BREEDING BIRD SURVEY COUNTS AS RELATED TO HABITAT AND DATE

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The Breeding Bird Survey (hereafter BBS) is a standardized technique designed to measure year-to-year changes in numbers of breeding birds (Robbins and Van Velzen 1967, 1969; Van Velzen and Robbins 1971). It has been carried out over much of North America each year since 1966. The factors causing variability in BBS counts, such as time of day, weather, and time of year, have been briefly discussed by Robbins and Van Velzen (1967). However, no detailed analysis has yet been made of the effects of these factors, nor of the relationship between BBS counts and habitat. In this paper, we describe some of these relationships for an area of southern Ontario, Canada.

We used the BBS to study breeding bird populations during 1971 in Waterloo County, Ontario (now the Regional Municipality of Waterloo). Our chief aim in conducting the study was to obtain an index to bird populations against which future changes could be measured and compared with changes in land use or other factors. Our purposes in this paper are: (1) to show that the BBS method, when considered together with land use data, is useful in relating bird populations to habitat; (2) to describe some of the bird-habitat relationships evident in our study area; and (3) to outline some of the problems in using the BBS as a technique for estimating bird populations, and particularly to evaluate the effect of time of year on numbers of birds recorded.

The field work for the study was done by Weber, but both of us participated in its planning and in the analysis of results.

STUDY AREA AND METHODS

Study area.—Waterloo County, located in southern Ontario about 100 km west-southwest of Toronto (Fig. 1), has an area of 1336 km^2 and a human population of 254,037 (1971 Canadian census). There are 2 large metropolitan areas in the county—Kitchener-Waterloo, with a population of 151,000, and Galt-Preston-Hespeler (recently amalgamated under the name of Cambridge), with a population of 62,000—as well as several smaller towns and villages. Urban growth in the county is extremely rapid (an increase of 46.4% from 1961 to 1971).

The area consists of old glacial outwash plains and rolling moraines, with an elevation of about 240 to 430 m; it lies entirely within the drainage basin of the Grand River. Soils range from coarse glacial sands and gravels to fine alluvial deposits along the rivers. The area is in a transition zone between the Great Lakes-St. Lawrence and Deciduous Forest Regions (Rowe 1972); the climax forests were dominated by sugar maple (*Acer saccharum*) and American beech (*Fagus grandifolia*), with some conifers such as eastern

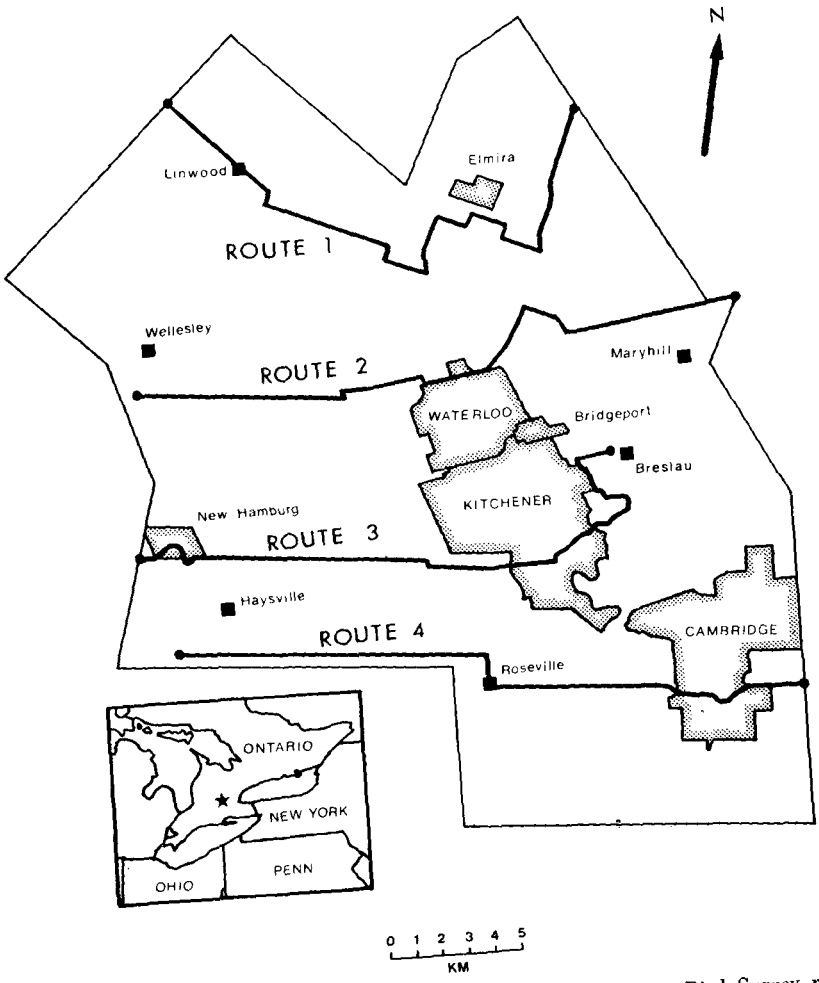

FIG. 1. Waterloo County, Ontario, showing locations of Breeding Bird Survey routes. Inset map shows general location of county in southern Ontario.

hemlock (*Tsuga canadensis*) and eastern white pine (*Pinus strobus*). Only about 10% of the land is now forested (less than in most surrounding areas), and most of this consists of small second-growth woodlots, often in pockets of swampy or poorly-drained soil unsuitable for farming. The county supports a fairly intensive agriculture dominated by dairying and the raising of crops such as corn, oats, barley, wheat, and hay.

