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THE NORTH AMERICAN BREEDING BIRD SURVEY

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ABSTRACT.—A brief history of the North American Breeding Bird Survey (BBS) and a discussion of the technique are presented. The approximately 2000 random roadside routes conducted yearly during the breeding season throughout North America produce an enormous bank of data on distribution and abundance of breeding birds with great potential use. Data on about one million total birds of 500 species per year are on computer tape to facilitate accessibility and are available to any serious investigator.

The BBS includes the advantages of wide geographic coverage, sampling of most habitat types, standardization of data collection, and a relatively simple format. The Survey is limited by placement of roads (e.g., marshes and rugged mountainous areas are not well sampled), traffic noise interference in some cases and preference of some bird species for roadside habitats. These and other problems and biases of the BBS are discussed.

The uniformity of the technique allows for detecting changes in populations and for creation of maps of relative abundance. Examples of each are presented.

In response to the need for a reliable index of North America bird populations, the U.S. Fish and Wildlife Service and the Canadian Wildlife Service initiated the North American Breeding Bird Survey. In 1965 the roadside technique was tested along 60 routes in Maryland and Delaware to determine its feasibility. Based on this pilot effort, the decision was made to sample the United States and Canada east of the Mississippi River in 1966, and about 600 routes were conducted that year. Coverage was expanded to include the Great Plains states and provinces in 1967 and the entire continent in 1968. The number of routes has slowly increased to approximately 2400 by 1980, with between 1800 and 1900 covered each year, entirely by volunteer observers.

Every effort was made to minimize biases on the BBS so the data could be used without modification and would be as widely useful as possible. In the course of the 15 years of the BBS, problems and questions have emerged, some of them anticipated, some not. The purpose of this paper is to discuss the uses, problems and criticisms of the BBS and the technique.

METHODS

A detailed description of the methods appears in Robbins and Van Velzen (1967), so this section will be brief. The basic unit of the BBS is the route. Each route is conducted on secondary roads and consists of 50 3-minute counting locations 0.8 km (½ mile) apart. In order to apply standard statistical methods to the results, it was necessary to insure random selection of routes; thus the starting point and direction of each route were selected from a table of random numbers.

A sampling scheme based on 1-degree blocks of latitude and longitude (latilongs) was devised for the distribution of routes. Throughout North America the number of routes per latilong varies according to availability of qualified observers, but is uniform across a state or province to prevent clustering of routes. In most of the West, the level of coverage is one route per latilong. In the East there are four to eight per latilong and two in most central states and provinces. The number of routes in a state or province is increased when coverage is complete and increased cooperation assured.

Each route is assigned a stratum number based on a stratification system I devised (Fig. 1), largely from the U.S. Forest Service's "Natural Land Use Area of the United States" (Barnes and Marschner 1933), also from Fenneman (1931, 1938) and Kuchler (1964). The Canadian portion was based on Aldrich's (1963) life zones, Munro and Cowan (1947) and the Atlas of Saskatchewan (Richards and Fung 1969). Fine adjustment of boundaries was done by examination of Canadian and U.S. topographic maps, using relief, elevation, tree cover and land use as a guide. In all analyses, these strata are used as the basic unit, on the assumption that the populations within each stratum are similar and that they differ from adjacent strata (see Peterson 1975). Table 1 briefly describes the 62 strata currently used.

In each state and province there is a volunteer coordinator who is in contact with a large portion of the local amateur ornithologists. The coordinators receive copies of each year's results for their respective areas and often prepare summaries for publication. Many of these highly dedicated individuals also run several routes.

Observers are supplied with rules and all necessary forms and maps, and are instructed to choose a day in June with good weather conditions on a date that is as close as possible to previous runs. Each observer starts at exactly ½ hour before local sunrise, counting and recording all birds detected in three minutes at the starting point. The counting is repeated at the remaining 49 stops. Only birds counted during the 50 3-minute stops are included in the totals. A route should take from 4 to 4½ hours to complete. It is important to finish in this time-frame because on most mornings total bird song decreases rapidly after the first four hours, and for many species, the first three hours.

