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CHANGES IN BREEDING BIRD POPULATIONS IN NORTH DAKOTA: 1967 TO 1992–93

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ABSTRACT.—We compared breeding bird populations in North Dakota using surveys conducted in 1967 and 1992–93. In decreasing order, the five most frequently occurring species were Horned Lark (*Eremophila alpestris*), Brown-headed Cowbird (*Molothrus ater*), Western Meadowlark (*Sturnella neglecta*), Red-winged Blackbird (*Agelaius phoeniceus*), and Eastern Kingbird (*Tyrannus tyrannus*). The five most abundant species—Horned Lark, Chestnut-collared Longspur (*Calcarius ornatus*), Red-winged Blackbird, Western Meadowlark, and Brown-headed Cowbird—accounted for 31–41% of the estimated statewide breeding bird population in the three years. Although species composition remained relatively similar among years, between-year patterns in abundance and frequency varied considerably among species. Data from this survey and the North American Breeding Bird Survey indicated that species exhibiting significant declines were primarily grassland- and wetland-breeding birds, whereas species exhibiting significant increases primarily were those associated with human structures and woody vegetation. Population declines and increases for species with similar habitat associations paralleled breeding habitat changes, providing evidence that factors on the breeding grounds are having a detectable effect on breeding birds in the northern Great Plains. *Received 30 January 1996, accepted 18 September 1996.*

THE DECLINE OF BREEDING BIRD POPULATIONS in forests of eastern North America has received considerable recent attention (Askins et al. 1990, Hagan and Johnston 1992, Finch and Stangel 1993). The status of bird populations in grasslands and midcontinental areas, however, has received far less attention. Yet, analyses of North American Breeding Bird Survey (BBS) data indicate that more breeding species are declining than increasing in the prairie regions of North America (Droege and Sauer 1994). Also, grassland species show greater and more consistent patterns of decline at the continental level than do other ecological guilds, including long-distance migrants in eastern forests (Askins 1993, Droege and Sauer 1994). These declines have been most pronounced in areas of intensive agriculture, such as the Midwest (Herkert 1991, 1995; Warner 1994) and the northern Great Plains (Johnson and Schwartz 1993, Reynolds et al. 1994).

Although the BBS is the best source of quantitative data on trends of breeding bird populations in the midcontinent, it has several limitations, including sparse coverage in central North America and biases associated with roadside surveys. Several studies have attempted to verify population trends from the BBS with data from independent, long-term surveys (e.g. Breeding Bird Atlas: Robbins et al. 1989; checklists: Temple and Cary 1990; Christmas Bird Count: Hagan 1993; migration counts: Dunn and Hussell 1995). Parallel trends derived from studying the same populations in different ways may provide corroborating evidence and strengthen the assessment of population trends of the BBS. Compared with eastern deciduous forests (e.g. Johnston and Hagan 1992), however, long-term data sets on breeding birds in the midcontinent are scarce.

Though a paucity of comparative information exists in the midcontinent, historic surveys provide an often overlooked source of baseline data on breeding bird populations (e.g. Graber and Graber 1963). These include the extensive survey of breeding birds in North Dakota conducted by Stewart and Kantrud (1972) in 1967 to obtain estimates of statewide breeding bird abundances and frequencies of occurrence. Data from the Stewart-Kantrud survey provided a unique opportunity to evaluate changes in breeding bird populations in the northern Great Plains. In 1992 and 1993, we repeated the Stewart-Kantrud survey using the same sample units and methods. Our objectives in this paper are

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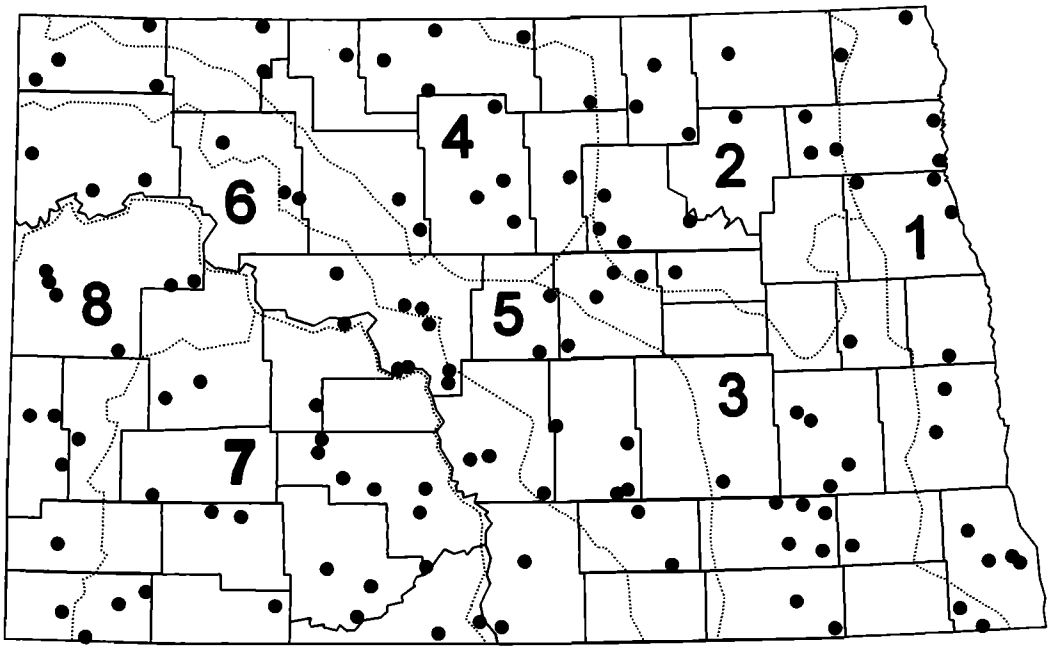

