

## POPULATION ESTIMATES OF BREEDING BIRDS IN NORTH DAKOTA

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REASONABLY accurate measurements of breeding bird populations on large land areas are needed if the overall effects of man's impact on the environment are to be measured and understood. Through use of these data, we will be able to detect the average response of these populations to generalized environmental changes caused by diverse and widespread land-use practices. As this kind of information becomes available, it will serve as the basis for developing appropriate management programs for the purpose of maintaining or increasing breeding bird populations.

Estimates of the summer population of birds in an entire state were first attempted for Illinois during 1907 (Forbes, 1908) and 1909 (Forbes and Gross, 1922), followed by a similar comparative study during 1956-58 by Graber and Graber (1963). These estimates were derived primarily from census data of summer birds on selected straight-line transects. Each of these routes contained segments of representative habitats that were considered to be typical of northern, central, and southern portions of the state. Projected statewide populations of summer birds were extrapolated by relating population densities per habitat type to known acreages of each habitat and expanding these data for the state as a whole. The Illinois studies represent a pioneering effort in the development of methods for censusing breeding birds over large areas. The resulting population estimates appear to be of reasonable magnitude. However, as the estimates were based on censuses of birds on sample units that were not randomly selected, their statistical reliability cannot be determined.

The total breeding land bird populations of Great Britain (Fisher, 1940) and Finland (Merikallio, 1958) have also been estimated. In the British study the population data were derived from bird censuses on selected types of land including croplands, grazing lands, and forest. In Finland bird censuses were conducted along transects selected according to biological provinces based on soil productivity and features of vegetation. Apparently a statistical evaluation of the reliability of the population data was not considered feasible in either study.

A more recent method for sampling breeding bird populations over extensive parts of the United States and Canada was developed by Robbins and Van Velzen (1967, 1969). This method is a cooperative venture, requiring large numbers of competent observers. The primary purpose is to obtain population indexes for each breeding species in

major political units (states, provinces) and natural areas that would be indicative of any appreciable future changes in population that might occur. Data were taken from standardized spot counts along certain types of roads that were randomly selected within 1-degree or 2-degree blocks. Over a period of 3 successive years these censuses proved to be satisfactory in yielding population indexes showing significant annual fluctuations in populations. Because of serious biases involved in the manner of selection of sample units and in the methods of census, this approach would be unreliable for estimating actual populations.

We undertook an extensive survey of breeding bird populations in North Dakota in 1967. The primary purpose was to obtain reliable estimates of breeding bird populations in the northern prairie region. In addition the survey yielded information that could be used in evaluating relationships between birds and generalized habitat conditions.

#### ENVIRONMENTAL ATTRIBUTES OF NORTH DAKOTA

North Dakota ranks 17th in size among the 50 states, with an area of approximately 70,594 square miles (Encyclopaedia Britannica, 1970). In contrast, it ranks 45th in population, with 617,761 people in 1970, or an average of 8.8 people per square mile. About 60 percent of the human population resides in rural areas and 40 percent in towns and small cities. The average farm size has increased steadily since World War I and was about 1,024 acres in 1971 (U. S. Soil Conserv. Serv., pers. comm.). Production of crops, mainly wheat, and cattle raising are the mainstays of the economy. Mineral resources are largely restricted to the western portions of the state and include oil, natural gas, and lignite coal. Because of the severity of the climate, sparse population, and distances to major markets, industrial development in North Dakota has been quite limited compared to other states.

*Climate.*—The climate of North Dakota according to Visher (1966) is of the cool, subhumid or semiarid, continental type. The more important climatic features, described in detail by Dietrich and Hove (1962), may be abstracted as follows: Average January temperature, from  $-2^{\circ}$  F in northeastern North Dakota to  $14^{\circ}$  F in the southwest. Average July temperature, from  $66^{\circ}$  F in the northern portion of the state to  $72^{\circ}$  F in the southern portion. Length of growing season, 100 to 130 days. Average annual precipitation, about 14 inches in extreme southwestern and in central northern North Dakota to slightly over 22 inches in the southeast.

The amount of annual precipitation often varies greatly, resulting in alternating wet and dry periods. One aspect of special significance is the fact that about 77 percent of the average annual precipitation is received

during the growing season. Snowfall averages about 32 inches per year (Bavendick, 1952). Evaporation exceeds precipitation throughout North Dakota. On the basis of differences in ratio of these two factors from east to west, Thorntwaite (1931) designated the eastern and western halves of the state as subhumid and semiarid, respectively. Evaporation rates are greatly influenced by the high winds, typical of the interior of North America and particularly of the Great Plains area. The average surface wind velocity is about 12 mph (Visher, 1966).

*Physiography.*—North Dakota lies at the center of the North American continent. It is crossed by a continental divide that separates the drainage system flowing to Hudson Bay from that terminating in the Gulf of Mexico. Two major physiographic provinces of the Interior Plains of North America are well-represented—the Central Lowland occupying approximately the northeastern half of the state, and the Great Plains occupying approximately the southwestern half (Fenneman, 1931). Elevations above sea level range from 790 feet in the northeastern corner to 3,506 feet at White Butte in the southwestern part.

The topographic features in the eastern and northern portions of North Dakota are due almost entirely to the effects of Wisconsin age glaciation (Colton et al., 1963). The predominant glacial landforms include lake plain, ground moraine, and dead-ice moraine. Fairly extensive areas of end moraine, glacial outwash, and deltaic sand occur locally. Common variations in topography may be illustrated by the flat lands of the lake plains, gently rolling surface of the ground moraine, knob-and-kettle formations of the dead-ice moraine, and the rather abrupt, elongated ridges representing end moraines. Prominent hills or steep escarpments in the region include the Turtle Mountains, Pembina Hills, portions of the Missouri Coteau (Figure 1), bluffs along the James, Sheyenne, Mouse, and Des Lacs Rivers, and small local areas including the northern tip of the Prairie Coteau in Sargent County and steep high moraines near the south shore of Devils Lake.

The more rugged topography of the southwestern portion of North Dakota, comprising about 40 percent of the total state area, includes an extensive unglaciated area bordered by a broad band that has been only slightly or moderately affected by glacial action. In this region the effects of glaciation are most noticeable along the marginal strip occurring between the Missouri Coteau and Missouri River trench. Unlike the adjacent, heavily glaciated Missouri Coteau, the drainage of this gently sloping area is well-integrated (Kume and Hansen, 1965), and a considerable part of the surface is covered with a thin veneer of sheet moraine. Other prominent topographic features include dissected valley walls and the valley-floor alluvium of river trenches along the

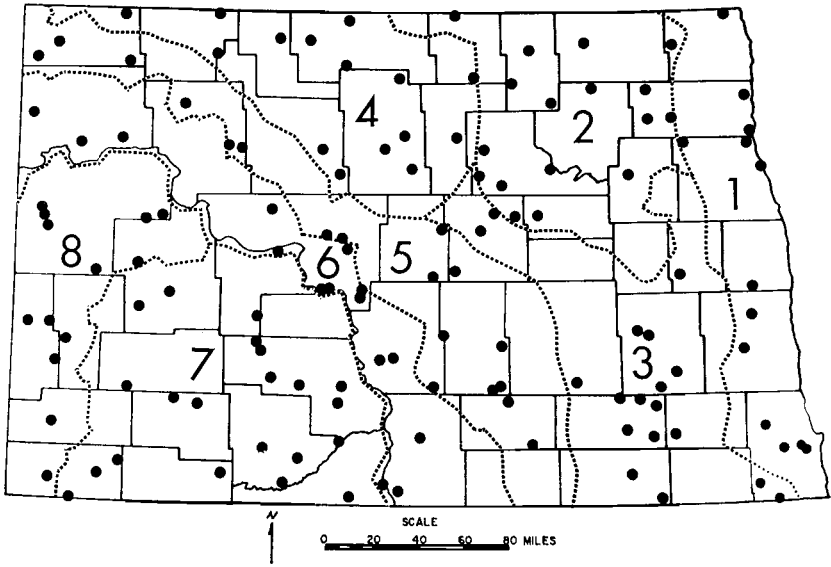


Figure 1. Biotic stratification of North Dakota and distribution of random quarter-section sample units. Numbered strata with boundaries indicated by dashed lines designated as follows: (1) Agassiz Lake Plain. (2) Northeastern Drift Plain. (3) Southern Drift Plain. (4) Northwestern Drift Plain. (5) Missouri Coteau. (6) Coteau Slope. (7) Missouri Slope. (8) Little Missouri Slope.