Each observer summarizes the results and returns all forms to the Migratory Bird and Habitat Research

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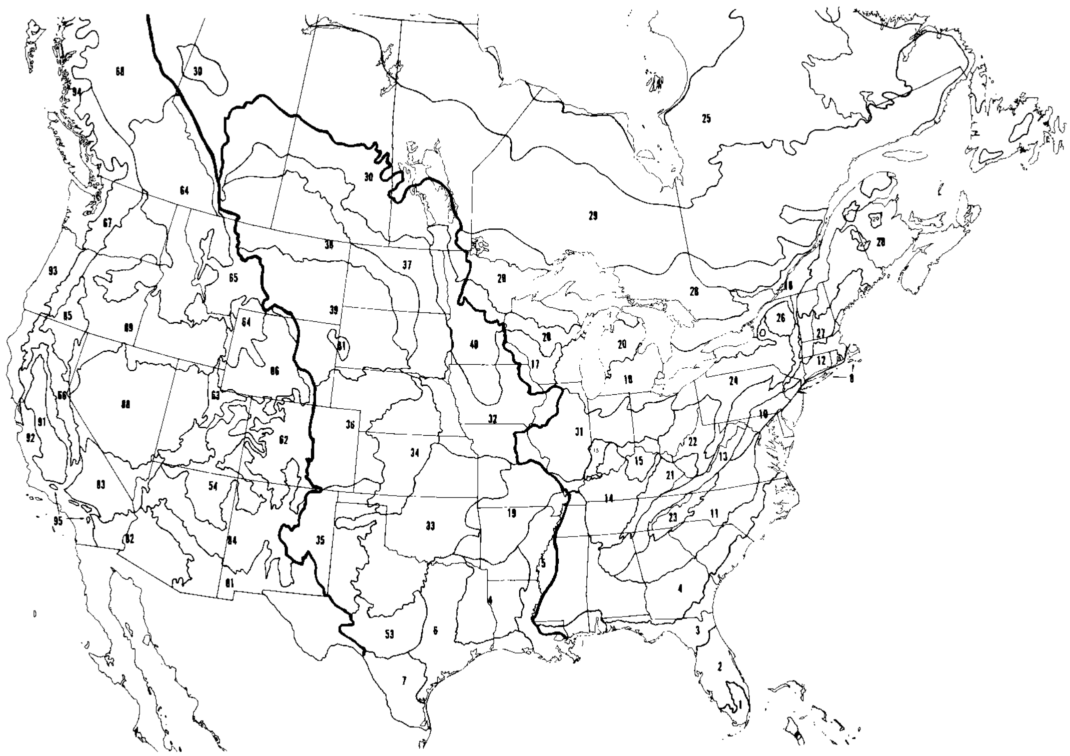

FIGURE 1. Physiographic stratification of North America as used in BBS analyses. Heavy lines delimit Eastern, Central and Western analysis regions. See Table 1 for legend.

Laboratory where biologists and clerks carefully edit them, comparing field to summary sheets and questioning observers on any discrepancies or unverified reports of rare species. All data are transferred to magnetic tape and subjected to various computer edits. Printouts of the results are sent to the observers to be compared to copies of the forms retained by them. After final corrections are made, the data for that year are ready for the preparation of various listings and analyses.

RESULTS

MONITORING POPULATIONS

Currently, the main analytical program for BBS data is an analysis for year to year change in population of 140 species and species groups. In most years only a few species exhibit significant annual population changes, and many of these are not meaningful. The Yellow-billed Cuckoo (*Coccyzus americanus*), for example, can fluctuate wildly in number between years from aberrant migration alone. Occasionally, a weather event drastic enough to cause a serious decline in the population of certain species occurs. After the extended cold of the winter of 1976–77, it was no surprise that the Carolina Wren (*Thryothorus ludovicianus*) population showed a significant decline in the summer of 1977. These wrens require open ground on which to feed by scratching for insects. Thus, the snow and ice prevented access to their food source. Conversely, warm winters mean an increased population. Figure 2 demonstrates graphically the increase in population during five warm winters and the drastic drop after one severe winter. Based on the 1978 through 1980 survey results, the population seems to be very slow to recover. The winter of 1977–78 was also harsh in the East, which kept the population low another year. Only in 1980 (based on preliminary data) does there seem to be a slight increase.