We divided habitats in the county into 4 major categories: fields, forest, urban habitats, and "miscellaneous" habitats (including wetlands and gravel pits). These were subdivided into 20 habitat types. This classification was intended not to correspond with plant

communities, but to reflect major physical and vegetational features of the habitat which are probably important to birds. Our habitat types were:

Fields.—These included: (1) pasture, hayfields, and alfalfa fields; (2) brushy pasture (not grazed or mowed for several years, usually with numerous shrubs or small trees); (3) cornfields; (4) other grains—mainly oats and barley (often mixed), some wheat; (5) other crops, mainly potatoes; and (6) bare earth.

Forest.—These included: (1) upland deciduous forest—mainly sugar maple-American beech forest, in various successional stages, but mostly young; (2) upland coniferous forest—plantations of red pine (*Pinus resinosa*) and eastern white pine; (3) upland mixed forest—like upland deciduous, but with eastern hemlock or eastern white pine also present (deciduous trees always dominant); (4) riparian deciduous forest—mainly willows (*Salix* spp.), also balsam poplar (*Populus balsamifera*), American elm (*Ulmus americana*), etc., along streams; (5) swamp coniferous forest—mainly northern white-cedar (*Thuja occidentalis*) and/or tamarack (*Larix laricina*); (6) swamp mixed forest —red maple (*Acer rubrum*), American elm, black ash (*Fraxinus nigra*), tamarack, northern white-cedar, eastern hemlock, etc.; (7) orchards (included under forests for lack of a better alternative).

Urban.—These included: (1) commercial—business districts, i.e., stores and offices; (2) industrial—factories, warehouses, railway yards, etc. (newer areas often interspersed with fields); (3) residential—both "estate" areas with widely-spaced houses and many trees, and more typical areas with more houses and fewer trees; (4) cemeteries and parks —usually with many trees.

Miscellaneous.—These included: (1) lakes and ponds; (2) marshes—both cattail (*Typha latifolia*) and shrub-willow (*Salix* spp.) marshes; (3) gravel pits.

Methods.—The BBS technique was developed by Chandler S. Robbins of the U.S. Fish and Wildlife Service from similar methods used for many years by wildlife biologists in surveys for American Woodcock, Ruffed Grouse, and other gamebirds. A survey route consists of 50 stops spaced at 0.8 km (½ mile) intervals; thus each route is 39.4 km (24.5 miles) long. The survey is begun ½ h before local sunrise. The observer spends 3 min at each stop and records all birds heard at any distance, and all seen within 0.4 km (¼ mile). In the continent-wide BBS, supervised by the U.S. Fish and Wildlife Service and Canadian Wildlife Service, each route is covered only once a year; in southern Canada, this may be done between 1 June and 7 July. For more details, see Robbins and Van Velzen (1967).

We set up 4 BBS routes in Waterloo County, spanning the county from east to west at intervals of about 12 km (Fig. 1). Each route was surveyed 8 times between 18 May and 16 July 1971. Direction of coverage was reversed in alternate weeks. Although surveys were continued for 8 weeks, only 5 weeks' results (28 May to 4 July) were used in the analysis (see Discussion for reasons).

In conjunction with the bird surveys, we estimated the area covered by each of the 20 habitat types along the survey routes. At each stop, the percentage covered by each type within a 0.4 km radius was estimated in the field to the nearest 10%. These data were then summed to give totals for each route.

We also noted the presence and importance at each stop of hedgerows (rows of trees or shrubs), scattered trees, farm buildings, and streams. Based on the habitat composition and the importance of hedgerows and scattered trees at each stop, we assigned it an "edge rating," as a rough index to the amount of forest-field edge present. These ratings ranged from 0, for little or no edge, to 2, for much edge. For example, a stop where forest and fields each covered 30% or more of the area was assigned a 2, whether or not hedgerows and scattered trees were present. If a stop was 100% fields but deciduous

TABLE 1

HABITAT COMPOSITION ALONG BREEDING BIRD SURVEY ROUTES

Habitat	Survey route[2]				
	1	2	3	4	Overall
FIELDS	85.2%	70.8%	70.0%	67.8%	73.5%
Pasture	30.0	26.4	29.2	22.4	27.0
Brushy pasture	–	0.2	1.8	5.2	1.8
Corn	22.6	22.6	24.6	26.8	24.2
Other grains	28.4	17.4	13.4	13.0	18.1
Other crops	–	4.0	0.2	–	1.1
Bare earth	4.2	0.2	0.8	0.4	1.4
FOREST	10.4	21.2	8.2	16.8	14.2
Upland deciduous	4.8	12.0	4.4	9.0	7.6
Upland coniferous	0.2	–	0.2	0.4	0.2
Upland mixed	–	3.4	0.4	0.4	1.1
Riparian deciduous	2.0	4.4	0.8	0.8	2.0
Swamp coniferous	1.4	1.0	0.4	0.6	0.9
Swamp mixed	2.0	0.2	1.2	5.6	2.3
Orchard	–	0.2	0.8	–	0.3
URBAN	3.4	6.6	20.4	14.6	11.3
Commercial	–	–	2.2	2.0	1.1
Industrial	0.2	0.8	5.8	1.6	2.1
Residential	3.2	5.8	12.2	10.2	7.9
Cemeteries and parks	–	–	0.2	0.8	0.3
MISCELLANEOUS	1.0	1.4	1.4	0.8	1.1
Lakes and ponds	–	0.4	–	–	0.1
Marsh	0.4	1.0	–	0.8	0.6
Gravel pits	0.6	–	1.4	–	0.5

[1] For brief descriptions of habitat types, see "Study Area."
[2] Route 1—Linwood to North Woolwich (see Fig. 1); Route 2—Ariss to New Prussia; Route 3—New Hamburg to Breslau; Route 4—Galt to Haysville.

hedgerows were important, the edge rating was 2; if both hedgerows and scattered trees were present but unimportant (covering a small area, or far from the observation point), the edge rating was 1; and if both were absent, the rating was 0. Edge ratings for individual stops were then summed to give a total for each route, ranging from a minimum possible 0 to a maximum possible 100.