Missouri River and some of its larger tributaries, many sedimentary bedrock valleys, broad rolling uplands, scattered high buttes, and badlands characterized by extremely eroded sedimentary bedrock consisting primarily of siltstones, sandstones, and shales (Kume and Hansen, 1965). In the 2,000-square mile area of badlands along the Little Missouri River the numerous steep slopes, pinnacles, arroyos, and knifelike ridges form one of the more rugged topographies in North America.

*Habitats.*—North Dakota lies entirely within the grassland biome (Shelford, 1963), and prior to settlement by white man, great uninterrupted expanses of nearly treeless prairie were the predominant habitats throughout. The only extensive tracts of forest were restricted to floodplains and east- or north-facing bluffs along rivers and large creeks and to certain prominent hills or escarpments, including the Turtle Mountains, Pembina Hills, and Devils Lake Hills in the northeastern quarter of the state, and the Killdeer Mountains in the west. Smaller pockets of forest and tall shrub thickets occurred locally on sites with humid or mesophytic microclimates.

Natural wetlands were well-represented, including the Red, James, Mouse, and Missouri Rivers and their tributaries, and hundreds of

thousands of shallow ponds and lakes in the glaciated region. In the western part of the state another distinctive habitat type was clay-scoria slopes prevalent in most badland areas. These slopes were subject to rapid water erosion, resulting in exposed claystones, scoria, shales, and sandstone that were only sparsely vegetated with scattered clumps of grass, forbs, and low shrubs.

Land use by white man since the late 1800s has made drastic changes in habitat conditions, often resulting in a general environmental deterioration (Aus, 1969). The former open-country aspect of North Dakota has been greatly modified by the establishment of thousands of miles of shelterbelts, tree claims, field windbreaks, and by buildings and tree growth in towns and farm residential sections. Agriculture has destroyed most of the native prairie sod, replacing it with tremendous acreages of croplands that are often subject to severe wind or water erosion. Most of the remaining native prairie is in the western part of the state, where it is either pastured by livestock, chiefly cattle, or mowed regularly for hay. A fairly large proportion of the native prairie tracts have been overgrazed with consequent deleterious effects on wildlife in general and on future economic interests as well.

Tens of thousands of natural ponds and lakes in the glaciated portion of the state have been drained, and their basins are now devoted to intensive agriculture. In small part, this loss has been compensated by the construction of small scattered stock-watering dugouts and impoundments on grazing lands, chiefly in the southwestern part of the state. Another great loss has been the elimination of most of the magnificent stands of floodplain forest along the Missouri and other rivers. This was done by impounding water behind huge dams to create large reservoirs for flood control and irrigation.

#### METHODS

*Stratification.*—Precise population estimates of animals whose general range includes large, heterogeneous tracts of land are often difficult to obtain because of the unequal distribution of the population. Under these conditions, unless sample sizes are extremely large, simple random sampling can result in inadequate sampling intensity in the major habitats or the exclusion of small, yet biologically important, habitats. Improvements in sample distribution can sometimes be attained through use of systematic sampling techniques, but valid variance estimates cannot be calculated from data obtained through systematic sampling (Cochran, 1963).

Sample units for this study were drawn randomly within strata created by drawing boundaries around relatively homogenous units within the entire state. Stratification allows possible gains in precision through reductions in the variance estimates for the statewide means. The population estimates for each stratum were also used to determine the distribution of populations within the state.

The interrelationships of physiography and the biota are evident, because of the influence of major landforms on soils, climate, and topography. Stratification was

based primarily on geographical variations in species composition of the fauna and flora as related to boundaries of physiographical regions. A biota characteristic of the northern mixed-grass prairie region is found generally throughout the state. Floristic and faunistic elements of the northern prairies overlap in varying degrees with elements of the eastern deciduous forest and tall-grass prairie regions toward the east and with elements of the Rocky Mountains and northern shrub desert toward the west. In addition the biota of north central and northeastern North Dakota are influenced by the proximity of the aspen parklands and boreal forest region.

Eight major strata, representing the basic biotic regions of the state, are outlined in Figure 1.

*Selection of sample units.*—The legal quarter section (160 acres or  $\frac{1}{2}$  mile  $\times$   $\frac{1}{2}$  mile) was chosen as the sample unit for the population studies for several reasons. Boundaries of quarter sections ordinarily are well-marked by roads, trails, or fence-lines, or else are recognized readily by differences in land use. The units are small enough so that two observers can make complete counts of birds on them in a reasonably short time—about 2 hours per sample unit on the average. Duplications in counts of ducks and other large wide-ranging birds are nearly eliminated; a large bird, once flushed in a quarter section, could usually be followed visually to determine if it moved outside the plot or remained within.

A sample size of 130 units was chosen on the basis of manpower availability and the probable time requirements for conducting the field work. The number of sample units allocated to each stratum was proportional to its area. Within each stratum, sample units were proportionally distributed according to relative size of substrata that were differentiated on the basis of prevalent habitat types. The number of substrata ranged from 2 to 6 for each of the 8 major strata and totaled 28 for the entire state. Sample units were selected at random without replacement and were plotted on U. S. Geological Survey topographic maps (1:250,000 scale). The distribution of the 130 quarter section sample units within strata boundaries over the entire state is shown in Figure 1.

*Census methods.*—The census of breeding birds on each sample unit was conducted on foot by two observers equipped with binoculars. Each observer was responsible for the census of birds on a rectangular half (80 acres) of the quarter section. We tried to follow a standardized census route within each 80-acre rectangle. This route was about 110 yards inside of and parallel to the boundary of the rectangle. Frequent deviations of up to 110 yards from the basic census route were necessary to cover all habitat types adequately. The rectangular halves of a sample unit were covered simultaneously and an interval of about 440 yards between observers was maintained. As this distance is much greater than the distance most species travel after flushing, there was little chance that an individual bird recorded by one observer would also be recorded by the other. Both observers compared field notes at the end of each coverage of a sample unit as a further check in preventing duplications in the counts of such wide-ranging birds as vultures, hawks, and crows.

Occasionally large wetlands required an entirely different type of coverage. Birds on open water were counted with a spotting scope from high ground near the shoreline. In zones of emergent marsh vegetation one observer tried to flush all large birds, particularly ducks and herons, by wading in a zigzag course throughout the marsh and making as much noise as possible. The more secretive marsh birds also were recorded by this method. The other observer was posted on a nearby, higher vantage point and was responsible for recording all large birds that were flushed,

as well as such conspicuous, territorial marsh birds as the Red-winged and Yellow-headed Blackbirds.

The censuses of breeding birds extended from 24 April to 19 July. All sample units were covered for early-nesting species during the period 24 April to 7 June, for mid-nesting species from 14 May to 10 July, and for late-nesting species from 22 May to 19 July. Counts of early-, mid-, or late-nesting species coincided when they were conducted during overlapping portions of their respective breeding periods.

The chronological advance in seasons during the spring and early summer is about 2 weeks earlier in southwestern North Dakota than in the northeastern portion of the state. In attempting to compensate for these phenological differences, the sequence in which sample units were covered progressed on a broad front from southwestern North Dakota toward the northeast.

All species were identified in the field by sight and/or sound. Censuses of birds on sample units with little or no woodland habitat were conducted between  $\frac{1}{2}$  hour after sunrise and  $\frac{1}{2}$  hour before sunset when sustained wind velocities did not exceed 15 mph. Singing and other activities of open-country birds were not appreciably affected by moderate winds or by time of day other than the early morning or late evening periods. Quarter sections containing fairly extensive woodland habitats were covered only on relatively calm, sunshiny days with wind velocities less than 5 mph from  $\frac{1}{2}$  hour after sunrise to 10:00. These limitations were necessary because song frequencies and other activities of most woodland birds are noticeably diminished (1) on cloudy days, (2) in moderate or high winds, and (3) at midday.