Another species that responded to these harsh winters is the Eastern Bluebird (*Sialia sialis*) (Bystrak 1979). The decrease was not, however, as drastic as that of the Carolina Wren. Despite chronic decreases in the population (Zeleny 1976), Eastern Bluebirds have recovered well from these latest winter disasters. In 27 states composing the bulk of the bluebird's range, the mean birds per route has increased from a low

TABLE 1
EXPLANATION OF PHYSIOGRAPHIC STRATIFICATION USED IN BREEDING BIRD SURVEY ANALYSES. (HIERARCHICAL DESIGNATIONS ARE TENTATIVE.)

- I. Northern Boreal Forest
    - 25 Open Boreal Forest
    - 28 Northern Spruce-Hardwoods
    - 29 Closed Boreal Forest
- II. Eastern Deciduous Forest
    - A. Appalachians
        - 8 Glaciated Coastal Plain
        - 10 Northern Piedmont
        - 12 Southern New England
        - 13 Ridge and Valley
        - 21 Cumberland Plateau
        - 22 Ohio Hills
        - 23 Blue Ridge Mountains
        - 24 Allegheny Plateau
        - 26 Adirondack Mountains
        - 27 Northern New England
    - B. Interior Plains
        - 14 Highland Rim
        - 15 Lexington Plain
        - 16 Great Lakes Plain
        - 17 Driftless Area
        - 18 St. Lawrence River Plain
        - 19 Ozark-Ouachita Plateau
        - 20 Great Lakes Transition
        - 31 Till Plains
- III. Southeastern Forest
    - A. Coastal Plain
        - 1 Subtropical
        - 2 Floridian
        - 3 Coastal Flatwoods
        - 4 Upper Coastal Plain
        - 5 Mississippi Alluvial Plain
        - 6 East Texas Prairies
        - 7 South Texas Brushlands
    - B. Foothills
        - 11 Southern Piedmont
- IV. Great Plains
    - A. Northern Plains
        - 30 Aspen Parklands
        - 32 Dissected Till Plains
        - 37 Drift Prairie
        - 38 Missouri Coteau
        - 39 Great Plains Roughlands
        - 40 Black Prairie
    - B. Southern Plains
        - 33 Osage Plain—Cross Timbers
        - 34 High Plains Border
        - 35 Staked and Pecos Plains
        - 36 High Plains
        - 53 Edward's Plateau
- V. Rocky Mountains
    - A. Basins and Deserts
        - 54 Colorado, Uinta Basins
        - 84 Pinyon-Juniper Woodlands
        - 85 Pitt-Klamath Plateau
        - 86 Wyoming Basin
        - 88 Great Basin
        - 89 Columbia Plateau
    - B. Forested Mountains
        - 61 Black Hills
        - 62 Colorado Rockies
        - 63 High Plateaus of Utah
        - 64 Northern Rockies
        - 65 Dissected Rockies
        - 68 Canadian Rockies
- VI. Pacific Mountains
    - A. Cascade-Sierra Axis
        - 66 Sierra Nevada
        - 67 Cascade Mountains
    - B. Pacific Ranges
        - 91 Central Valley
        - 92 California Foothills
        - 93 S. Pacific Rainforests
        - 94 N. Pacific Rainforests
        - 95 Los Angeles Ranges
- VII. Southwestern Arid
    - 81 Mexican Highlands
    - 82 Sonoran Desert
    - 83 Mojave Desert

of 1.88 in 1978 to 2.89 in 1980. This almost compares to the pre-disaster mean of 3.48 in 1976.

Long-term population increases and decreases can also be plotted. Figure 3 gives some examples of declines and increases of selected species. These four species all exhibited statistically significant long-term trends at the continental level over the 12-year period shown. The data are also analyzed by three major regions (Fig. 1) and by strata and state and province. The species in Figure 3 each exhibited significant trends in the three regions as well as on the continental level.

