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Monitoring bird populations with Breeding Bird Survey and atlas data

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The principal means of monitoring avian species in North America since 1966 is the Breeding Bird Survey (BBS). Nearly 2 000 random roadside routes of 50 3-minute stops each are run once each summer by experienced observers. Two-year and long-term population trends have been calculated for 250 of the more common species. We show how Breeding Bird Atlas data for two periods of time can also be used to calculate population trends, and we compare atlas trends with those from the BBS. If coverage is intensive and consistent between time periods, atlas data may be useful for monitoring species that are not adequately sampled by the BBS.

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1. Introduction

Under the provisions of international treaties with neighboring nations, the U. S. Fish & Wildlife Service has the responsibility of protecting bird species that migrate across our international boundaries. Populations of waterfowl, doves, and a few other species that are hunted are carefully monitored through banding results, questionnaires submitted by hunters, and special breeding ground surveys. Our chief method for monitoring songbirds and other nongame species is the Breeding Bird Survey, which is sponsored jointly by the U. S. Fish & Wildlife Service and the Canadian Wildlife Service. These surveys are conducted annually by nearly 2 000 carefully selected volunteers.

Nocturnal and rare species, and those found in habitats distant from roadsides, are poorly sampled by the BBS. During the summers of 1984–87 we have been studying Breeding Bird Atlas methodology to see whether atlas results can be used to supplement BBS data for these species. All of the northeastern states, most of the Canadian provinces, and many of the central, southern, and western states have recently been involved in conducting or planning Breeding Bird Atlases.

The purpose of this paper is to compare trends detected by repetition of a county atlas study with regional trends detected by the BBS, to see whether trends detected by the two methods are in general agreement, and to determine whether intensive atlas studies can be used to supplement data from national or continental monitoring systems such as the BBS.

2. Methods

2.1. Breeding bird survey

The BBS is a highly standardized roadside survey consisting of randomly distributed routes of 50 3-minute stops. Each route is conducted on one morning each June (also late May in the far South and the first week in July in Canada). Counting begins at exactly one-half hour before local sunrise. At each stop all birds seen within 1/4 mile (400 m) or identified at any distance by sound are recorded. No birds observed between stops, which are one-half mile (800 m) apart, are counted. Coverage of the 50 stops requires about 4 to 4 1/2 hours.

The operation and early results of this survey have been described in the Proceedings of several Bird Census Conferences (Bystrak 1981, Geissler & Noon 1981, Robbins & Van Velzen 1974, Robbins et al. 1980, 1983), and are explained in detail in our 15-year summary (Robbins et al. 1986). The chief improvement in analysis since the 15-year summary has been to compensate for changes in observers from year to year by including observers as covariables in the route-regression analysis (Geissler 1984).

Other improvements include software to produce computer-generated colored maps of breeding distributions and densities,

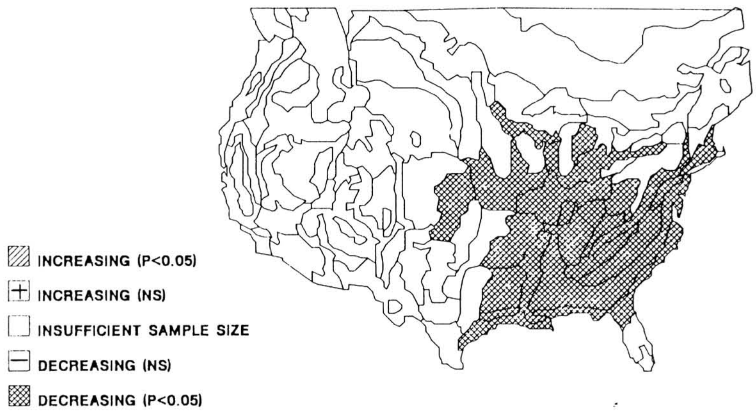

Fig. 1. Population trend in northern bobwhite, 1966–85.

population changes, and annual indices. For this paper we use some of these maps to illustrate population trends for the period 1966–85 for a few species that have been declining over a large portion of the North American continent. Trends were calculated and mapped within ecological strata (Bystrak 1981).