Counts of breeding birds were based primarily on the number of indicated pairs on breeding grounds (territories or home ranges) during peak breeding periods. For most species, nearly all indicated pairs were observed as segregated pairs or as territorial males. Segregated pairs and lone females of the Wilson's Phalarope were recorded as indicated pairs. For a few species, including the polygynous Red-winged and Yellow-headed Blackbirds, the number of territorial males represents, in terms of pairs, a minimum population. Breeding populations of Brown-headed Cowbirds generally occurred as scattered secretive females searching for active bird nests to parasitize and resident flocks composed chiefly of nonterritorial males. For this species the number of indicated pairs was based on the total number of males seen per sample unit. In the case of colonial birds that are not sexually dimorphic, such as the Eared Grebe, Black Tern, and Cliff Swallow, the number of indicated pairs was based either on a count of occupied nests or was derived by halving the total number of individuals counted.

The procedures used to determine the number of pairs of breeding ducks were more complicated than for other types of birds. Generally our interpretations of segregated pairs, lone males, small flocks of males, and mixed flocks of both sexes agreed with those of Hammond (1969). The only major exception concerns lone dabbling duck (*Anatinae*) females. Occasionally we found that the number of lone females on a given sample unit exceeded the number of males unaccompanied by females. In this case each excess lone female was considered to represent an indicated pair.

Certain birds observed during the censuses were not considered to be breeding and therefore were not included in the counts. These included migrant flocks and individuals of species that do not breed in North Dakota, and individuals or flocks of nonbreeding, vagrant water birds in summer. Also omitted were individuals or flocks of wide-ranging colonial water birds such as pelicans and gulls seen passing the sample units high overhead.

*Analysis of census data.*—Breeding bird records were keypunched on standard 80-column IBM cards, verified, and calculated on an IBM 360/50 computer at North Dakota State University, Fargo. Statistical procedures followed those of Cochran (1963) for estimating population means and variances from stratified random sampling with proportional allocation. The calculated probability limits of means refer to highest probability density (HPD) intervals (Schmitt, 1969). These intervals, which are analogous to confidence intervals, were constructed utilizing the fact that the number of breeding pairs present cannot be negative. Mean density estimates and highest probability density intervals, calculated from data obtained on the quarter-section sample units, were expressed in terms of pairs per square mile.

The exact biases involved in these surveys were not ascertained, and therefore it was not feasible to appraise their effects on the accuracy of the population estimates. Undoubtedly both positive and negative biases were present to some degree. In conducting the breeding bird counts, every effort was made to minimize any apparent biases, usually through minor adjustments in census techniques.

The estimated numbers of pairs for many species were based in part on numbers of territorial males recorded, because males generally are much more conspicuous than females. This was done on the assumption that most, if not all, territorial males were mated and therefore indicated pairs. A probable positive bias in these counts may have resulted because it is likely that a certain, unknown proportion of territorial males were actually unmated. For a few species, particularly Red-winged and Yellow-headed Blackbirds, this apparent bias would be at least partially counterbalanced by the fact that some of the territorial males were polygynous.

Population data for each species were derived from censuses taken during only one coverage of the sample units. A probable negative bias may have been introduced because it is extremely doubtful that all the pairs present were consistently recorded during a single census coverage. Daily schedules of breeding birds involve many diverse activities including singing, feeding, courtship, and territorial defense, each of which may be characterized by differences in conspicuousness of the birds.

We consider that the census methods yielded satisfactory results for both the major groups of birds and the more important species. This is suggested in part by what appears to be reasonable degrees of magnitude for the census totals. Exceptions included certain species or groups of birds of regular occurrence that are difficult to observe because of their silent, secretive behavior or their reluctance to flush from dense cover. Birds of this type included the Pied-billed Grebe, rails, and gallinaceous birds. The population data appear to be fairly reliable for most species that inhabit fields, grasslands, or other open habitats, but that the census procedures used are as effective in areas containing large tracts of woodland is doubtful. Breeding bird populations in large political or geographical units that are extensively forested probably should be censused by other means.

#### VARIETY OF BREEDING BIRDS

During extensive field investigations from 1961 to 1970, definite breeding records (eggs or young) were obtained for 176 species in North Dakota (Stewart, 1971). Other evidence indicates that about 5 additional species probably were nesting in the state during that period. Of this total 131 species were recorded on the 130 random sample units of the 1967 study, leaving about 50 species of breeding birds that were not recorded in the survey. All of these with the exception of the Downy



Woodpecker (*Dendrocopos pubescens*) are rare, very local, or sporadic in occurrence. Inasmuch as the Downy Woodpecker is fairly common, rather widely distributed, and not overly shy, it is somewhat surprising that it was not recorded on any of the sample units.

The number of species recorded per quarter section throughout the state ranged from 5 to 46, with a mean of 19. Variation in total number of species recorded among the strata also was considerable. The greatest variety occurred in the Northeastern Drift Plain (Stratum 2) and Coteau Slope (Stratum 6), with totals of 86 and 84 species, respectively. This was undoubtedly due to the fairly large proportions of woodlands in these two strata in combination with moderately extensive areas of other natural habitats, including wetlands and native prairie. At the other extreme, the Agassiz Lake Plain (Stratum 1) with a total of 47 species could be considered comparatively impoverished in its variety of birds. This stratum is more intensively farmed than the others, which has resulted in the destruction of very large tracts of natural habitat, and their replacement by croplands and other man-made disturbed types that are relatively sterile in breeding birds.

The proportional composition by species of the state avifauna may be approximated by the relative numbers of pairs of each species recorded on the random survey (Table 1). Numerical importance is indicated by categorizing the various species as primary, secondary, or tertiary. The four species classified as primary comprised 35.7 percent of the total number of breeding birds recorded; 11 species classified as secondary comprised 32.3 percent; and 116 species classified as tertiary comprised 32.0 percent. The primary and secondary species, ranked in decreasing order of their relative abundance, were:

#### Primary Species

- |                               |                         |
|-------------------------------|-------------------------|
| 1. Horned Lark                | 3. Red-winged Blackbird |
| 2. Chestnut-collared Longspur | 4. Western Meadowlark   |

#### Secondary Species

- |                         |                         |
|-------------------------|-------------------------|
| 5. Lark Bunting         | 11. Grasshopper Sparrow |
| 6. Savannah Sparrow     | 12. Mourning Dove       |
| 7. Brown-headed Cowbird | 13. Mallard             |
| 8. Clay-colored Sparrow | 14. Bobolink            |
| 9. American Coot        | 15. Vesper Sparrow      |
| 10. Blue-winged Teal    |                         |

The relative numbers of each breeding species in the eight major strata often varied greatly. The principal strata for a particular species were defined as those in which mean numbers of recorded pairs per