MAPPING DISTRIBUTION AND ABUNDANCE

For some species, maps can be prepared showing changes in distribution. By examination of yearly range maps prepared from BBS data the fluctuations in the Dickcissel (*Spiza americana*) breeding distribution can be followed (Robbins and Van Velzen 1969 and 1974). This is perhaps the only North American species that regularly shows significant annual fluctuations in breeding range. The southward spread of the breeding range of the Barn Swallow (*Hirundo rustica*) has been well documented during the 14 years of the BBS (Bystrak 1979). Figure 4 shows a similar expansion in breeding range of the House Finch (*Carpodacus mexicanus*) in the eastern United States, where it was introduced in the 1940's.

Because the data are all gathered uniformly, range maps showing relative abundance can be prepared. Yearly maps (Robbins and Van Velzen 1967 and 1969) are difficult to interpret and rather incomplete because peripheral portions of a species' range show largely as zeros, and adjacent routes in the center of the range may have very different counts in any one year just from chance. When long-term route means are used, high and low counts are averaged out, yielding smoother isolines and filling in peripheral portions. Thus, maps based on several years are more easily interpreted. Figure 5 shows the breeding range of Scissor-tailed Flycatcher (*Muscivora forficata*) prepared from 13-year route means. Such maps are potentially useful to biogeographers, taxonomists, population biologists and birders (see also Bystrak 1979).

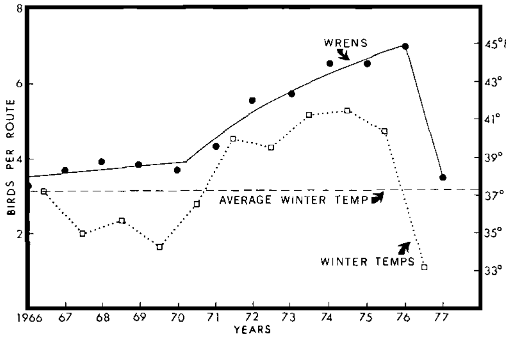

FIGURE 2. Population index of Carolina Wren for states and provinces east of the Mississippi River from BBS data, plotted against winter temperatures for Washington, D.C. (from Bystrak 1979).

DISCUSSION

Uses of BBS Data

The BBS has demonstrated its usefulness as an effective index of bird population levels, both temporally and spatially. In addition to these intended uses, the BBS has been used for many other purposes. Data requests are received weekly from other Department of Interior agencies, the U.S. Forest Service, State Fish and Game departments, Environmental Impact consulting firms, university personnel and other researchers.

The BBS technique has been used in other more intensive studies such as Thompson's (1980) Circle West where it was shown to be an effective method of baseline data gathering, and in the form of mini-routes to aid with data gathering on Atlas projects (Klimkiewicz and Solem 1978). Rotenberry and Wiens (1976) used an adaptation of the technique to estimate species dispersion within various grassland habitats. Rotenberry and Wiens (1978) also used the data from 60 BBS routes to define avifaunal regions of the Pacific Northwest. These regions agreed rather closely with the stratification system used for the BBS. This implies that birds are a useful measure of ecoregions, considering that the BBS stratification system is based on physical characteristics and land use.

Nearly every state ornithological journal has included articles using its state's BBS data (e.g., Van Velzen 1966, Whitney 1967, Zimmerman 1968, Davis 1969, Monroe 1970, Robbins 1971, Evans and Dawson 1976, Cortelyou 1978). BBS data have also been incorporated into state bird books (Imhof 1976, Hall in prep., Robbins, in prep.). Numerous other papers, either summarizing or using BBS data, have been published.

The BBS has even made interesting contributions to state ornithological records, by encouraging bird observations in remote areas during June, when most such activity normally slackens. Several pioneer records have been discovered on BBS routes. Examples include the first Great-tailed Grackle (*Quiscalus mexicanus*) in Arkansas, the first Cassin's Sparrow (*Aimophila carpalis*) in South Dakota, the first Gray Kingbird (*Tyrannus dominicensis*) and White-winged Dove (*Zenaida asiatica*) in Maryland, and the first Willow Flycatchers (*Empidonax traillii*) in Nova Scotia.

Results of the BBS routes and the technique have been used often in Master's and Ph.D. thesis work. Examples include Wallace's (1970) evaluation of the technique with particular references to seasonal changes, weather, time of day, and conspicuousness and Baker's (1977) analysis of California routes relative to environmental parameters.