2.2. Breeding bird atlas

Atlases in North America are conducted the same way as in Europe, generally with a 5-km grid (2.5 minutes of latitude by 3.75 minutes of longitude) over a period of 5 years. Each U. S. state or Canadian province is atlased separately, but codes are standardized.

Our research in atlas methodology has included participation in the Maine, New Hampshire, and Maryland atlases, where we have compared effectiveness of different grid sizes, sampling methods, and field procedures. The most concentrated effort has been in Maryland, where we have intensively covered a 2% random sample of the 1 250 5-km atlas blocks, keeping separate records by quarter-blocks (2.5 km on a side). We have also helped with re-atlasing three counties that were originally atlased in the 1970's, including Howard County, which was atlased with 2.5-km quarter-blocks.

In addition to the normal atlas routine of searching all available habitats for breeding species, our procedures have included repeated coverage of roadside Miniroutes (Bystrak 1980), nocturnal coverage of each quarter-block for crepuscular species, surveys by canoe when possible, and interviews with land owners. Most of our random blocks were visited from one to four times each summer. During the last two summers, searches were made in each quarter-block for species that had not been previously recorded.

We did not set a goal of a certain number of hours of field work. Rather, we tried for saturated coverage of all habitats present. We did try to surpass the statewide goals of 80 species per block with no more than 25% of the species in the "Possible" category. We also tried to locate a minimum of 60 species in each quarter-block in the random Maryland sample and in each quarter-block in Howard County, Maryland.

Changes in species' population sizes were inferred from the Howard County data, as this county had been atlased intensively in a similar manner by many of the same observers a decade earlier (Klimkiewicz & Solem 1978). Data from 1973–75 were used to predict the number of quarter-blocks in which a species should be detected in 1983–87, given no population change, after adjusting for a 16.8% increase in total number of records (a measure of effort) in the present atlas. The ratio between the observed and predicted number of quarter-blocks in which the species was detected was used to express percent change.

3. Results

3.1. Breeding bird survey

The following examples illustrate long-term trends of widespread North American species that have been declining because of habitat loss, severe winter weather, changes in farming practices, or competition with other avian species. Population trends were calculated for all ecological strata in which the species was detected on ten or more routes.

The northern bobwhite (*Colinus virginianus*) has shown a gradual decline throughout its range over the past 20 years (Fig. 1). In addition it suffered heavy mortality during two consecutive severely cold winters in 1976–77 and 1977–78, which encompassed practically the entire range of this species.

The black tern (*Chlidonias niger*) has been showing a continuous decline, averaging –8.1% per year for the period 1966–85 (Fig. 2). This decline is probably associated with the continuing loss of wetlands.

The Bewick's wren (*Thryomanes bewickii*) has disappeared from much of the eastern portion of its breeding range during the 20-year period of the BBS,

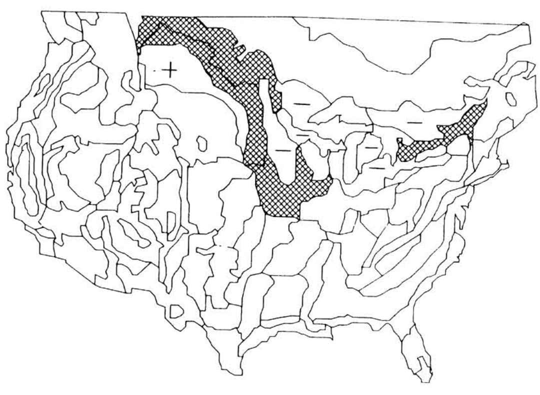

Fig. 2. Population trend in black tern, 1966–85. See Fig. 1 for symbols.

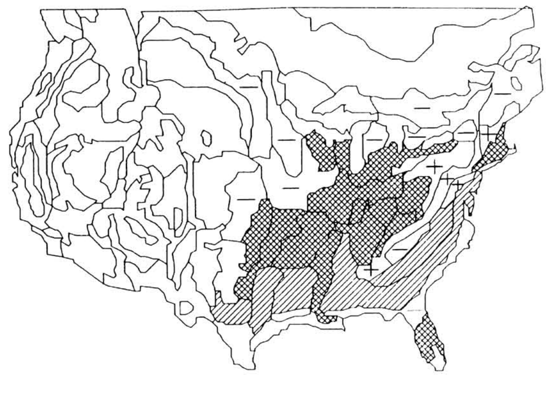

Fig. 4. Population trend in eastern bluebird, 1966–85. See Fig. 1 for symbols.