TABLE 1  
SPECIES COMPOSITION OF BREEDING BIRDS

Species <sup>1</sup>	No. of pairs recorded (% of total pairs of all species in parentheses)	Principal strata <sup>2</sup>
Horned Grebe ( <i>Podiceps auritus</i> ) ***	3 ( + ) <sup>3</sup>	2
Eared Grebe ( <i>Podiceps caspicus</i> ) ***	40 ( 0.3)	4, 5
Pied-billed Grebe ( <i>Podilymbus podiceps</i> ) ***	12 ( 0.1)	2, 3, 4, 5
Great Blue Heron ( <i>Ardea herodias</i> ) **	2 ( + )	6
Black-crowned Night Heron ( <i>Nycticorax nycticorax</i> ) ***	17 ( 0.1)	2, 4, 5
American Bittern ( <i>Botaurus lentiginosus</i> ) ***	10 ( 0.1)	2, 3, 5
Mallard ( <i>Anas platyrhynchos</i> ) *	218 ( 1.8)	2, 3, 5
Gadwall ( <i>Anas strepera</i> ) **	100 ( 0.8)	2, 3, 4, 5
Pintail ( <i>Anas acuta</i> ) *	176 ( 1.5)	2, 3, 4, 5, 6
Green-winged Teal ( <i>Anas carolinensis</i> ) **	50 ( 0.4)	2, 3, 4
Blue-winged Teal ( <i>Anas discors</i> ) **	309 ( 2.6)	2, 3, 5
Shoveler ( <i>Anas clypeata</i> ) **	93 ( 0.8)	2, 4, 5
American Widgeon ( <i>Mareca americana</i> ) **	26 ( 0.2)	2, 3, 4
Wood Duck ( <i>Aix sponsa</i> ) *	1 ( + )	3
Redhead ( <i>Aythya americana</i> ) ***	29 ( 0.2)	2, 4, 5
Ring-necked Duck ( <i>Aythya collaris</i> ) **	2 ( + )	2
Canvasback ( <i>Aythya valisineria</i> ) **	11 ( 0.1)	5
Lesser Scaup ( <i>Aythya affinis</i> ) ***	3 ( + )	2, 5, 6
Ruddy Duck ( <i>Oxyura jamaicensis</i> ) ***	36 ( 0.3)	3, 4, 5
Turkey Vulture ( <i>Cathartes aura</i> ) **	1 ( + )	8
Cooper's Hawk ( <i>Accipiter cooperii</i> ) **	3 ( + )	2, 4, 6
Red-tailed Hawk ( <i>Buteo jamaicensis</i> ) **	7 ( 0.1)	1, 2, 3, 8
Swainson's Hawk ( <i>Buteo swainsoni</i> ) **	7 ( 0.1)	4, 5, 6
Ferruginous Hawk ( <i>Buteo regalis</i> ) **	3 ( + )	5, 8
Marsh Hawk ( <i>Circus cyaneus</i> ) **	16 ( 0.1)	3, 4, 5, 6
Sparrow Hawk ( <i>Falco sparverius</i> ) **	5 ( + )	4, 6, 7, 8
Sharp-tailed Grouse ( <i>Pedioecetes phasianellus</i> ) *	13 ( 0.1)	4, 5, 7
Ring-necked Pheasant ( <i>Phasianus colchicus</i> ) *	3 ( + )	3, 6
Gray Partridge ( <i>Perdix perdix</i> ) *	17 ( 0.1)	1, 4, 5, 6
Virginia Rail ( <i>Rallus limicola</i> ) **	3 ( + )	3, 5, 6
Sora ( <i>Porzana carolina</i> ) **	30 ( 0.3)	2, 3, 5
American Coot ( <i>Fulica americana</i> ) **	352 ( 2.9)	2, 3, 4, 5
Piping Plover ( <i>Charadrius melodus</i> ) **	5 ( + )	5
Killdeer ( <i>Charadrius vociferus</i> ) *	106 ( 0.9)	1, 2, 3, 6
Upland Plover ( <i>Bartramia longicauda</i> ) **	63 ( 0.5)	3, 4, 5, 6
Spotted Sandpiper ( <i>Actitis macularia</i> ) ***	12 ( 0.1)	2, 4, 5, 6
Willet ( <i>Catoptrophorus semipalmatus</i> ) **	19 ( 0.2)	2, 3, 4, 5
Marbled Godwit ( <i>Limosa fedoa</i> ) **	17 ( 0.1)	3, 4, 6
American Avocet ( <i>Recurvirostra americana</i> ) **	14 ( 0.1)	3, 4, 5
Wilson's Phalarope ( <i>Steganopus tricolor</i> ) **	79 ( 0.7)	2, 3, 5
Ring-billed Gull ( <i>Larus delawarensis</i> ) **	1 ( + )	5
Franklin's Gull ( <i>Larus pipixcan</i> ) **	22 ( 0.2)	3, 4, 6
Forster's Tern ( <i>Sterna forsteri</i> ) **	3 ( + )	2, 5
Common Tern ( <i>Sterna hirundo</i> ) **	6 ( 0.1)	5
Black Tern ( <i>Chlidonias niger</i> ) **	125 ( 1.0)	2, 3, 5
Mourning Dove ( <i>Zenaidura macroura</i> ) **	295 ( 2.5)	3, 4, 6, 8
Black-billed Cuckoo ( <i>Coccyzus erythrophthalmus</i> ) ***	7 ( 0.1)	2, 3, 4, 6
Great Horned Owl ( <i>Bubo virginianus</i> ) *	2 ( + )	2, 6
Burrowing Owl ( <i>Speotyto cunicularia</i> ) **	3 ( + )	4, 7
Common Nighthawk ( <i>Chordeiles minor</i> ) ***	10 ( 0.1)	6, 7
Chimney Swift ( <i>Chaetura pelagica</i> ) ***	1 ( + )	6
Yellow-shafted Flicker ( <i>Colaptes auratus</i> ) **	41 ( 0.3)	3, 4, 6
Red-shafted Flicker ( <i>Colaptes cafer</i> ) **	12 ( 0.1)	6, 8

TABLE 1—Continued

Species <sup>1</sup>	No. of pairs recorded (% of total pairs of all species in parentheses)	Principal strata <sup>2</sup>
Red-headed Woodpecker ( <i>Melanerpes erythrocephalus</i> ) ***	2 ( + )	1, 6
Hairy Woodpecker ( <i>Dendrocopos villosus</i> ) **	2 ( + )	2, 8
Eastern Kingbird ( <i>Tyrannus tyrannus</i> ) ***	164 ( 1.4 )	2, 3, 5, 6
Western Kingbird ( <i>Tyrannus verticalis</i> ) ***	103 ( 0.9 )	2, 3, 4, 6
Great Crested Flycatcher ( <i>Myiarchus crinitus</i> ) ***	3 ( + )	2
Eastern Phoebe ( <i>Sayornis phoebe</i> ) ***	2 ( + )	2
Say's Phoebe ( <i>Sayornis saya</i> ) ***	6 ( 0.1 )	5, 7, 8
Traill's Flycatcher ( <i>Empidonax traillii</i> ) ***	29 ( 0.2 )	1, 2, 6
Least Flycatcher ( <i>Empidonax minimus</i> ) ***	23 ( 0.2 )	1, 2, 6
Eastern Wood Pewee ( <i>Contopus virens</i> ) ***	2 ( + )	2
Horned Lark ( <i>Eremophila alpestris</i> ) *	1255 ( 10.5 )	4, 6, 7
Tree Swallow ( <i>Iridoprocne bicolor</i> ) ***	3 ( + )	2, 3, 4
Bank Swallow ( <i>Riparia riparia</i> ) ***	77 ( 0.6 )	2, 6
Rough-winged Swallow ( <i>Stelgidopteryx ruficollis</i> ) ***	7 ( 0.1 )	2, 6
Barn Swallow ( <i>Hirundo rustica</i> ) ***	99 ( 0.8 )	1, 2, 3, 6
Cliff Swallow ( <i>Petrochelidon pyrrhonota</i> ) ***	152 ( 1.3 )	6, 8
Purple Martin ( <i>Progne subis</i> ) ***	2 ( + )	2, 4
Blue Jay ( <i>Cyanocitta cristata</i> ) **	15 ( 0.1 )	2, 3, 6, 8
Black-billed Magpie ( <i>Pica pica</i> ) *	20 ( 0.2 )	6, 8
Common Crow ( <i>Corvus brachyrhynchos</i> ) *	30 ( 0.3 )	1, 2, 4, 6, 8
Black-capped Chickadee ( <i>Parus atricapillus</i> ) ***	3 ( + )	2, 6, 8
White-breasted Nuthatch ( <i>Sitta carolinensis</i> ) ***	3 ( + )	2
House Wren ( <i>Troglodytes aedon</i> ) ***	55 ( 0.5 )	1, 3, 6, 8
Long-billed Marsh Wren ( <i>Telmatodytes palustris</i> ) ***	51 ( 0.4 )	3, 4
Short-billed Marsh Wren ( <i>Cistothorus platensis</i> ) ***	10 ( 0.1 )	2, 4
Rock Wren ( <i>Salpinctes obsoletus</i> ) ***	10 ( 0.1 )	8
Catbird ( <i>Dumetella carolinensis</i> ) ***	49 ( 0.4 )	1, 2, 5, 6
Brown Thrasher ( <i>Toxostoma rufum</i> ) ***	42 ( 0.4 )	6, 7
Robin ( <i>Turdus migratorius</i> ) *	71 ( 0.6 )	1, 3, 6, 8
Veery ( <i>Hylocichla fuscescens</i> ) ***	13 ( 0.1 )	2, 8
Eastern Bluebird ( <i>Sialia sialis</i> ) **	1 ( + )	8
Mountain Bluebird ( <i>Sialia currucoides</i> ) **	8 ( 0.1 )	8
Sprague's Pipit ( <i>Anthus spragueii</i> ) **	7 ( 0.1 )	4, 5, 6, 8
Cedar Waxwing ( <i>Bombicylla cedrorum</i> ) ***	24 ( 0.2 )	2, 6
Loggerhead Shrike ( <i>Lanius ludovicianus</i> ) **	8 ( 0.1 )	5, 6, 7, 8
Starling ( <i>Sturnus vulgaris</i> ) *	12 ( 0.1 )	1, 3, 6
Red-eyed Vireo ( <i>Vireo olivaceus</i> ) ***	31 ( 0.3 )	2, 8
Warbling Vireo ( <i>Vireo gilvus</i> ) ***	19 ( 0.2 )	2, 3, 6
Black-and-white Warbler ( <i>Mniotilta varia</i> ) ***	9 ( 0.1 )	8
Yellow Warbler ( <i>Dendroica petechia</i> ) ***	111 ( 0.9 )	2, 6, 8
Ovenbird ( <i>Seiurus aurocapillus</i> ) ***	17 ( 0.1 )	8
Northern Waterthrush ( <i>Seiurus noveboracensis</i> ) ***	2 ( + )	2
Yellowthroat ( <i>Geothlypis trichas</i> ) ***	135 ( 1.1 )	2, 5, 8
Yellow-breasted Chat ( <i>Icteria virens</i> ) ***	7 ( 0.1 )	8
American Redstart ( <i>Setophaga ruticilla</i> ) ***	22 ( 0.2 )	2, 8
House Sparrow ( <i>Passer domesticus</i> ) *	109 ( 0.9 )	1, 3, 6, 7, 8
Bobolink ( <i>Dolichonyx oryzivorus</i> ) ***	216 ( 1.8 )	1, 2, 3, 4
Western Meadowlark ( <i>Sturnella neglecta</i> ) *	924 ( 7.7 )	4, 5, 6, 7, 8
Yellow-headed Blackbird ( <i>Xanthocephalus xanthocephalus</i> ) **	94 ( 0.8 )	2, 3, 4, 5
Red-winged Blackbird ( <i>Agelaius phoeniceus</i> ) **	963 ( 8.0 )	2, 3, 4
Orchard Oriole ( <i>Icterus spurius</i> ) ***	18 ( 0.2 )	1, 3, 6
Baltimore Oriole ( <i>Icterus galbula</i> ) ***	21 ( 0.2 )	1, 2, 3
Brewer's Blackbird ( <i>Euphagus cyanocephalus</i> ) **	19 ( 0.2 )	1, 4, 5, 7