The BBS is the only program of its kind in North America. The only similar program in the world known to the author is that of Winterbottom (1972) in South Africa. Because there is no effort as comprehensive and uniform, the BBS has often been used as a standard against which to compare other studies. Hussell (1981), for example, compared migration data with BBS data for determining population trends.

Problems

Differences in detectability.—Although the BBS appears to be an effective, versatile technique, it does suffer from certain problems. Per-

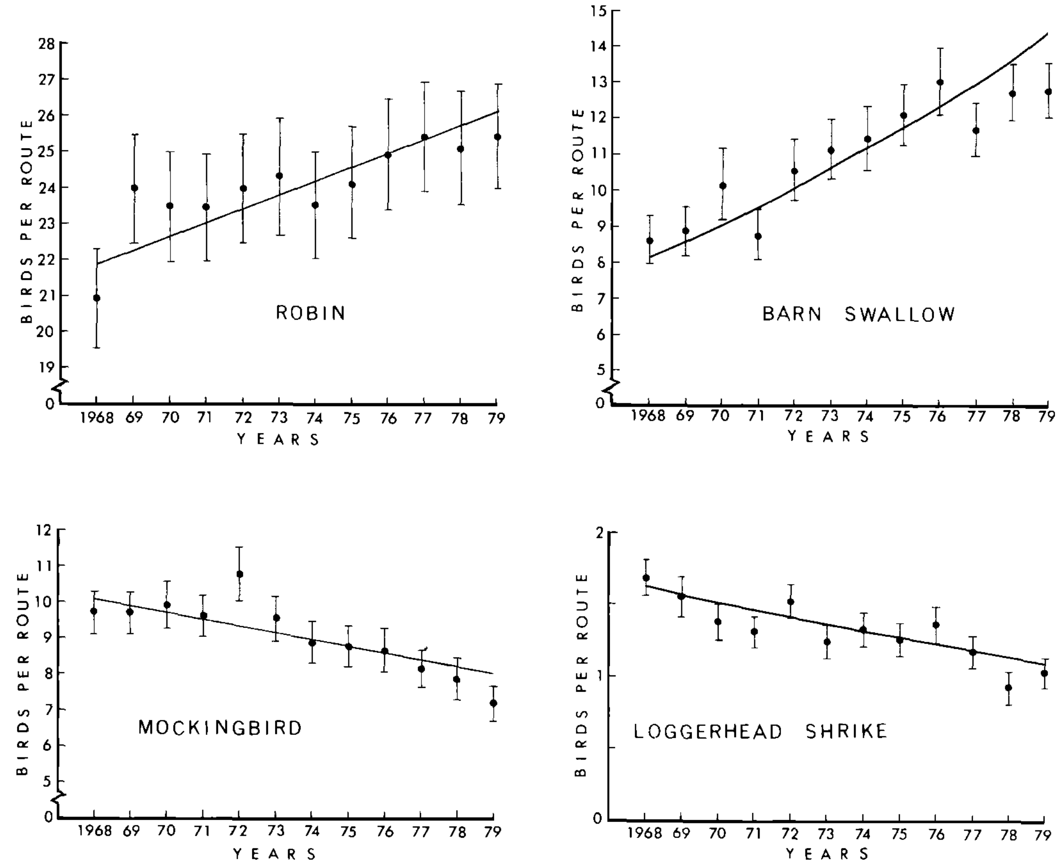

FIGURE 3. Continental population trends for Barn Swallow, Mockingbird (*Mimus polyglottos*), American Robin (*Turdus migratorius*) and Loggerhead Shrike (*Lanius ludovicianus*). Annual means are depicted with 95% confidence limits.

haps the most potentially serious relate to the credibility of the technique. One major criticism offered is that only species characteristic of roadsides are accurately counted. Related to this is the aural detectability difference among species. Wallace (1970) calculated conspicuousness indices for several species, comparing among species and across time. Because each species sings at a different volume and rate, some are easier to detect than others. Because the main purpose of the BBS is to detect population trends within species from year to year, these are not serious problems. The BBS is an index derived from randomly selected routes, all conducted uniformly; therefore, conclusions can be made when comparing one species to itself from year to year or geographically. No pretense is made that one species can be compared to another, although even this may be possible if a conspicuousness index is employed.