RESULTS

Habitat composition along survey routes.—The percentage of area occupied by each habitat on the 4 survey routes is shown in Table 1. Fields occupied an average of 74% of the area, ranging from 68% on Route 4 to 85% on Route 1. Forest occupied only 14% of the area overall, but was more impor-

TABLE 2

TOTAL NUMBERS OF BIRDS (SELECTED SPECIES) RECORDED ALONG BREEDING BIRD SURVEY ROUTES, 28 MAY TO 4 JULY 1971

Species	Survey route 1	2	3	4
FIELD SPECIES				
Killdeer	102	85	74	88
Horned Lark	124	65	49	34
Bobolink	123	106	53	77
Savannah Sparrow	470	346	336	275
URBAN SPECIES				
Chimney Swift	28	41	55	60
Purple Martin	–	3	20	–
FOREST SPECIES				
Black-capped Chickadee	2	20	4	13
Veery	1	12	2	6
Red-eyed Vireo	25	35	23	30
FOREST-EDGE SPECIES				
Gray Catbird	5	18	2	34
Brown Thrasher	3	14	6	13
Yellow Warbler	17	49	9	34
Song Sparrow	163	213	138	190

tant on Routes 2 and 4 (21% and 17%, respectively) than on Routes 1 and 3 (10% and 8%). Urban habitats took up 20% on Route 3 and 15% on Route 4, and averaged 11% over the 4 routes.

Comparison of bird numbers among routes.—Weber recorded 101 bird species (not including 6 migrants and non-breeders) on the 4 routes between 28 May and 4 July. For many species, differences in total numbers among routes showed a close relationship with habitat composition; some of these species are included in Table 2. (See appendix for scientific names of all birds mentioned in this paper.) Several birds characteristic of fields (Killdeer, Horned Lark, Bobolink, Savannah Sparrow) were most abundant on Route 1, which was 85% fields; another species, the Upland Sandpiper, occurred only on Route 1. Two highly urban species, the Purple Martin and Chimney Swift, reached peak numbers respectively on Routes 3 and 4, the routes with most urban habitat. Numbers of Field Sparrows paralleled the extent of brushy pasture on the survey routes.

Many forest and forest-edge species were numerous on Routes 2 and 4, which had many wooded areas, but scarcer on Routes 1 and 3. Fig. 2 shows

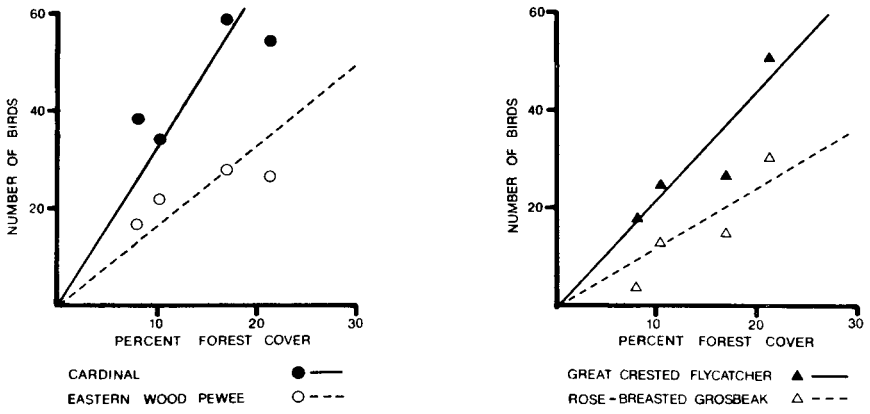

FIG. 2. Comparison of numbers of birds recorded, 28 May to 4 July, with percent forest cover on survey routes.

graphs for 4 forest species—Great Crested Flycatcher, Eastern Wood Pewee, Cardinal, and Rose-breasted Grosbeak—whose numbers showed particularly close relationships with percent forest cover. Fig. 3 does the same for 4 forest-edge species—Mourning Dove, Common Flicker, House Wren, and Indigo Bunting—using the "edge rating" for each route instead of percent forest cover. Edge ratings were 50, 67, 54, and 66 for Routes 1, 2, 3, and 4 respectively. These ratings refer only to forest-field edge; other types of edge (urban-field, urban-forest) were far less extensive.

As the amount of edge on each route was roughly proportional to the amount of forest, bird species whose numbers closely reflected edge ratings would also closely reflect percent forest cover. To determine whether a bird was best considered a forest or forest-edge species, we relied both on published information and on our own observations during the study. Of our "forest" birds, the Great Crested Flycatcher and Cardinal also occur to some extent in non-forested habitats; but Dow (1970) in Ontario and Emlen (1972) in Texas found that Cardinal densities increased with vegetation density. Hespenheide (1971) considered the Eastern Wood Pewee a forest-edge species, but in comparison with, for instance, the Eastern Kingbird, a more typical edge species, we would still consider the Wood Pewee a forest bird. Bird species display a complete spectrum from those preferring dense forest to those inhabiting treeless fields, and the distinction between "forest" and "forest-edge" species must sometimes be arbitrary.