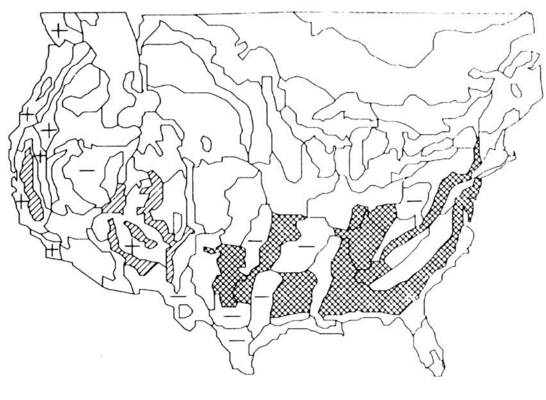

Fig. 3. Population trend in Bewick's wren, 1966–85. See Fig. 1 for symbols.

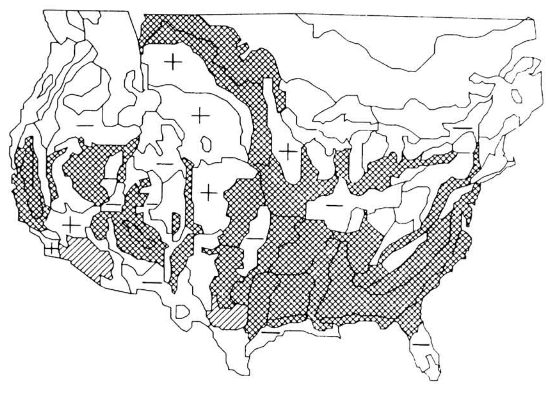

Fig. 5. Population trend in loggerhead shrike, 1966–85. See Fig. 1 for symbols.

although the western populations are remaining stable (Fig. 3). Competition from the aggressive house wren (*Troglodytes aedon*) has been blamed for the decline of Bewick's wren, but severe winter weather has certainly been a contributing factor.

The eastern bluebird (*Sialia sialis*) is a favorite among American birders, who erect nesting boxes for this species. Northern and Florida populations have declined, while intermediate populations have increased (Fig. 4). It is, however, very susceptible to cold winter weather (Robbins et al. 1986), and this together with severe competition from the house sparrow (*Passer domesticus*) keeps populations depressed for long periods. After reaching very low population levels in the late 1970's, this species has finally returned to numbers characteristic of the 1960's.

The loggerhead shrike (*Lanius ludovicianus*) is another species that has been continually declining in the East during recent decades (Fig. 5). The 20-year continental trend is an alarming –3.7% per year, and in most of the Northeast the population is now too low to be monitored by the BBS.

Of no real concern to Americans is the recent decline in the introduced European starling (*Sturnus vulgaris*). Through 1979 this species was still increasing in the central and western portions of North

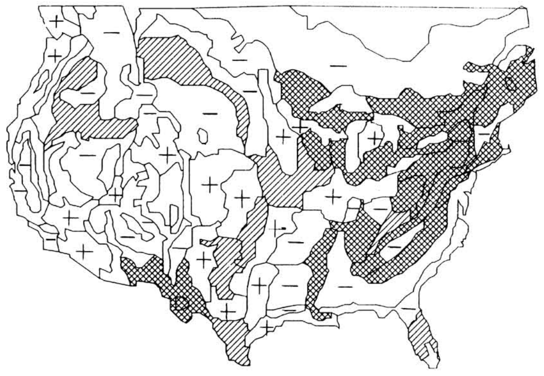

Fig. 6. Population trend in European starling, 1966–85. See Fig. 1 for symbols.