Habitat.—Because BBS routes are along roadsides, an unavoidable built-in sampling bias is that certain habitats such as marshes and steep mountainsides tend to be avoided in road construction. As a result, the BBS seriously undersamples these habitats. Related to this is the criticism that habitat parameters along BBS routes are not measured. Weber and Theberge (1977) suggested that the value of the BBS would be enhanced by collection of land use and habitat data along routes. They believed that land use will be the most important single factor responsible for long-term changes in bird numbers, and without recording these data, changes attributable to subtle causes like pesticides may be masked by land use changes. This is a legitimate suggestion, but one not easily incorporated into the Survey. A simple classification of North American habitats is not available, and we are reluctant to ask too much of an all-volunteer crew. An experiment with a raptor survey along BBS routes in 1980 (Patterson, in prep.) indicated the reluctance of most observers to make a return trip over their routes, usually citing time, gasoline prices and exhaustion as the main reasons. Because habitat evaluation would extend the coverage time excessively, it would have to be done on an additional trip, and thus present the same problems. In Maryland, Robbins (unpubl. data) has experimented with a simple habitat form, which may used on a voluntary trial basis on the 1981 BBS. Satellite imagery and/or aerial photography, as proposed by Skaley (pers. comm.), may be useful tools, if these techniques will provide the necessary resolution and not be too expensive. Skaley suggested testing such a classification scheme for avian habitats with BBS data.

Unmated birds.—Berthold (1976) catalogues several papers that approach the problem of unpaired singing males in bird populations. Opinions vary on the extent to which unpaired males sing and the effect they would have on population sampling if they did represent a large percentage of the population. If the percentage is consistent throughout a species' range, however, it should have no adverse effect on the BBS.

Overloading.—Another problem is that of high densities masking change. A BBS stop at which eight Red-eyed Vireos (*Vireo olivaceus*) are recorded may actually have 25 singing males present, but the human ear cannot resolve that many. If the population decreased to 12 the next year, eight might still be the number recorded. Fortunately, for most species, few stops have more than three singing males of any species, so those at which this problem occurs are probably an insignificant proportion of the total. The "dawn chorus" presents a more serious problem on most routes. The flurry of activity by most species makes sorting and counting of birds difficult. These facts suggest that the first several stops produce the least reliable and repeatable data on BBS routes, especially considering that this is when the observer is least prepared.

Operational problems.—Operationally, the BBS also has its share of problems, traffic being perhaps the most serious. In addition to distractions and potential dangers, the traffic noise on some routes can seriously hamper hearing. Other noise factors include streams, dogs, livestock, and curious residents. Unfamiliarity with routes can also present problems. Much time may be lost making wrong turns or missing stops, especially on first runs. This situation is often amplified by poor maps, which frequently are the only maps available. Time is also lost to unexpected detours caused by situations such as bridge washouts, stripmines and locked gates. Many observers complain that 50 stops are too many and that fatigue affects their results on the last 10 or 20.

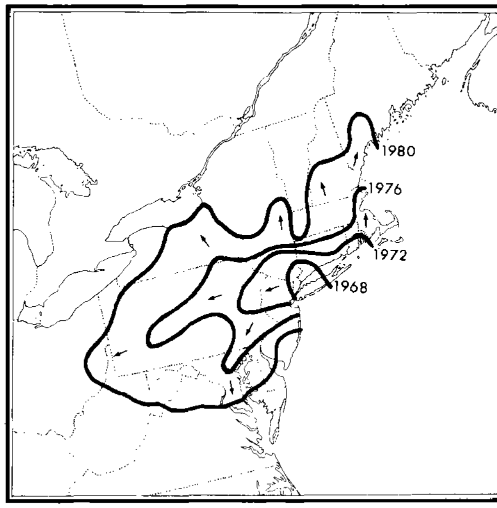

FIGURE 4. Range expansion of the House Finch in the eastern United States as recorded by the BBS. Isolines encompass most extreme records during each 4-year period indicated.