TABLE 1—Continued

Species <sup>1</sup>	No. of pairs recorded (% of total pairs of all species in parentheses)	Principal strata <sup>2</sup>
Common Grackle ( <i>Quiscalus quiscula</i> ) **	157 ( 1.3)	3, 6
Brown-headed Cowbird ( <i>Molothrus ater</i> ) **	461 ( 3.9)	2, 4, 6
Rose-breasted Grosbeak ( <i>Pheucticus ludovicianus</i> ) ***	2 ( +)	1, 2
Black-headed Grosbeak ( <i>Pheucticus melanocephalus</i> ) ***	5 ( +)	6, 8
Blue Grosbeak ( <i>Guiraca caerulea</i> ) ***	1 ( +)	6
Indigo Bunting ( <i>Passerina cyanea</i> ) ***	2 ( +)	2, 6
Lazuli Bunting ( <i>Passerina amoena</i> ) ***	21 ( 0.2)	6, 8
Dickcissel ( <i>Spiza americana</i> ) ***	63 ( 0.5)	1, 3, 6, 7
American Goldfinch ( <i>Spinus tristis</i> ) ***	108 ( 0.9)	1, 2, 3, 6
Rufous-sided Towhee ( <i>Pipilo erythrophthalmus</i> ) ***	100 ( 0.8)	8
Lark Bunting ( <i>Calamospiza melanocorys</i> ) ***	607 ( 5.1)	4, 7
Savannah Sparrow ( <i>Passerculus sandwichensis</i> ) **	525 ( 4.4)	2, 3, 4, 5, 6
Grasshopper Sparrow ( <i>Ammodramus savannarum</i> ) ***	296 ( 2.5)	5, 6, 7, 8
Baird's Sparrow ( <i>Ammodramus bairdii</i> ) **	170 ( 1.4)	5, 6
LeConte's Sparrow ( <i>Passerherbulus caudacutus</i> ) ***	6 ( 0.1)	2, 4
Sharp-tailed Sparrow ( <i>Ammodramus caudacuta</i> ) ***	3 ( +)	3, 4
Vesper Sparrow ( <i>Pooecetes gramineus</i> ) ***	205 ( 1.7)	1, 2, 4, 8
Lark Sparrow ( <i>Chondestes grammacus</i> ) **	46 ( 0.4)	6, 8
Chipping Sparrow ( <i>Spizella passerina</i> ) ***	33 ( 0.3)	8
Clay-colored Sparrow ( <i>Spizella pallida</i> ) **	366 ( 3.1)	2, 5
Brewer's Sparrow ( <i>Spizella breweri</i> ) ***	2 ( +)	8
Field Sparrow ( <i>Spizella pusilla</i> ) ***	52 ( 0.4)	8
Song Sparrow ( <i>Melospiza melodia</i> ) **	55 ( 0.5)	1, 2, 3, 6
McCown's Longspur ( <i>Rhynchophanes mccownii</i> ) **	22 ( 0.2)	4, 6, 7
Chestnut-collared Longspur ( <i>Calcarius ornatus</i> ) **	1132 ( 9.5)	6, 7
TOTAL PAIRS	11,965 (100.0)	2, 4, 6, 7

<sup>1</sup> Asterisks following species names indicate peak breeding periods during which counts were made. \*, early-nesting species, peak breeding period 24 April to 7 June 1967. \*\*, mid-nesting species, peak breeding period 14 May to 10 July. \*\*\*, late-nesting species, peak breeding period 22 May to 19 July.

<sup>2</sup> Principal strata are those in which the strata mean (number of recorded pairs per sample unit) exceeded the statewide mean.

<sup>3</sup> A + indicates a percentage of less than 0.05.

sample unit exceeded the statewide mean (Table 1). The relative overall use of each stratum may be evaluated by the number of species that had mean densities greater than the statewide mean. On this basis, the strata may be ranked in decreasing order of importance as follows:

Northeastern Drift Plain (Stratum 2)	66 species
Coteau Slope (Stratum 6)	64 species
Southern Drift Plain (Stratum 3)	49 species
Northwestern Drift Plain (Stratum 4)	47 species
Missouri Coteau (Stratum 5)	44 species
Little Missouri Slope (Stratum 8)	39 species
Agassiz Lake Plain (Stratum 1)	22 species
Missouri Slope (Stratum 7)	16 species

The Northeastern Drift Plain (Stratum 2) and Coteau Slope (Stratum 6) had the larger number of species and also contained the greater variety of extensive habitat types. In contrast, the Missouri Slope (Stratum 7) and Agassiz Lake Plain (Stratum 1) were of importance to relatively few breeding species, reflecting the marked limitations in variety of extensive habitat types present.

#### FREQUENCY AND POPULATION ESTIMATES OF BREEDING BIRDS

Breeding birds occurred on all 130 sample units. The density of all species combined ranged from 60 pairs per square mile (9 pairs per 100 acres) on one sample unit of the Agassiz Lake Plain (Stratum 1) to 1,396 pairs per square mile (218 pairs per 100 acres) on one sample unit of the Northwestern Drift Plain (Stratum 4). The mean density of birds for all sample units throughout the state was 368 pairs per square mile (95 percent HPD interval of 337–400). The projected total breeding bird population for the entire state was estimated to be about 25,990,000 pairs (95 percent HPD interval of 23,761,000–28,218,000 pairs).