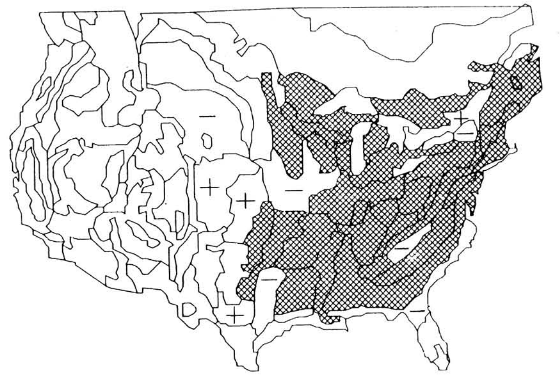

Fig. 8. Population trend in field sparrow, 1966–85. See Fig. 1 for symbols.

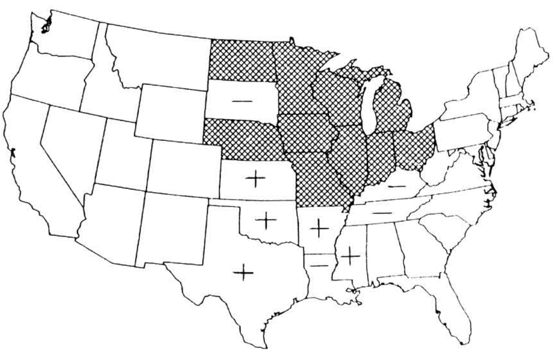

Fig. 7. Population trend in dickcissel, 1966–85. See Fig. 1 for symbols.

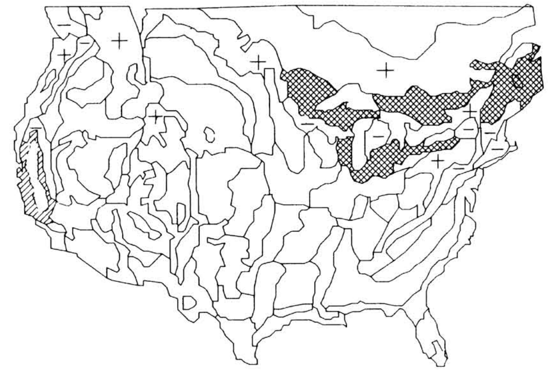

Fig. 9. Population trend in purple finch, 1966–85. See Fig. 1 for symbols.

America, but a decrease had begun in the East (Fig. 6). By 1986 the continental figures were showing a small but significant decline, averaging –0.7% per year.

The dickcissel (*Spiza americana*) is a bird of the central plains and prairies whose distribution varies greatly from year to year depending on weather conditions and land use. It is highly migratory, wintering in northern South America. The 20-year trend is a modest –1.6% per year, and it is declining throughout its range (Fig. 7).

The decline in the eastern field sparrow (*Spizella pusilla*) is partly a result of loss of abandoned fields, and partly a severe weather phenomenon. The continuing decline, throughout its range (Fig. 8), of a once common bird at the high rate of –4.0% per year is cause for concern.

Concern for the purple finch (*Carpodacus purpureus*, Fig. 9) stems largely from possible competition from the house finch (*C. mexicanus*), a western species that was introduced into New York in the early 1940's and has now spread into all the eastern states and most of the eastern provinces of Canada (Fig. 10). Because the house finch is a more southern species, competition so far has been primarily during the winter when both species visit feeding stations.

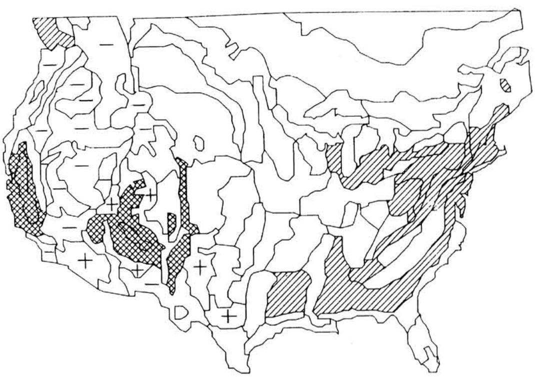

Fig. 10. Population trend in house finch, 1966–85. See Fig. 1 for symbols.