Comparable results.—Maintaining comparable results on routes from year to year also can be a problem. Because of traffic noise, missing bridges and road closings, it is occasionally necessary to make changes on some routes. Minor changes affecting a few stops are not considered serious, but because comparability is important, a route that would require major changes affecting many stops is, instead, replaced by a new route on adjacent roads in similar habitat. Because many routes were drawn hurriedly from poor maps, these substitutions have been all too common. Replacement routes are, of course, given new names and numbers so results are not compared directly. Exact stop locations are not recorded on many routes, so when observers change, stop locations often do too. This also happens when an observer changes cars or even tires, because odometers are notoriously inaccurate. Fortunately, changes in stop locations seem to have little effect on total counts, although no experimentation has been done with this. Nontheless, observers are encouraged to mark exact stop locations and to always use the marked stops. Changing observers presents another problem in maintaining route comparability because we have no way to know the extent to which observers are competent or of sim-

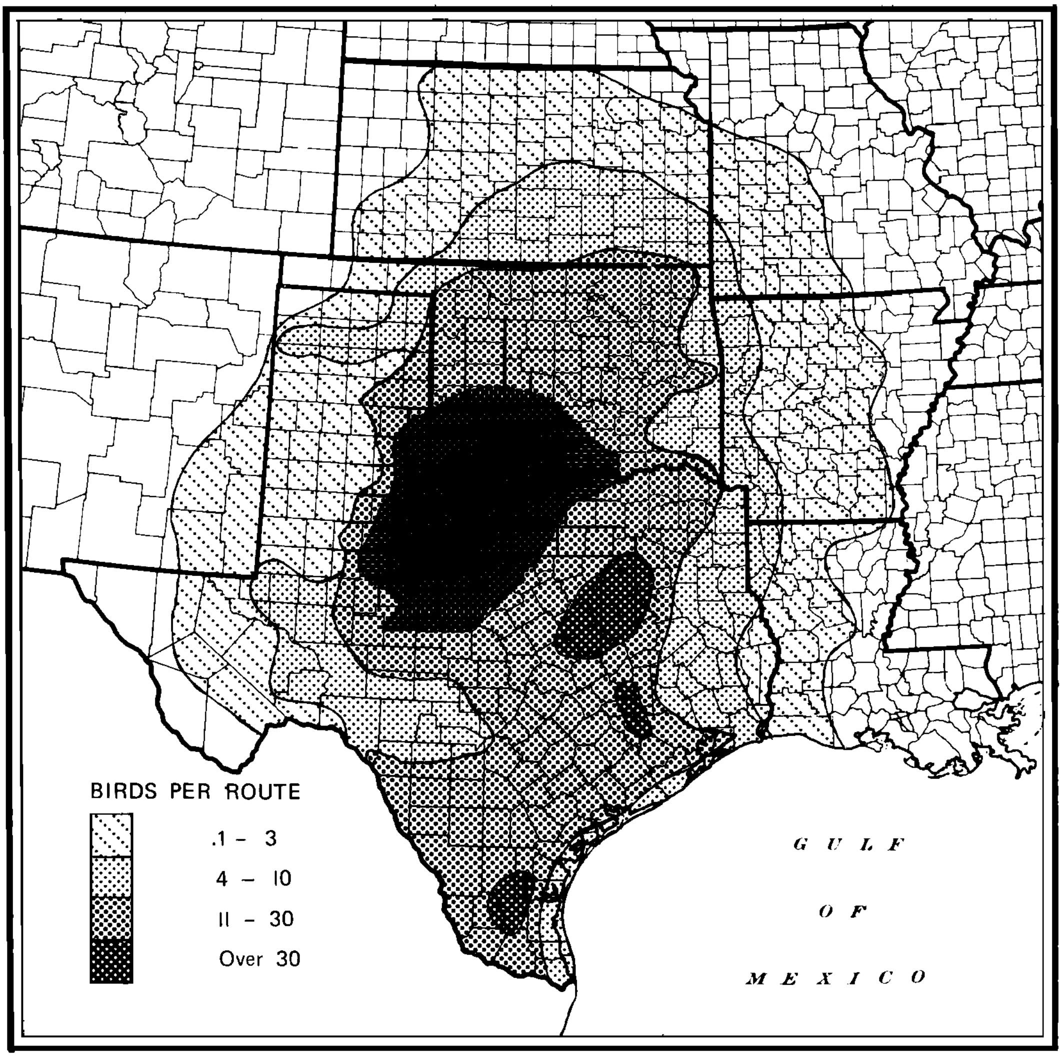

FIGURE 5. Breeding range of Scissor-tailed Flycatcher from BBS data showing relative density.