In Illinois the statewide population of breeding birds was estimated to be 30,666,000 pairs (548 pairs per square mile) in 1909; 29,889,000 pairs (520 pairs per square mile) in 1957; and 32,793,000 pairs (586 pairs per square mile) in 1958 (Graber and Graber, 1963). In Illinois the greater diversity of habitat conditions, less extensive areas of uninterrupted, monotypic croplands, and greater acreages of woodland undoubtedly account, in part, for the higher densities and projected populations of breeding birds. Croplands in particular are relatively unattractive to most breeding birds, while woodlands are especially productive in supporting large populations.

Population estimates of the total breeding land birds have been made in two foreign countries. In Great Britain (England, Wales, and Scotland) Fisher (1940) estimated the population at 120 million (or 60 million pairs), or about 676 pairs per square mile. Merikallio (1958) estimated the breeding bird population of Finland to be about 32,160,000 pairs or 247 pairs per square mile.

Among the major taxonomic groups of birds in North Dakota, nine orders were represented by breeding populations with frequency occurrence of 10 percent or more in the quarter sections surveyed (Table 2). Passeriformes (passerine birds) was of universal importance, being the only order occurring in all quarter sections surveyed. Other orders with relatively high frequencies of occurrence included the Charadriiformes (shorebirds, gulls, terns, etc.), 79.2 percent; the Anseriformes (water-

TABLE 2  
BREEDING POPULATIONS OF MAJOR ORDERS OF BIRDS<sup>1</sup>

Order	Frequency (% occurrence in sample units and HPD interval) <sup>2</sup>	Maximum density (prs/mi <sup>2</sup> ) <sup>3</sup>	Mean density (prs/mi <sup>2</sup> and HPD interval) <sup>4</sup>	Projected statewide population (pairs and HPD interval) <sup>5</sup>
Ciconiiformes	12.3 ( 7.2-18.3)	36 (5)	0.89 ( 0.27- 1.52)	63,000 ( 19,000- 107,000)
Anseriformes	70.8 (62.8-78.3)	304 (4)	32.31 ( 24.12- 40.50)	2,281,000 ( 1,703,000- 2,859,000)
Falconiformes	29.2 (21.7-37.2)	8 (2, 5, 6, 8)	1.29 ( 0.94- 1.65)	91,000 ( 66,000- 116,000)
Galliformes	20.0 (13.6-27.2)	16 (5)	1.02 ( 0.62- 1.41)	72,000 ( 43,000- 100,000)
Gruiformes	25.4 (18.3-33.1)	432 (4)	11.85 ( 3.90- 19.79)	836,000 ( 276,000- 1,397,000)
Charadriiformes	79.2 (72.0-85.8)	128 (5)	14.52 ( 11.62- 17.42)	1,025,000 ( 821,000- 1,230,000)
Columbiformes	56.2 (47.6-64.5)	76 (6)	9.08 ( 6.97- 11.19)	641,000 ( 492,000- 790,000)
Piciformes	22.3 (15.6-29.7)	36 (6)	1.75 ( 0.97- 2.54)	124,000 ( 69,000- 179,000)
Passeriformes	100	764 (8)	292.80 (271.13-314.47)	20,670,000 (19,140,000-22,200,000)

<sup>1</sup> Major orders are those with statewide frequency of 10 percent or more.  
<sup>2</sup> Highest probability density (HPD) interval contains 95 percent of the probability content of the statistical distribution of the frequency.  
<sup>3</sup> Numbers in parentheses indicate the strata in which maximum density occurred.  
<sup>4</sup> Highest probability density (HPD) interval contains 95 percent of the probability content of the statistical distribution of the density.  
<sup>5</sup> Highest probability density (HPD) interval contains 95 percent of the probability content of the statistical distribution of the population.

fowl), 70.8 percent; and the Columbiformes (Mourning Dove), 56.2 percent.

Population densities among the various orders (Table 3) were overshadowed by the Passeriformes with a statewide mean density of 293 pairs per square mile and a maximum density of 764 pairs per square mile on one sample unit in the Little Missouri Slope (Stratum 8). Other orders with fairly high densities included Anseriformes, Charadriiformes, Gruiformes, and Columbiformes. Of special interest to conservationists and wildlife managers is the mean statewide density for Anseriformes (dabbling and diving ducks combined). This was 32 pairs per square mile, with a maximum density of 304 pairs per square mile recorded on one sample unit in the Northwestern Drift Plain (Stratum 4).

The combined projected populations of the nine major orders in North Dakota (Table 2) comprised about 99.5 percent of the total breeding pairs of all species in 1967. The Passeriformes alone, with a projected population of 20,670,000 pairs, constituted about 79.6 percent of the total breeding bird population of all species combined.

Fifty species of breeding birds had statewide frequencies of 10 percent or more (Table 3). These included 31 species of Passeriformes; 7 species of Anseriformes; 6 species of Charadriiformes; 2 species of Gruiformes; and 1 species each of Falconiformes, Galliformes, Columbiformes, and Piciformes. Statewide frequencies of 7 species of passerine birds (Eastern Kingbird, Horned Lark, Western Meadowlark, Red-winged Blackbird, Brown-headed Cowbird, Savannah Sparrow, and Vesper Sparrow), 2 species of ducks (Mallard, Pintail), and the Mourning Dove were found to exceed 50 percent.

Densities in terms of pairs per square mile were determined for the 50 major species with a frequency occurrence of 10 percent or more (Table 3). Maximum densities of 100 pairs or more per square mile were recorded for 13 species. These included a high density of 432 pairs per square mile for the American Coot on one sample unit in the Northwestern Drift Plain (Stratum 4) and densities of 256, 204, and 160 pairs per square mile for the Chestnut-collared Longspur, Lark Bunting, and Horned Lark, respectively, on single sample units of the Missouri Slope (Stratum 7). The statewide mean densities for the 50 species with frequencies of 10 percent or more ranged from 0.5 to 38.6 pairs per square mile. Especially high mean densities were obtained for the Horned Lark with 38.6 pairs per square mile, the Chestnut-collared Longspur with 34.8 pairs per square mile, the Red-winged Blackbird with 29.6 pairs per square mile, and the Western Meadowlark with 28.4 pairs per square mile.

