.0	113.3	126.7
Total community	265.5	250.8	232.9	224.4	118.3	133.3	128.3
Relative activity (%)	100	94.5	87.7	100	53	59	57

[a] Average for all June and July data.
[b] Data for third week of July only.
[c] Number of sessions.

from week to week (Table 2). For the community as a whole, the incidence of 4-min listening periods during which birds sang declined gradually from a peak in early June to mid-July and then rather steeply to the end of the season in early August. Most species maintained high song frequencies through most of the season, a few (e.g. Brown Thrasher) declined early in the season, and several (Mourning Dove, Eastern Wood-Pewee, Wood Thrush, and Common Yellowthroat) increased, reaching their peaks in late July. Because singing activity waxes and wanes with the stage of the individual's breeding cycle in some species (Slagsvold 1977, Best 1981), records based on only a few territories have limited value as indicators of species-specific seasonal patterns, but the temporal distribution of the singing of individual territory residents of actively singing species in this study had few breaks in singing activity of more than 3–6 days for any species except the Brown Thrasher.

Song activity varies with the time of day and in a pattern that differs from species to species (Järvinen et al. 1977, Robbins 1981a). In this study overall singing activity was highest during the first 3 h after sunrise and lowest (53% of the early morning level) during the rest of the morning; it then rose slightly during the early (59%) and late (57%) afternoon hours (Table 3). During the 3 hours of the early morning period song frequencies declined slowly (100–95.5–87.7) (Table 3). Most of the species with sufficient sample sizes followed this pattern; a few (Mourning Dove, Eastern Wood-Pewee, Wood Thrush)—all of which had a late-summer revival of singing—showed strong late afternoon song activity.

Weather extremes can suppress both avian singing activity and observer acuity (Alexander 1931, O'Connor and Hicks 1980, Robbins 1981b). Such variables were largely controlled in the 1982 field test by limiting observations to days with moderate conditions. Heavy clouds, wind, cold, and traffic noise within the limited range of variation sampled on the 45 census days of the study apparently tended to suppress song activity slightly (Table 4). Precipitation and foliage wetness, similarly limited, apparently had no effect.

APPLYING STRIP-MAP DATA TO DETECTION COUNTS

The detection-threshold distance and song-frequency values generated in strip-mapping censuses may prove to be useful in providing the areal denominators and cue-production corrections required for converting detection counts to densities in transect and point-count censuses.

Areal denominators for count conversions are now generally determined independently for

TABLE 4. Relation of weather-related and other conditions to early morning singing activity in the Madison census area (June–July 1982).

Conditions	Singing activity (all species)[a]			Number of mornings with data
	High	Medium	Low	
Sky cover (tenths)				45
Cloudy (8–10)	4	8	5	
Medium (3–7)	2	8	1	
Clear (0–2)	3	13	1	
Precipitation				45
Rain	0	2	0	
Mist or fog	1	1	0	
None	7	27	7	
Wind				45
Moderate	0	2	1	
Light	0	6	1	
Calm	8	23	4	
Temperature[b]				45
Warm	3	9	1	
Mild	3	15	2	
Cool	2	7	3	
Foliage moisture				23
Wet	1	2	1	
Damp	2	6	1	
Dry	0	10	0	
Traffic noise				27
Loud	1	1	2	
Medium	1	12	1	
Light	3	6	0	

[a] A 5-point moving average of song counts through June and July was plotted for the community (sum for all species). Days with ≥7 counts above this line were designated high, ≥7 counts below the line, low.
[b] Days with sunrise morning temperature ≥2°C above the mean for the week were designated warm; those ≥2° below the line, cool; those with intermediate means, mild.

each census operation from subjective estimates of observer-to-bird distances for all detections recorded at the site, but the lack of evidence for appreciable site-related variability in detection distances suggests that average, species-specific values based on extensive, competently derived, threshold data for the specified region and habitat type may be preferable to site-specific data based on subjective distance estimations and collected by variously inexperienced practitioners. Recent tests directly measuring detection-threshold distances on a sample of 12 species at a series of deciduous forest sites (Emlen and DeJong 1981) revealed coefficients of variation of only 10–15%, suggesting that reference tables of conversion values could be prepared and made broadly available for direct application to detection counts (also see Best 1981).

The distances to strip boundaries determined by the procedures described in this paper retain subjective elements but are far less subjective than the nearly "blind" distance estimates characteristic of many detection count censuses (DeJong and Emlen in prep.). How reliable map-generated, detection-threshold distances prove to be in different situations and habitat types remains to be seen.

The adjustment of detection counts for the temporarily silent (undetected) members of a population has received little attention in the census literature (Emlen 1977, Christman in press). The strip-mapping procedure described in this paper can provide song-frequency and, in some cases, other cue-frequency values suitable for preparing a second set of reference tables for direct application in point-count censuses. Song frequencies expressed in terms of incidence per standard listening period (4 min in this study) are, of course, applicable only to count periods of the same specified duration and cannot be used in transect censuses in which the observer counts continuously as he or she advances. The concern, commonly expressed by listening-station counters, that stations must be widely spaced to avoid double counting of individual birds, happily does not apply to counts where results are recorded as birds per areal unit (i.e. count overlaps are acceptable when matched by area overlaps). With a limited number of stations, however, close or uneven spacing should be avoided to minimize the chances of either under- or over-representing rare or localized species.

Thus, with two standardized reference tables, one for determining areas of detection (species-specific detection-threshold distances) and one for adjusting for silent (undetected) birds in those areas (species-specific, season-, and hour-adjusted song frequencies), reasonably reliable and broadly comparable indices of density and community structure could be obtained from simple detection counts at a string of listening points without the distractions and hazards of estimating distances and attempting to avoid detection overlaps.

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