ilar ability. Two highly qualified observers produce only slight differences in results, but underqualified observers submit results that are less comparable even to themselves (Faanes and Bystrak 1981). Because of the volunteer nature of the BBS, rejection of underqualified observers has been a difficult approach. Careful selection of observers and even more careful use of data are the best solutions to this problem.

Weather.—Variable weather also contributes to a lack of comparability, so observers are urged to choose weather conditions as similar as possible to previous years. Often there is only one opportunity to run a particular route, so it may be run under less than ideal conditions. Again, data obviously affected by weather must be rejected from most analyses. They are useful, however, in analyzing effects of weather on counts (Robbins 1981).

Logistics.—The volume of the data presents some logistical problems. The number of records on magnetic tape is staggering, with approximately 100,000 new records added each year. Such a huge data bank limits the extent to which the data can be manipulated. Massive sorts are necessary for many otherwise simple programs, and storage of data in a more accessible format is prohibitively expensive. Locating and correcting errors is also difficult because the data bank is so large and analysis procedures so complex.

Analysis problems.—Analysis for year-to-year changes is straightforward, but the results rarely show significant changes. Response to extreme conditions is usually the cause of any meaningful yearly aberrations. However, analysis for long-term trends is far more complicated. Bird population trends rarely behave in any predictable fashion. Some populations may be cyclic over time periods longer than that of the history of the BBS and an erroneous conclusion of a significant decrease or increase could be made during a downward or upward portion of the cycle. Geissler and Noon (1981) have experimented extensively with parametric and non-parametric approaches to long-term analysis of BBS data. In addition to the unpredictability inherent in bird populations, there is the problem of uneven coverage. Because routes are covered voluntarily, efforts to reduce clumping are effective on the state level, but many areas of the continent remain severely wanting in coverage. Likewise, individual routes are rarely covered for extended time periods without a break of one or more years. Weighting of data is necessary to compensate for both of these deficiencies. Geissler and Noon (1981) have also experimented with proper weighting techniques. It cannot be overstressed how desperately help is needed in many remote parts of the continent. As the BBS continues to prove itself, I feel it will become more obvious that a system of compensating observers for conducting routes in remote areas is necessary to make the BBS more meaningful and reliable, especially in the increasingly crucial intermontane west.

Stratum crossers.—Another minor problem is that of routes crossing stratum boundaries. Most of the routes were first plotted before the present stratification system was developed. As a result, approximately four percent of the routes cross the present stratum boundaries. In each instance, a route is classified according to its predominant stratum. Some of these crossings are serious because the adjacent stratum is very different in bird composition. Because most analyses involving BBS data use these strata as a basic unit, these routes can contribute misleading data.

The Future

The future of the BBS is, unfortunately, closely tied to the continued availability of affordable transportation. A few observers have already dropped out, using gasoline prices as the reason. This is certain to have an adverse affect on the more remote routes, but, until outdoor recreation in general is seriously hampered by gasoline prices, a serious decrease in BBS coverage is not likely. Short-term crises like the "gas shortage of 1979," which occurred during the height of the breeding season, will probably continue to plague us. However, even in 1979, few routes were sacrificed because of gasoline unavailability.

If we can assume that gasoline will be unavailable or prohibitively expensive some day, experimentation with an alternative such as routes covered on foot should begin soon. One problem such routes might present is a lack of random route distribution, with clustering near population centers. I personally feel that as long as there is a basic need for Americans to be mobile, the BBS will go on, although it may suffer a depression as gasoline prices continue to increase. "Mobile American Thinking" will surely produce an alternative to petroleum-dependent transportation, and the BBS should continue to prosper.