The lines in Figs. 2 and 3 were fitted by eye. Those for forest birds (Fig. 2) were drawn through the origin, on the assumption that numbers

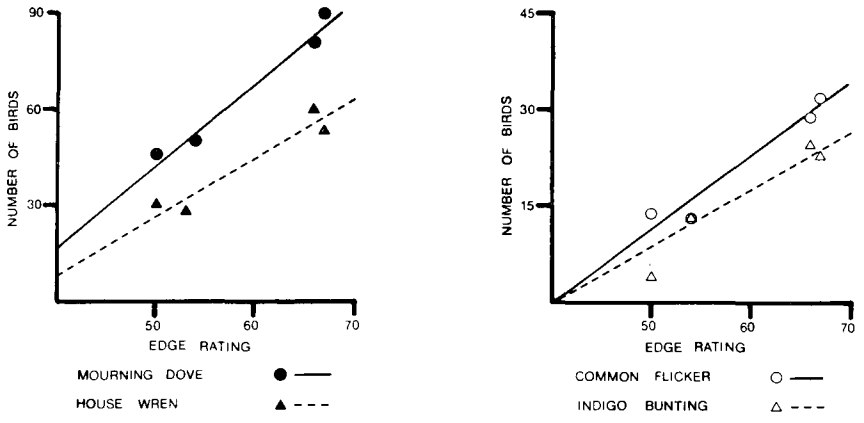

FIG. 3. Comparison of numbers of birds recorded, 28 May to 4 July, with edge ratings on survey routes.

of forest birds should decline to 0 only when forest cover approaches 0. However, edge rating is a much less precise measure than percent forest cover, and is relative rather than absolute. Notice that the lines for Common Flicker and Indigo Bunting (Fig. 3) decline to 0 birds with an edge rating of about 40.

Comparison of bird numbers in different habitats.—The data in Table 3, comparing the abundance of the commoner bird species in each major habitat category, were obtained by a stop-by-stop tabulation of the number of birds at selected stops over the 28 May to 4 July period. A total of 47 stops in fields, 11 in forest, and 19 in urban areas were used; thus only 77 of the total of 200 stops were included in this analysis. For fields, we included only those stops which were 100% fields; but for forest and urban habitats, because of their small extent, we included all stops which were 60% or more forest or urban, respectively.

The 40 species recorded in largest numbers accounted for 97.1% of the total birds recorded at the selected stops. Of these 40, 6 species, comprising 43.0% of total individuals, were considered characteristic of urban areas and farm buildings; 18 (30.4% of individuals) were forest-edge species; 7 (21.8% of individuals) were field species; 7 (3.2% of individuals) were forest species; and 2 (1.6% of individuals) were water-associated species.

Because of the nature of the habitats, the majority of stops selected for analysis contained some "edge." The field stops, although none included any forest or urban habitat, nearly all contained some hedgerows and scattered trees which attracted numerous "edge" birds. Both the forest and urban

TABLE 3

ABUNDANCE OF BIRDS IN DIFFERENT HABITATS (BIRDS PER 100 STOPS)

Species	Habitat			
	Overall	Fields	Forest	Urban
1. Starling (U)[1]	416.3	514.9	67.3	384.2
2. House Sparrow (U)	371.6	528.9	101.8	412.6
3. Red-winged Blackbird (W, FI)	160.1	131.1	78.2	22.1
4. Common Grackle (E)	151.3	137.0	103.6	178.9
5. Savannah Sparrow (FI)	142.7	211.9	29.1	38.9
6. Rock Dove (U)	95.3	173.6	25.5	85.2
7. American Robin (E)	88.8	66.8	89.1	117.9
8. Common Crow (E)	77.9	74.9	85.5	42.1
9. Song Sparrow (E)	70.4	52.3	89.1	18.9
10. Brown-headed Cowbird (E)	55.7	49.8	41.8	38.9
11. American Goldfinch (E)	41.8	36.2	36.4	28.4
12. Eastern Meadowlark (FI)	36.0	27.2	12.7	22.1
13. Bobolink (FI)	35.9	46.8	5.4	–
14. Vesper Sparrow (FI)	35.2	46.4	32.7	1.1
15. Killdeer (FI)	34.9	48.1	9.1	10.5
16. Chipping Sparrow (E)	32.4	26.0	9.1	58.9
17. Bank Swallow (W)	29.4	17.0	14.5	6.3
18. Horned Lark (FI)	27.2	48.9	1.8	5.3
19. Mourning Dove (E)	26.7	15.3	36.4	24.2
20. Barn Swallow (U)	21.4	29.8	5.4	6.3
21. Cedar Waxwing (E)	19.6	8.9	41.8	37.9
22. Cardinal (FO)	18.4	7.7	41.8	16.8
23. Chimney Swift (U)	18.4	5.1	16.4	116.8
24. Northern Oriole (E)	18.0	11.1	27.3	11.6
25. House Wren (E)	17.1	2.6	29.1	10.5
26. Eastern Kingbird (E)	13.9	13.2	9.1	4.2
27. Great Crested Flycatcher (FO)	12.1	3.0	43.6	4.2
28. Red-eyed Vireo (FO)	11.3	4.2	50.9	6.3
29. Yellow Warbler (E)	10.9	–	7.3	8.4
30. Cliff Swallow (U)	9.7	2.6	–	6.3
31. Eastern Wood Pewee (FO)	9.4	0.4	54.5	5.3
32. Blue Jay (FO)	9.1	0.9	25.5	2.1
33. Warbling Vireo (E)	8.8	1.3	7.3	6.3
34. Common Flicker (E)	8.8	3.0	9.1	9.5
35. Indigo Bunting (E)	6.5	1.3	32.7	11.6
36. Rose-breasted Grosbeak (FO)	6.3	0.9	38.2	1.1
37. Gray Catbird (E)	5.9	–	14.5	3.2
38. Spotted Sandpiper (W)	5.1	7.2	7.3	–
39. Willow/Alder flycatcher (E)[2]	4.8	0.4	7.3	1.1
40. Black-capped Chickadee (FO)	3.9	0.4	32.7	1.1

[1] Letters in parentheses after species name designate major habitat type considered "typical" for species (i.e., where it reaches highest densities). E = forest-edge; FI = fields; FO = forest; U = urban areas and farm buildings; W = water (lakes, streams, and their edges).

[2] Both Willow and Alder flycatchers were present along the routes, in about equal numbers, but were not always recorded separately.