TABLE 3  
BREEDING POPULATION ESTIMATES OF MAJOR SPECIES OF BIRDS<sup>1</sup>

Species	Frequency (% occurrence in sample units and HPD interval) <sup>2</sup>	Maximum density (prs/mi <sup>2</sup> ) <sup>3</sup>	Mean density (prs/mi <sup>2</sup> and HPD interval) <sup>4</sup>	Projected statewide population (pairs and HPD interval) <sup>5</sup>
Mallard	60.8 (52.3-69.0)	40 (2, 3)	6.71 ( 5.51- 7.90)	474,000 ( 389,000- 558,000)
Gadwall	28.5 (21.0-36.4)	68 (4)	3.08 ( 1.56- 4.60)	217,000 ( 110,000- 324,000)
Pintail	52.3 (43.8-60.8)	32 (3)	5.42 ( 4.32- 6.51)	382,000 ( 305,000- 460,000)
Green-winged Teal	17.7 (11.6-24.6)	20 (2, 3, 4)	1.54 ( 0.89- 2.19)	109,000 ( 63,000- 154,000)
Blue-winged Teal	38.5 (30.3-46.9)	100 (2)	9.63 ( 6.79-12.47)	680,000 ( 479,000- 881,000)
Shoveler	29.2 (21.7-37.2)	44 (2)	2.86 ( 1.70- 4.02)	202,000 ( 120,000- 284,000)
American Widgeon	12.3 ( 7.2-18.3)	20 (4)	0.80 ( 0.29- 1.31)	56,000 ( 20,000- 93,000)
Marsh Hawk	12.3 ( 7.2-18.3)	4 (3, 4, 5, 6, 7, 8)	0.49 ( 0.27- 0.72)	35,000 ( 19,000- 51,000)
Gray Partridge	11.5 ( 6.6-17.4)	8 (5, 6)	0.52 ( 0.26- 0.79)	37,000 ( 18,000- 56,000)
Sora	11.5 ( 6.6-17.4)	16 (2, 3)	0.92 ( 0.46- 1.39)	65,000 ( 32,000- 98,000)
American Coot	23.1 (16.2-30.6)	432 (4)	10.83 ( 3.06-18.60)	764,000 ( 216,000-1,313,000)
Killdeer	49.2 (40.7-57.8)	24 (6)	3.26 ( 2.53- 3.97)	230,000 ( 180,000- 280,000)
Upland Plover	27.7 (20.3-35.6)	20 (4, 6)	1.94 ( 1.29- 2.59)	137,000 ( 91,000- 183,000)
Willet	13.8 ( 8.4-20.2)	8 (2)	0.58 ( 0.34- 0.83)	41,000 ( 24,000- 58,000)
Marbled Godwit	12.3 ( 7.2-18.3)	8 (3)	0.52 ( 0.28- 0.76)	37,000 ( 20,000- 54,000)
Wilson's Phalarope	23.1 (16.2-30.6)	24 (2, 5)	2.43 ( 1.54- 3.32)	172,000 ( 109,000- 235,000)
Black Tern	21.5 (14.9-28.9)	120 (5)	3.85 ( 1.67- 6.03)	272,000 ( 118,000- 425,000)
Mourning Dove	56.2 (47.6-64.5)	76 (6)	9.08 ( 6.97-11.19)	641,000 ( 492,000- 790,000)
Yellow-shafted Flicker	16.9 (10.9-23.7)	20 (3)	1.26 ( 0.67- 1.86)	89,000 ( 47,000- 131,000)
Eastern Kingbird	55.4 (46.8-63.8)	36 (5)	5.05 ( 3.92- 6.17)	356,000 ( 277,000- 436,000)
Western Kingbird	37.7 (29.6-46.1)	24 (2, 3, 4, 6)	3.17 ( 2.30- 4.03)	224,000 ( 163,000- 285,000)
Trail's Flycatcher	12.3 ( 7.2-18.3)	24 (2)	0.89 ( 0.38- 1.41)	63,000 ( 27,000- 99,000)
Horned Lark	85.4 (79.0-91.0)	160 (7)	38.62 (33.50-43.73)	2,726,000 (2,365,000-3,087,000)

<sup>1</sup> Major species are those with statewide frequency of 10 percent or more.  
<sup>2</sup> Highest probability density (HPD) interval contains 95 percent of the frequency.  
<sup>3</sup> Number in parentheses indicate the strata in which maximum density occurred.  
<sup>4</sup> Highest probability density (HPD) interval contains 95 percent of the probability content of the statistical distribution of the density.  
<sup>5</sup> Highest probability density (HPD) interval contains 95 percent of the probability content of the statistical distribution of the population.



TABLE 3—Continued

Species	Frequency (% occurrence in sample units and HPD interval) <sup>2</sup>	Maximum density (ps/mi <sup>2</sup> ) <sup>3</sup>	Mean density (ps/mi <sup>2</sup> and HPD interval) <sup>4</sup>	Projected statewide population (pairs and HPD interval) <sup>5</sup>
Barn Swallow	40.8 (32.5-49.2)	20 (2, 3)	3.05 ( 2.32- 3.78)	215,000 ( 164,000- 267,000)
Common Crow	19.2 (12.9-26.3)	8 (1, 2, 3, 8)	0.92 ( 0.58- 1.27)	65,000 ( 41,000- 89,000)
House Wren	16.2 (10.3-22.8)	40 (6)	1.69 ( 0.85- 2.54)	119,000 ( 60,000- 179,000)
Catbird	11.5 ( 6.6-17.4)	40 (6)	1.51 ( 0.58- 2.43)	106,000 ( 41,000- 172,000)
Brown Thrasher	18.5 (12.2-25.4)	24 (6)	1.29 ( 0.67- 1.92)	91,000 ( 47,000- 135,000)
Robin	16.2 (10.3-22.8)	52 (6)	2.18 ( 1.06- 3.31)	154,000 ( 75,000- 234,000)
Yellow Warbler	23.1 (16.2-30.6)	68 (2)	3.42 ( 1.82- 5.01)	241,000 ( 128,000- 354,000)
Yellowthroat	30.0 (22.4-38.0)	68 (5)	4.15 ( 2.56- 5.75)	293,000 ( 181,000- 406,000)
House Sparrow	18.5 (12.2-25.4)	80 (7)	3.35 ( 1.48- 5.23)	237,000 ( 105,000- 369,000)
Bobolink	44.6 (36.2-53.2)	100 (2)	6.65 ( 4.47- 8.83)	469,000 ( 315,000- 623,000)
Western Meadowlark	92.3 (87.3-96.3)	96 (6)	28.43 (25.16-31.70)	2,007,000 (1,776,000-2,238,000)
Yellow-headed Blackbird	13.1 ( 7.8-19.2)	124 (4)	2.89 ( 0.65- 5.13)	204,000 ( 46,000- 362,000)
Red-winged Blackbird	78.5 (71.1-85.1)	164 (2)	29.63 (24.71-34.55)	2,092,000 (1,745,000-2,439,000)
Baltimore Oriole	11.5 ( 6.6-17.4)	20 (1)	0.65 ( 0.27- 1.02)	46,000 ( 19,000- 72,000)
Common Grackle	26.2 (19.0-33.9)	92 (3)	4.83 ( 2.93- 6.73)	341,000 ( 207,000- 475,000)
Brown-headed Cowbird	80.8 (73.7-87.1)	152 (4)	14.18 (11.27-17.10)	1,001,000 ( 795,000-1,207,000)
American Goldfinch	38.5 (30.3-46.9)	40 (6)	3.32 ( 2.31- 4.34)	235,000 ( 163,000- 306,000)
Rufous-sided Towhee	10.0 ( 5.4-15.6)	104 (8)	3.08 ( 1.26- 4.90)	217,000 ( 89,000- 346,000)
Lark Bunting	42.3 (34.0-50.8)	204 (7)	18.68 (13.21-24.14)	1,318,000 ( 933,000-1,704,000)
Savannah Sparrow	63.1 (54.7-71.1)	120 (7)	16.15 (12.51-19.79)	1,140,000 ( 883,000-1,397,000)
Grasshopper Sparrow	47.7 (39.2-56.2)	60 (6, 7, 8)	9.11 ( 6.59-11.62)	643,000 ( 465,000- 821,000)
Baird's Sparrow	23.8 (16.9-31.4)	88 (5, 6)	5.23 ( 2.88- 7.58)	369,000 ( 203,000- 535,000)
Vesper Sparrow	53.1 (44.5-61.5)	40 (8)	6.31 ( 5.04- 7.57)	445,000 ( 356,000- 535,000)
Lark Sparrow	10.0 ( 5.4-15.6)	48 (6)	1.42 ( 0.40- 2.43)	109,000 ( 28,000- 172,000)
Clay-colored Sparrow	40.0 (31.8-48.5)	132 (5)	11.26 ( 7.54-14.98)	795,000 ( 532,000-1,058,000)
Song Sparrow	20.0 (13.6-27.2)	40 (2)	1.69 ( 0.94- 2.45)	119,000 ( 66,000- 173,000)
Chestnut-collared Longspur	47.7 (39.2-56.2)	256 (7)	34.83 (27.04-42.62)	2,459,000 (1,909,000-3,009,000)

The projected statewide breeding populations of the 50 major species (Table 3) comprised about 91 percent of the total breeding bird population. Twelve species, representing only 6.7 percent of the total number of species known to breed in North Dakota, comprised 62.7 percent of the statewide total bird population in 1967. Four species; the Horned Lark, Chestnut-collared Longspur, Red-winged Blackbird, and Western Meadowlark, were represented by more than 2,000,000 pairs each. Populations between 500,000 and 2,000,000 pairs were estimated for each of eight species as follows: Lark Bunting, Savannah Sparrow, Brown-headed Cowbird, Clay-colored Sparrow, American Coot, Blue-winged Teal, Grasshopper Sparrow, and Mourning Dove. Other birds of considerable importance included 27 species that were each represented by 100,000 to 500,000 pairs, and together comprised 25.5 percent of the total breeding bird population. These included 5 species of ducks, 4 species of shorebirds and terns, and 18 species of passerine birds.