The decline in purple finches is a recent one and may not become serious. In California, where the house finch is native and abundant, purple finch populations are stable or increasing.

3.2. Breeding bird atlas

More than 80 species (range 81–101) were recorded in each of the 34 5-km Howard County atlas blocks during 1983–87, and 60 or more species were found in 92% of the 136 quarter-blocks (range 50 to 93 species). Sørensen's Similarity Indices (1984) were calculated for a sample of 28 Howard County quarter-blocks. The mean similarity was 0.906 (range 0.86 to 0.94). Similarity indices from a sample of 48 quarter-blocks in adjacent Carroll County, where atlas coverage was less intense, had a mean of only 0.843 (range 0.78 to 0.89). As the habitats are generally similar to those in Howard County, the comparatively high similarity indices are a good indication of consistent intensive coverage in Howard County.

During both time periods, coverage of Howard County quarter-blocks was conducted in a similar manner and by many of the same observers. Therefore, we feel justified in using the adjusted 1973–75 results for comparison with the 1983–87 occurrence, correcting only for the difference in total volume of quarter-block records for the two periods (i.e., multiplying them by 1.168). All of the species for which the atlas data showed significant changes are listed in Table 1.

Most of the atlas changes for common species were also suggested by BBS data for the State of Maryland and for the Northern Piedmont (BBS stratum 10), although many of the BBS trends were not significant. These two geographic regions are used for comparison with Howard County atlas data because the Maryland Piedmont sample had too few routes (13 routes) by itself to detect significant changes. No species showed disagreement in significant trends between atlas data and both BBS samples.

4. Discussion

Population trends of about 250 species of birds are adequately monitored annually by the BBS. Some data are obtained on 150 additional species, but for a variety of reasons BBS data can not be used to estimate population trends for most of these other species. Some species occur in habitats that are not adequately sampled in roadside surveys. Other species are either too limited in distribution or are too rare over most of their ranges to allow for estimation of population trends with our current statistical methodology.

Data from the Howard County atlas have permitted the first American attempt to detect population changes by the atlas technique. The atlas trends for common species are in accord with those from the BBS, and the atlas has also detected trends for many additional species for which the BBS had not shown significant changes. We believe, therefore, that atlases can be used to monitor many of the scarcer species that are poorly sampled by the BBS or by extensive annual surveys in other countries. Atlases are especially valuable when there is a need to monitor trends on a local scale. In this analysis we have assumed a consistency of coverage that probably is not generally achieved in atlas data. For population monitoring, it will be necessary to use intensive sampling, as many species can be missed on surveys that sample only roadside habitats.

Rather than adjusting results by the number of hours spent in the field, we believe that saturation coverage, including searches for individual species, is important if trends are to be detected. Setting an arbitrary species goal for each block is not sufficient because important species may be missed. We recommend that where intensive coverage of all atlas blocks cannot be attained, special effort be directed to a random sample of blocks that could be used for monitoring future changes. High similarity indices

Table 1. Changes[1] in breeding bird distribution in Howard County, Maryland from 1973–75 (adjusted) to 1983–87 based on detection in atlas quarter-blocks. Trends from the Breeding Bird Survey, 1966–1986, are shown in the two right columns. BBS trends based on fewer than 15 routes are indicated with an asterisk (*). Other BBS trends that are not significant at $P<0.05$ are in parentheses.