TABLE 4

COMPOSITION OF BREEDING AVIFAUNA IN DIFFERENT HABITATS

Group of birds	Habitat		
	Fields	Forest	Urban
FIELD BIRDS			
No. of species[1]	7	3	4
Individuals per 100 stops[1]	560.4	140.0	93.6
Individuals as % of total	24.0%	11.1%	5.5%
FOREST-EDGE BIRDS			
No. of species	11	11	15
Individuals per 100 stops	491.5	612.8	604.0
Individuals as % of total	21.1%	48.3%	35.1%
FOREST BIRDS			
No. of species	1	8	1
Individuals per 100 stops	7.7	319.9	16.8
Individuals as % of total	0.3%	25.2%	1.0%
URBAN AND FARM-BUILDING BIRDS			
No. of species	4	3	5
Individuals per 100 stops	1247.2	194.6	1005.1
Individuals as % of total	53.5%	15.3%	58.4%
WATER-ASSOCIATED BIRDS			
No. of species	2	–	–
Individuals per 100 stops	24.2	–	–
Individuals as % of total	1.0%	–	–
TOTAL INDIV. (25 commonest spp.)	2331.0	1267.3	1719.5
TOTAL INDIV. (all spp.)	2375.3	1600.0	1790.5

[1] Out of 25 commonest species in each habitat.

stops included other habitats, mostly fields; thus "edge" was also present there: Only 72.7% of the area at "forest" stops was actually forested, and only 78.9% of the area at "urban" stops was actually urban. Only one of the 200 stops was 100% forest.

At the 47 stops in fields (Table 4), only 7 of the 25 commonest species (24.0% of individuals) were true "field" birds, nesting on the ground and carrying out all other activities in fields. Three of the 4 commonest species —House Sparrow, Starling, and Rock Dove—were associated with, and nested in, farm buildings. These 3 are often considered urban birds (Weber 1972), but in Waterloo County, their total numbers in rural areas almost

TABLE 5

COMPARISON OF NUMBERS OF EDGE BIRDS IN FIELDS WITH AND WITHOUT DECIDUOUS HEDGEROWS

Species	Number of birds per 100 stops[1]		
	Fields overall	Fields with hedgerows	Fields without hedgerows
Mourning Dove[2]	15.3	14.3	12.7
Eastern Kingbird[2]	13.2	18.6	14.5
Common Crow[2]	74.9	74.3	61.8
American Robin[2]	66.8	65.7	50.9
Cedar Waxwing[2]	8.9	5.7	16.4
Red-winged Blackbird[2]	131.1	155.7	112.7
Northern Oriole[2]	11.1	15.7	5.5
Common Grackle[3]	137.0	115.7	125.5
Brown-headed Cowbird[2]	49.8	64.3	50.9
American Goldfinch[2]	36.2	45.7	29.1
Chipping Sparrow[3]	26.0	18.6	21.8
Song Sparrow[2]	52.3	62.9	40.0
TOTALS—12 edge species	622.6	657.2	541.8
TOTALS—all species	2375.3	2332.4	2314.1

[1] Data based on 47 stops for fields overall; 14 stops for fields with hedgerows; and 11 stops for fields without hedgerows.
[2] Species characteristic of deciduous hedgerows.
[3] Species characteristic of coniferous hedgerows.

certainly exceeded those in cities, even if their densities were lower. Forest-edge birds were also important in fields (11 out of 25 species, 21.1% of individuals).

In forest, only 8 of the 25 commonest species, and 25.2% of individuals, were true forest birds; forest-edge birds (11 species) accounted for 48.3%. This is a result of the unavoidable inclusion of some fields in the forest stops analyzed, plus the edge created by the road rights-of-way. Even farm-building birds (3 species, 15.3% of individuals) and field birds (3 species, 11.1% of individuals) crept into the top 25 forest species.

In urban habitats, only 5 of the top 25 species were typical urban birds, but they made up 58.4% of individuals. Forest-edge birds accounted for 15 species, though only 35.1% of individuals; their importance is not surprising, as many urban areas (at least residential areas) consist, in effect, of almost continuous "edge." Five species of field and forest birds also entered the urban list, but were relatively unimportant.

Effect of deciduous hedgerows on bird numbers in fields.—Forest-edge birds are numerous in fields, as we have noted. However, the Ontario

TABLE 6

COMPARISON OF NUMBERS OF FARM-BUILDING BIRDS IN FIELDS WITH AND WITHOUT FARM BUILDINGS

Species	Number of birds per 100 stops[1]		
	Fields overall	Fields with farm buildings	Fields without farm buildings
Rock Dove	173.6	234.3	92.0
Barn Swallow	29.8	30.0	28.0
Starling	514.9	512.9	560.0
House Sparrow	528.9	695.7	300.0
TOTALS—4 farm-building species	1247.2	1472.9	980.0
TOTALS—all species	2375.3	2573.0	2300.0

[1] Data based on 47 stops for fields overall; 14 stops for fields with farm buildings; and 5 stops for fields without farm buildings.

Department of Agriculture has advocated more intensive use of farmland, including removal of hedgerows. To evaluate the significance of hedgerows to birds, we compared numbers of birds at 14 stops in fields where deciduous hedgerows were important with those at 11 stops in fields where they were lacking (Table 5). All stops containing coniferous hedgerows were excluded from this analysis.

Twelve species of "edge" birds totalled 541.8 individuals per 100 stops without hedgerows, and 657.2 (21.1% higher) with hedgerows; 9 of the 12 were commoner with hedgerows. Nevertheless, even where hedgerows were absent, many "edge" birds were supported by scattered trees or by forest-field edge beyond the 0.4 km radius (from which birds were counted if heard).

Of the 3 edge species not positively associated with deciduous hedgerows, 2 (Common Grackle and Chipping Sparrow) preferred coniferous hedgerows, which were excluded from this analysis. The third species, the Cedar Waxwing, was commoner without hedgerows for reasons unknown—perhaps merely the small sample size.