The remainder of the breeding bird population, involving at least 131 minor species (including 50 species not recorded in the present study), comprised only about 9 percent of the statewide total. Frequency of occurrence for each of these species was less than 10 percent. For these species it is obvious that the 130 randomly selected sample units were not adequate for satisfactory estimates of statewide population densities. For many of these species the lower limit of the highest probability density interval was zero.

The general ecological affinities of the 50 major breeding species in North Dakota (Table 3) differ considerably. Eleven species typical of grasslands comprised 46 percent of the total statewide breeding population, 17 species typical of wetlands comprised 23.3 percent, 14 species characteristic of edge situations (combination of wooded or brushy habitats and open fields or grassland) comprised 14.5 percent, and 8 species that inhabit brushy thickets comprised 6.8 percent. Of the 12 predominant species with populations ranging from 641,000 pairs to 2,730,000 pairs, 6—the Horned Lark, Chestnut-collared Longspur, Western Meadowlark, Lark Bunting, Savannah Sparrow, and Grasshopper Sparrow—are typical of grasslands; 3—the Red-winged Blackbird, American Coot and Blue-winged Teal—are typical of wetlands; 2—the Brown-headed Cowbird and Mourning Dove—are characteristic of edge situations; and 1—the Clay-colored Sparrow—inhabits brushy thickets.

The characteristic birds of other habitat types are generally of less importance in North Dakota than in most states or Canadian provinces. Many of the extensive, uniform cropland fields in the state are largely devoid of breeding birds, except for the ever present populations of Horned Larks, and very limited numbers of a few other species, par-

ticularly those characteristic of edge situations. As might be expected, breeding birds typical of the restricted woodland tracts in the state are of little numerical importance. The same is also true of most of the familiar, commonplace edge species that are associated with lawns, gardens, trees, and shrubbery of farmyards and town residential districts. In general these birds, although often quite common locally, rank far below the more widespread grassland and wetland species in total numbers.

The Horned Lark, which had an estimated population of 2,730,000 pairs, was found to be the most numerous breeding bird in North Dakota. This species not only inhabits the native prairies in large numbers but also has been able to adapt to the extensive, man-created tracts of cropland much more successfully than the other common prairie species.

The second most plentiful species, the Chestnut-collared Longspur, had an estimated population of 2,460,000 pairs. This species is largely restricted to tracts of native prairie, although small numbers also inhabit croplands occasionally. It is significant that densities of breeding Chestnut-collared Longspurs on native prairie are noticeably greater than densities of breeding Horned Larks. It is very probable, therefore, that under primitive conditions before the advent of the plow, the Chestnut-collared Longspur was the most numerous breeding species in North Dakota. This theory is supported by the writings of many early pioneering ornithologists, including Allen (1874), Coues (1874, 1878), Grinnell (1875), and Judd (1917), all of whose reports comment on the great abundance of this species on the North Dakota prairies.

#### BIOGEOGRAPHICAL DISTRIBUTION OF BREEDING BIRD POPULATIONS

Variations in distribution of breeding bird populations in North Dakota are influenced primarily by the occurrence and prevalence of certain biotic communities. Major biotic communities within the state are croplands, grasslands, wetlands, woodlands, clay-scoria scrub, and residential areas of man. Each of these may be subdivided into types that exhibit important secondary differences in floral and faunal affinities. The occurrence and distribution of these communities are, in turn, related to basic environmental factors including edaphic conditions, microclimate, and land-use practices of man. The distribution of breeding bird populations is also influenced to a lesser degree by generalized variations in prevailing climatic conditions over large portions of the state. Gradual clinal decreases in average precipitation from east to west and in average temperature from south to north are especially important in this regard.

The range in densities of breeding bird populations was quite variable

TABLE 4  
BIOGEOGRAPHICAL DISTRIBUTION OF TOTAL BIRDS OF ALL SPECIES

	Stratum							
	1. Agassiz Lake Plain	2. Northeastern Drift Plain	3. Southern Drift Plain	4. Northwestern Drift Plain	5. Missouri Coteau	6. Coteau Slope	7. Missouri Slope	8. Little Missouri Slope
No. of sample units	13	17	18	15	18	15	21	13
Density (prs/mi <sup>2</sup> )								
Range	60-312	128-808	164-588	168-1,396	84-1,048	96-808	256-536	124-788
Mean	174	423	364	404	359	435	403	332
HPD interval <sup>1</sup>	123-225	323-523	290-438	238-570	257-461	325-545	368-438	218-446
Populations (in millions)								
Total pairs	1.21	3.62	3.55	3.40	3.60	3.53	4.96	2.14
HPD interval <sup>2</sup>	0.86-1.56	2.76-4.48	2.83-4.27	2.01-4.79	2.58-4.62	2.63-4.43	4.52-5.40	1.41-2.87
% Distribution of statewide population	4.7	13.9	13.6	13.1	13.8	13.6	19.1	8.2

<sup>1</sup> Highest probability density (HPD) interval contains 95 percent of the probability content of the statistical distribution of the density.  
<sup>2</sup> Highest probability density (HPD) interval contains 95 percent of the probability content of the statistical distribution of the population.

among the strata (Table 4). Differences in mean population densities and differences in stratum area accounted for considerable differences in projected populations of total breeding birds. Estimates of breeding pairs ranged from a low of 1,210,000 in the Agassiz Lake Plain (Stratum 1) to a high of 4,960,000 in the Missouri Slope (Stratum 7). The breeding populations in the Northeastern, Southern, and Northwestern Drift Plains, Missouri Coteau, and Coteau Slope (Strata 2, 3, 4, 5, and 6) were remarkably similar in magnitude, comprising 13.9, 13.6, 13.1, 13.8, and 13.6 percent, respectively, of the statewide breeding population.

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#### SUMMARY

Two observers censused breeding bird populations throughout North Dakota by intense ground search on 130 quarter section sample units in 1967. Sample units were proportionally allocated to 8 major strata and randomly distributed within 28 substrata that were differentiated on the basis of ecological, biogeographical, and physiographical factors.

A total of 11,965 indicated pairs of 131 species were recorded during the study. The estimated statewide breeding bird population was about 26 million pairs, or 368 pairs per square mile. Nine orders had breeding populations with statewide frequency values of 10 percent or more. The order Passeriformes was most abundant, with a statewide frequency of 100 percent and a projected population of about 21 million pairs (293 pairs per square mile). The order Anseriformes had a frequency of 70.8 percent and a population of about 2,281,000 pairs (32 pairs per square mile). The other major orders in decreasing magnitude of populations were the Charadriiformes, Gruiformes, Columbiformes, Piciformes, Falconiformes, Galliformes, and Ciconiiformes.

Statewide frequencies of occurrence for six species exceeded 60 percent. These listed in decreasing order of frequency were: Western Meadowlark, Horned Lark, Brown-headed Cowbird, Red-winged Blackbird, Savannah Sparrow, and Mallard. In contrast, the six most plentiful species in decreasing numerical order were: Horned Lark, Chestnut-collared Longspur, Red-winged Blackbird, Western Meadowlark, Lark Bunting, and Savannah Sparrow. Estimated statewide populations of these six species ranged from 2,726,000 to 1,140,000 pairs, and collectively, they comprised 45 percent of the total breeding bird population

in North Dakota. Fifty major species with statewide frequencies of 10 percent or more, and 131 minor species with frequencies of less than 10 percent comprised, respectively, 91 percent and 9 percent of the total population.

Among the strata, mean breeding pair densities per square mile (all species combined) ranged from 174 on the Agassiz Lake Plain to 435 on the Coteau Slope. The Agassiz Lake Plain also had the lowest projected breeding population of 1.2 million pairs, but the Missouri Slope had the highest projected breeding population of 5.0 million pairs.

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