	Number of 2.5-km quarter blocks				BBS Trend	
	1973–75		1983–87	%	Maryland	Stratum 10
	Observed	Adjusted	Observed	change		
Increase:						
Canada goose *Branta canadensis*	8	9	43	+359	(+)	+
Mallard *Anas platyrhynchos*	49	57	86	+50	+	(+)
Black vulture *Coragyps atratus*	18	21	71	+237	+	(+)
Red-tailed hawk *Buteo jamaicensis*	48	56	93	+66	(+)	+
Red-shouldered hawk *Buteo lineatus*	68	80	115	+45	+	(+)
Great horned owl *Bubo virginianus*	29	34	60	+77	+	+
Ruby-throated hummingbird *Archilochus colubris*	59	69	107	+55	(+)	+
Hairy woodpecker *Picoides villosus*	61	71	98	+37	(+)	(+)
Pileated woodpecker *Dryocopus pileatus*	29	34	86	+153	+	(+)
Rough-winged swallow *Stelgidopteryx serripennis*	29	34	50	+47	(+)	(+)
Cliff swallow *Hirundo pyrrhonota*	6	7	20	+185	+*	–*
Fish crow *Corvus ossifragus*	50	59	114	+95	+	(+)
White-breasted nuthatch *Sitta carolinensis*	55	64	105	+63	+	(–)
Eastern bluebird *Sialia sialis*	71	83	122	+47	(+)	(+)
Cedar Waxwing *Bombycilla cedrorum*	17	20	56	+182	(+)	+
Yellow-throated vireo *Vireo flavifrons*	44	51	70	+36	(+)	+
Blue-winged warbler *Vermivora pinus*	13	15	31	+104	–*	–
Northern parula *Parula americana*	44	51	72	+40	(–)	(+)
Yellow warbler *Dendroica petechia*	66	77	106	+37	+	+
Prairie warbler *Dendroica discolor*	45	53	75	+42	–	(–)
Hooded warbler *Wilsonia citrina*	43	50	74	+47	(+)	–*
House finch *Carpodacus mexicanus*	0	0	129	+	+	+
Decrease:						
American black duck *Anas rubripes*	10	12	4	–66	(–)	–*
Black-billed cuckoo *Coccyzus erythropthalmus*	19	22	8	–64	+	(+)
Yellow-billed cuckoo *Coccyzus americanus*	109	128	101	–21	(+)	(+)
Whip-poor-will *Caprimulgus vociferus*	30	35	21	–40	–	+*
Horned lark *Eremophila alpestris*	47	55	18	–67	(–)	–
Bank swallow *Riparia riparia*	9	11	2	–81	(+)	–*
Blue-gray gnatcatcher *Polioptila caerulea*	104	122	100	–18	+	(+)
Prothonotary warbler *Protonotaria citrea*	9	11	3	–72	(+)	+*
Yellow-breasted chat *Icteria virens*	103	121	108	–10	–	–
Vesper sparrow *Pooecetes gramineus*	51	60	21	–65	–	–
Grasshopper sparrow *Ammodramus savannarum*	103	121	76	–37	–	–
Eastern meadowlark *Sturnella magna*	126	147	102	–31	–	–

[1] $P<0.01$, χ^2 test, for Atlas data; $P<0.05$ for BBS data.

among ecologically similar atlas blocks may be a good indication of satisfactory coverage for monitoring purposes, although it is important to recognize that species composition can vary even among similar blocks.

If it can be assumed that a species, if present, will be observed in a block that has undergone saturation coverage, the proportion of blocks that contain the species can be used as the measure of abundance, and changes in the proportion over time can be used as a measure of population trend. Variances of proportions are easy to estimate, hence the statistical significance of increases or decreases can be assessed. If the number of blocks studied in the region remains constant over time, the total number of blocks in which the species occurred can be used as the dependent variable in analysis (as was illustrated in the example presented in this paper). Many of the species that may be best monitored using atlas data are relatively rare, so an estimate of proportion of area occupied (or proportion of stops at which detected) may provide a reasonable estimate of relative abundance.

Saturation coverage of a group of atlas blocks requires a great deal of effort, so trends based on atlas studies may have to be computed by decades rather than annually. Atlasing attempts at more frequent intervals would probably lead to haphazard or incomplete sampling that would provide data of questionable value in determining population trends. At some time in the future, when breeding bird atlases incorporate numerical counts, as the British and Irish did in their winter atlas (Lack 1986), our ability to measure changes will be greatly improved.

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Appendix: Why supplement an atlas study with an intensive random sample?

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The Breeding Bird Atlas of Maryland and the District of Columbia was conducted by the Maryland Ornithological Society and the Maryland Forest, Park, and Wildlife Service during 1983–1987. U. S. Fish & Wildlife Service biologists at the Patuxent Wildlife Research Center have studied intensively for four summers a 2% random sample of the 1 250 5-km atlas blocks in Maryland. This is part of a study of atlas methodology, undertaken to improve field techniques and increase ability of atlases to monitor populations of species that are inadequately sampled by the Breeding Bird Survey. The Statewide atlas was not quite complete at the time of this report, so comparisons are tentative.