Effect of farm buildings on bird numbers in fields.—Like hedgerows, farm buildings have a great effect on numbers of birds recorded in fields. Table 6 compares bird numbers at 5 stops where no farm buildings were present within 0.4 km with those at 14 stops where farm buildings were important (close to the observation point, or 2 or more farmsteads present within 0.4 km). Total numbers of 4 "farm-building" species were 50.3% higher with farm buildings than without them (1473 versus 980 per 100 stops); Rock Doves and House Sparrows were more than twice as abundant. Starlings

TABLE 7

DIVERSITY AND DENSITY OF BIRDS IN DIFFERENT HABITATS

Habitat	No. of stops	Total no. of species	Species per stop	Individuals per stop
Fields	47	56	9.61	23.7
Forest	11	71	11.60	16.0
Urban	19	50	7.62	17.9

would undoubtedly have shown the same pattern had surveys been done earlier in the season, before wandering flocks of juveniles appeared.

DISCUSSION

Diversity and density of birds in different habitats.—Diversity will be discussed only in terms of numbers of species. Out of 101 species (excluding migrants and non-breeders) recorded on the survey routes from 28 May to 4 July, we recorded 50 species at urban stops, 56 at field stops, and 71 at only 11 forest stops (Table 7). Another indication of diversity is the mean number of species per stop, which varied from 7.6 in urban habitats to 11.6 in forest. Although these figures may be inflated by the inclusion of some edge habitat in each category, forests clearly have more species than either fields or urban habitats.

A similar pattern was found by Speirs et al. (1967, 1970, 1975) in a comprehensive census-plot study of bird populations in Ontario County, Ontario, about 130 km east-northeast of Waterloo County. They found a total of 30 species on 11 10-ha study plots in fields; 79 species on 11 forest plots; and 52 species on 10 urban plots. Their low species count in fields is explained by the fact that they largely excluded trees, shrubs, and farm buildings (Speirs and Orenstein 1967); for example, they recorded no Rock Doves, Bank Swallows, Common Crows, House Sparrows, or Northern Orioles in fields.

As the BBS does not measure absolute density, the trends in avian density suggested by our data are misleading. From Table 7, it would appear that the highest densities (individuals per stop) are in fields. This results merely from the observer's ability to see and hear birds at much greater distances in fields than elsewhere. In forest and urban areas, trees and buildings impede the detection of distant birds, and noise from traffic and other sources further reduces detectability in urban areas. Speirs et al. (1970) give mean total bird densities for Ontario County of 240 pairs per 100 ha in fields, 613 in forest, and 1005 in urban areas; the same trend undoubtedly holds true in Waterloo County. Even allowing for the birds added by farm buildings and

hedgerows (largely excluded by Speirs et al.), fields unquestionably have lower densities than any other habitat.

Critique on the method.—The BBS technique is not a reliable indicator of the relative abundance of different species because of differences in conspicuousness among species. Emlen (1971) has quantified conspicuousness as the coefficient of detectability (CD)—the proportion of individuals in an area which is ordinarily detected by an observer. Not only does CD differ greatly among species, but the CD value for each species varies with habitat. For instance, though we made no measurements, our guess is that the mean detection distance in forest is about ⅓ that in fields. As a result, differences among habitats in a species' numbers may be over- or underestimated.

One advantage of the BBS is that it inevitably samples "edge" habitats as well as "pure" habitats; in fact, it is considerably biased toward edge habitats, as roadsides usually create an edge situation. In contrast, the usual approach in census-plot studies is to include only "pure" habitats, and to deliberately avoid mixed habitats and "edge." As an illustration of this, the Common Crow, a typical edge species which ranked 8th in abundance on our surveys, was not even listed among the commoner species in Ontario County by Speirs et al. (1970), whose plot censuses covered all the major pure habitat types. Pure habitats, unmixed with edge, do not cover any extensive areas in southern Ontario. Thus the BBS records a segment of the bird population hardly touched by traditional census-plot methods.

The factors causing variability in BBS counts are discussed by Robbins and Van Velzen (1967:6–12). These include the observer, time of day, weather, and time of year. As all our surveys were conducted by one observer, only the other 3 factors need concern us here.

Most species of birds sing less frequently as the morning progresses, although the rate of decrease varies with the species (Robbins and Van Velzen 1967:11). This becomes particularly noticeable when the direction of coverage is reversed in alternate weeks, as we did. A cogent example is the number of Mourning Doves recorded on Route 1. Mourning Doves sing frequently for about an hour after sunrise, but much less frequently thereafter. Most of the forest-edge on Route 1, hence most of the Mourning Doves, were near the east end of the route. When the survey was begun at the east end, a mean of 12.5 Mourning Doves was recorded. When it was begun at the west end, only 4.3 were recorded; the birds at the east end had stopped singing by the time the observer arrived there.

BBS routes are generally not surveyed during rain, steady drizzle, or fog, or when winds exceed Beaufort force 3 (19 km/h). Within these constraints, however, weather affects counts less than we had anticipated. A case in point is the survey of 1 July, which was begun under marginal weather conditions