Methods

Our intensive coverage of a 2% sample of the Maryland atlas blocks included:

1) Subdivision of each block into four 2.5-km quarter-blocks for intensive coverage of each; the intensive coverage was only for distribution, so the highest category obtained for a species in a block was applied to all quarter-blocks in which it was detected;
2) Two timed early morning coverages of a 15-stop Miniroute in each block (with 3 minutes at each stop);
3) Additional untimed coverages of the Miniroute stops for adding other species and for upgrading those species that needed it;

4) Several nocturnal trips into each quarter-block to locate owls and caprimulgids;
5) Searches of off-road habitats not well represented along roadsides;
6) Coverage of navigable waters by canoe;
7) Repeated searches for expected species that had been missed either in the entire block or in one of the quarter-blocks; and
8) Interviews with landowners.

Our intensive results for four years (1984–87) are compared here with the first four years (1983–86) of the statewide effort, and will subsequently be analyzed with a variety of statistical procedures.

Results

Even after 10–15 visits, most additional trips continued to yield new species and upgrades. The average number of species detected per random block was raised from 74 the first year to 78 the second year, 85 the third year, and 87 the fourth. These totals include a few birds Observed but not nesting within the block, such as colonial herons and gulls. Many of the common species that were found in all of our random blocks were found in 85 to 97 percent of the blocks statewide; by the end of the fifth year, statewide coverage for these species should be very satisfactory. For many species, however, the percentage of blocks in which they were found statewide was only 50–75% of what it was in the random blocks (examples in Table A1); and for certain local and secretive species the statewide percentage was less than half that obtained in the random blocks (Table A2).

Table A1. Relative efficiency of statewide coverage. Percentage of 5-km blocks in which selected moderately well-sampled species were detected compared to random sample.

	Statewide	Random	Statewide/ random
Aix sponsa	43	68	63
Buteo borealis	59	100	59
Scolopax minor	25	48	52
Melanerpes erythrocephalus	18	32	56
Dryocopus pileatus	52	84	62
Empidonax traillii	21	36	58
Eremophila alpestris	30	52	58
Tachycineta bicolor	26	48	54
Corvus ossifragus	60	88	68
Dendroica pinus	44	60	73
Protonotaria citrea	22	36	61
Helmitheros vermivorus	33	52	63
Seiurus aurocapillus	69	96	72
Seiurus motacilla	41	68	60
Ammodromus savannarum	53	84	63
Icterus spurius	62	96	65

Table A2. Relative efficiency of statewide coverage. Percentage of 5-km blocks in which selected poorly sampled species were detected compared to random sample.

	Statewide	Random	Statewide/ random
Accipiter cooperii	11	52	21
Tyto alba	12	28	43
Otus asio	45	92	49
Strix varia	42	84	50
Caprimulgus vociferus	30	64	47
Riparia riparia	3	12	25
Bombycilla cedrorum	50	100	50
Spiza americana	2	8	25
Pooecetes gramineus	20	48	42

Conclusions

1. When results from the random blocks are compared with statewide results, nocturnal, secretive, and rare and local species are found to be poorly sampled by the average atlaser. In a large-scale atlas program, many blocks receive excellent coverage over a period of years, while others are visited on only one or two days in a single year. If the poorly covered blocks are evenly distributed, the resulting maps are unbiased, but percentage occurrence is severely underestimated for certain species, and ability to detect change over a period of years is reduced.

2. If random blocks are designated for special intensive annual coverage during the period of the atlas, the atlas results can be calibrated by comparing the total results with those of the random blocks. Furthermore, similar intensive coverage of the random blocks during a subsequent atlas period, such as 10 or 20 years in the future, can give a better measure of change than can the total results by themselves.

3. A quarter-block (2.5 km) or tetrad (2 km) grid is strongly recommended for the intensive coverage because it will permit changes in many more species to be detected.

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