TABLE 8

WEEKLY COUNTS (ALL SURVEY ROUTES COMBINED) OF COMMON BIRD SPECIES

Species	Week[1] 1	2	3	4	5	6	7	8	CV[2]
Killdeer	70	63	61	74	76	75	96	58	.10
Rock Dove	102	177	147	248	237	144	244	272	.26
Mourning Dove	39	64	42	45	55	61	38	71	.18
Chimney Swift	26	39	37	31	44	33	24	14	.14
Eastern Kingbird	39	30	29	27	23	30	41	46	.11
Great Crested Flycatcher	15	29	23	30	20	19	7	7	.21
Eastern Wood Pewee	4	15	21	21	17	20	20	16	.14
Horned Lark	63	60	56	55	58	43	48	37	.12
Bank Swallow	36	56	40	68	43	87	164	192	.33
Barn Swallow	54	60	33	27	39	55	67	90	.33
Cliff Swallow	0	16	4	7	20	50	113	52	.94
Blue Jay	40	48	13	11	12	7	10	12	.92
Common Crow	110	152	143	150	171	163	147	154	.07
House Wren	15	31	31	25	42	42	32	34	.22
American Robin	156	189	157	163	195	184	196	226	.09
Cedar Waxwing	8	9	60	42	36	49	47	30	.49
Starling	485	688	1000	775	955	745	1133	1611	.16
Red-eyed Vireo	6	22	17	27	21	26	12	17	.18
Yellow Warbler	19	22	22	22	23	20	12	10	.05
House Sparrow	607	657	726	726	816	791	1006	936	.08
Bobolink	90	73	65	65	79	75	57	38	.09
Eastern Meadowlark	82	64	63	81	79	73	67	53	.12
Red-winged Blackbird	335	304	304	338	344	311	271	327	.06
Northern Oriole	63	41	37	33	44	25	17	23	.21
Common Grackle	346	298	300	286	381	253	287	522	.16
Brown-headed Cowbird	122	124	117	104	110	102	85	55	.08
Cardinal	26	37	33	40	35	39	23	29	.07
American Goldfinch	143	124	67	66	74	87	76	107	.29
Savannah Sparrow	213	230	257	276	318	346	336	310	.16
Vesper Sparrow	69	60	66	70	84	72	69	61	.13
Chipping Sparrow	53	55	63	71	74	61	58	66	.12
Song Sparrow	130	135	120	147	153	149	150	175	.10
TOTAL INDIVIDUALS (all species)	3838	4227	4344	4360	4920	4484	5206	5873	
TOTAL SPECIES	92	87	82	82	79	81	82	79	

[1] Weeks are as follows: Week 1, 18 to 21 May; Week 2, 28 May to 1 June; Week 3, 4 to 9 June; Week 4, 10 to 18 June; Week 5, 19 to 23 June; Week 6, 28 June to 4 July; Week 7, 7 to 10 July; Week 8, 12 to 16 July.

[2] CV = coefficient of variation (standard deviation divided by mean) for Weeks 2 to 6 (28 May to 4 July).

(low clouds, wind 16 km/h) and was halted by heavy rain after 12 stops (it was completed the next day). On these 12 stops, 234 birds of 38 species were recorded, compared with a mean of 248 birds of 36 species—almost identical—on 5 previous coverages of this section of the route. We conclude, as does Anthony J. Erskine (pers. comm.), that weather during a survey generally has little effect on counts if rain and strong winds are avoided.

Time of year had a very noticeable effect on counts for most species. Table 8 shows week-by-week total counts for the 32 commonest species. A Friedman non-parametric analysis of variance (Siegel 1956:166) showed that time of year had a significant effect on counts ($p < .05$). Much of the variation was contributed by Week 1 (18 to 21 May) and Weeks 7 and 8 (7 to 16 July); for most species, counts during these 3 weeks tended to be either higher or lower than those during Weeks 2 to 6 (28 May to 4 July). For 30 of the 32 commonest species, at least 1 of the counts during Weeks 1, 7, and 8 lay outside the range of those in Weeks 2 to 6; for 15 of the 32, all 3 counts in Weeks 1, 7, and 8 lay outside this range.

During Week 1 (18 to 21 May), high counts were recorded for several species (e.g. Blue Jay, Bobolink, and Northern Oriole), probably because they were still migrating in numbers. Interestingly, a sizable Blue Jay migration was noted on 18 and 19 May, the same dates when Weir (1972) reported an influx at Prince Edward Point, Ontario, about 305 km to the east. On the other hand, numbers of several insectivorous species (e.g. Great Crested Flycatcher, Eastern Wood Pewee, House Wren, Cedar Waxwing, and Red-eyed Vireo) were low, presumably because many individuals had not yet arrived from the south. During Week 2 (28 May to 1 June), Blue Jays were still migrating, and most Cedar Waxwings still had not arrived. Even during Week 3 (4 to 9 June), a few migrants were recorded. The presence of migrants in June may be unusual, however, as April and May 1971 were abnormally cold in southern Ontario, and bird migration was noticeably delayed as a result (Fairfield 1971, Goodwin 1971, Weir 1972).

During Weeks 7 and 8 (7 to 16 July), a number of species (e.g. Great Crested Flycatcher, Red-eyed Vireo, Yellow Warbler, Bobolink, Cardinal) were recorded less often because they had stopped singing or sang less often. Most of these are species usually detected by ear. In fact, at least 3 species (Horned Lark, Brown Thrasher, and Northern Oriole) had noticeably decreased their song frequency even by Week 6 (28 June to 4 July). In contrast, a number of visually-conspicuous species (e.g. Eastern Kingbird, Bank and Barn swallows, American Robin, Starling, House Sparrow) showed peak counts in Weeks 7 and 8; this is attributable to the presence of fledged young and of noisy, highly visible family groups or flocks.

Restricting our attention to Weeks 2 to 6 (28 May to 4 July), we found

that counts varied little for most species, although the coefficients of variation ranged from .05 for the Yellow Warbler to .94 for the Cliff Swallow. Two species, the Blue Jay and Cedar Waxwing, showed high coefficients (.92 and .49) only because migratory movements occurred in Weeks 2 and 3; later counts of these species were quite consistent. There was a tendency for highly-localized or colonial species (e.g. Cliff and Bank swallows, Rock Doves) to have high coefficients, although there were exceptions to this. Nevertheless, the median coefficient of variation for the 32 species was only .135, indicating that, for most species, one count in the period 28 May to 4 July is almost as reliable as 5 counts.

We conclude from these data that the period 28 May to 4 July is best for conducting Breeding Bird Surveys in southern Ontario. This is 3 or 4 days earlier than the period of 1 June to 7 July recommended by the U.S. Fish and Wildlife Service for southern Canada, but southern Ontario lies farther south than other parts of southern Canada, and undoubtedly the nesting season is correspondingly earlier.

Finally, we wish to offer some suggestions concerning the continent-wide Breeding Bird Survey. We believe that the value of the Survey would be greatly enhanced by the collection of data similar to ours on land use along survey routes. Land use data could be collected either on the ground, by individual Survey cooperators, or possibly by centralized interpretation of data from high-level aerial photography. Such data need not be collected annually, but perhaps only once every 3 or 4 years.

The main stated purpose of the Survey is to measure year-to-year changes in the abundance of breeding birds (Robbins and Van Velzen 1967, Erskine 1970). We suspect that changes in land use will be the most important single factor responsible for long-term changes in bird numbers; but without information on land use along the actual survey routes, it will be difficult to determine whether changes in numbers have resulted mainly from land use changes or from other, more subtle causes like pesticides. This is especially true in areas sparsely sampled by BBS routes, such as most of the western United States, where land use along BBS routes may not reflect land use over the area as a whole. Before information on land use can be gathered, however, a classification of habitats usable throughout North America is needed. This classification must reflect important features of both natural and man-altered habitats, and must be easily comprehensible to amateur ornithologists, but its development would be well worth the effort.

Even if it does not prove practicable to collect land use data on a continent-wide basis, we hope that our approach will be useful to others who wish to study changes in bird populations in a localized area such as the one we studied.

SUMMARY

We used the Breeding Bird Survey technique to study breeding bird populations in relation to habitat in Waterloo County, Ontario, in 1971. Four survey routes across the county were each covered 8 times between 18 May and 16 July. In conjunction with these surveys, we devised a classification of habitat types and estimated the coverage of each type at each sampling point.

We compared bird numbers among survey routes, and found that numbers of several species were closely related to the extent of particular habitat types. We also compared bird numbers in 3 major habitat categories (fields, forest, and urban areas), based on results from selected sampling points. Because of the nature of the sampling and of the habitats themselves, all 3 contained a high proportion of forest-edge birds. Our data support those of others showing that forests have the most species of birds and urban areas fewest, and are consistent with a pattern of densities highest in urban areas and lowest in fields.

In a critique on the method, we looked at the effects of time of day, weather, and especially time of year on bird counts. Counts in the third week of May were high for some species which were still migrating in large numbers, and low for others which were still arriving. Counts after 4 July were high for some visually-conspicuous species which congregate in family groups or flocks, and low for other species because of a decrease in song. Between 28 May and 4 July, however, counts varied little for most species.

We conclude that interpretation of the significance of changes in bird numbers shown by Breeding Bird Surveys would be facilitated if complementary data on land use were gathered. We recommend the development of a classification of habitats usable throughout North America, and its application in conjunction with the continent-wide Breeding Bird Survey.

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APPENDIX: SCIENTIFIC NAMES OF BIRDS MENTIONED IN TEXT AND TABLES

Ruffed Grouse, *Bonasa umbellus*; Killdeer, *Charadrius vociferus*; American Woodcock, *Philohela minor*; Upland Sandpiper, *Bartramia longicauda*; Spotted Sandpiper, *Actitis macularia*; Rock Dove, *Columba livia*; Mourning Dove, *Zenaida macroura*; Chimney Swift, *Chaetura pelagica*; Common Flicker, *Colaptes auratus*; Eastern Kingbird, *Tyrannus tyrannus*; Great Crested Flycatcher, *Myiarchus crinitus;* Willow Flycatcher, *Empidonax traillii*; Alder Flycatcher, *Empidonax alnorum*; Eastern Wood Pewee, *Contopus virens*; Horned Lark, *Eremophila alpestris*; Bank Swallow, *Riparia riparia*; Barn Swallow, *Hirundo rustica*; Cliff Swallow, *Petrochelidon pyrrhonota*; Purple Martin, *Progne subis*; Blue Jay, *Cyanocitta cristata*; Common Crow, *Corvus brachyrhynchos*; Black-capped Chickadee, *Parus atricapillus*; House Wren, *Troglodytes aedon*; Gray Catbird, *Dumetella carolinensis*; Brown Thrasher, *Toxostoma rufum*; American Robin, *Turdus migratorius*; Veery, *Catharus fuscescens*; Cedar Waxwing, *Bombycilla cedrorum*; Starling, *Sturnus vulgaris*; Red-eyed Vireo, *Vireo olivaceus*; Warbling Vireo, *Vireo gilvus*; Yellow Warbler, *Dendroica petechia*; House Sparrow, *Passer domesticus*; Bobolink, *Dolichonyx oryzivorus*; Eastern Meadowlark, *Sturnella magna*; Red-winged Blackbird, *Agelaius phoeniceus*; Northern Oriole, *Icterus galbula*; Common Grackle, *Quiscalus quiscula*; Brown-headed Cowbird,

Molothrus ater; Cardinal, *Cardinalis cardinalis*; Rose-breasted Grosbeak, *Pheucticus ludovicianus*; Indigo Bunting, *Passerina cyanea*; American Goldfinch, *Carduelis tristis*; Savannah Sparrow, *Passerculus sandwichensis*; Vesper Sparrow, *Pooecetes gramineus*; Chipping Sparrow, *Spizella passerina*; Field Sparrow, *Spizella pusilla*; Song Sparrow, *Melospiza melodia.*

NEW LIFE MEMBER

Robert D. Burns has become a life member of the Wilson Ornithological Society. Dr. Burns is presently a professor of biology at Kenyon College in Gambier, Ohio. His principal interests in ornithology are primarily in the area of population ecology; he has published several studies on the Cardinal. Dr. Burns is also a member of the AOU, The American Society of Mammalogists, and other natural history organizations. He has been very active in the Wilson Society and has served as an elected council member and a member of WOS committees. Dr. Burns is married and has two children.