Fig. 1. Distribution of 128 quarter-sections in North Dakota where bird surveys were conducted during 1967 and 1992–93. Strata are indicated by dashed lines: (1) Agassiz Lake Plain, (2) Northeastern Drift Plain, (3) Southern Drift Plain, (4) Northwestern Drift Plain, (5) Missouri Coteau, (6) Coteau Slope, (7) Missouri Slope, and (8) Little Missouri Slope.

to: (1) examine changes in breeding bird populations in North Dakota; (2) compare patterns in breeding bird population changes with trends from the BBS; and (3) assess the likelihood that population changes have been influenced by changes in land use in North Dakota.

Study Area and Methods

Study area.—Situated in the geographical center of North America, North Dakota has a climate characterized by warm summers and long, cold winters. The distribution of precipitation is highly seasonal, with about 75% of the annual precipitation occurring during the growing season (April–September; Jensen 1972). Precipitation for January through June ($\bar{x}$ = 22.4 cm, 1961–1990) in North Dakota was nearly normal in 1967 (21.8 cm), below normal in 1992 (18.0 cm), and above normal in 1993 (25.7 cm; NOAA 1967, 1992, 1993). Many areas in North Dakota and the northern Great Plains experienced moderate to extreme drought conditions from 1988 to early 1993 (NOAA 1988–1993, Igl and Johnson 1995).

In 1967, Stewart and Kantrud (1972) divided the state into eight major strata based on biogeographical, physiographical, and ecological characteristics (Fig. 1). From these eight strata, Stewart and Kantrud (1972) selected 130 sample units by random selection without replacement. The number of sample units allocated to each stratum was proportional to the area of the stratum. Within each stratum, sample units were proportionately distributed according to the relative size of substrata that were differentiated on the basis of prevalent habitat types. The number of substrata ranged from two to five for each of the eight major strata and totaled 27 for the state. The stratification used by Stewart and Kantrud (1972) was effective in reducing the estimated variance in population estimates by as much as 15% compared with simple random sampling (Nelms et al. 1994).

To facilitate a direct comparison, we surveyed the same sample units used by Stewart and Kantrud (Fig. 1; H. A. Kantrud unpubl. data). We visited 128 of the 130 quarter-sections (each ca. 64.7 ha) originally surveyed by Stewart and Kantrud in 1967; landowners denied access to the two other quarter-sections. Comparisons among years are based on the 128 quarter-sections that were surveyed in all three years.

Methods.—We surveyed breeding birds using the same methods employed by Stewart and Kantrud (1972; H. A. Kantrud pers. comm.). Surveys were conducted by two observers on foot. Each observer surveyed a rectangular half (805 × 402 m; 32.37 ha) of a quarter-section by following a standardized survey route. This route was 100 m inside of and parallel to

the boundary of the rectangle. Deviations up to 100 m from the route often were necessary to survey all habitats adequately. The rectangular halves usually were surveyed simultaneously, and an interval of 400 m was maintained between observers. Both observers compared field notes at the end of each coverage of a sample unit to prevent duplications in the counts of wide-ranging birds such as vultures, hawks, and crows. We minimized observer bias in 1992 and 1993 by using the same two observers in both years. In 1993, some of the quarter-sections were surveyed by a single, experienced observer, who censused both rectangular halves on the same day.

Large wetlands required a different type of coverage. Birds on open water were counted with a spotting scope from the shoreline. In large zones of emergent vegetation, one observer attempted to flush large (e.g. ducks and herons) or secretive (e.g. rails and bitterns) species by wading in a zigzag course throughout the wetland while making noise. From a nearby vantage point, the second observer recorded all birds flushed, including conspicuous, colonial marsh birds such as Red-winged Blackbirds (*Agelaius phoeniceus*).

The phenological advance in seasons during the spring and early summer is about two weeks earlier in southwestern North Dakota than in the northeastern portion of the state. To compensate for these differences, the sequence in which sample units were covered progressed from southwestern to northeastern North Dakota. We matched the date that a quarter-section was surveyed in 1992 and 1993 as closely as feasible to the date that it was surveyed in 1967 (H. A. Kantrud unpubl. data). The surveys of breeding birds extended from 24 April to 19 July in 1967, from 27 April to 18 July in 1992, and from 24 April to 21 July in 1993. The overall absolute difference between the 1967 surveys and the 1992 and 1993 surveys averaged 3.3 days and 1.7 days, respectively.

In each year, sample units were surveyed once or twice; the number of breeding pairs for each species, however, was based on single counts during each species' peak breeding period. All sample units were surveyed for early-nesting species between 24 April and 7 June, for mid-nesting species between 14 May and 10 July, and for late-nesting species between 22 May and 21 July (Table 1). When a survey was conducted during an overlapping portion of the peak breeding periods, counts of early-, mid-, and late-nesting species coincided. Thus, quarter-sections that were visited between 22 May to 7 June were surveyed only once, and those that were surveyed before 22 May were surveyed again after 7 June to include species from all three breeding periods. Peak breeding periods for some species differ from those in Stewart and Kantrud (1972) due to typographical errors in the original publication; these errors did not affect statewide population estimates or variances in Stewart and Kantrud (1972). Stewart and Kantrud (1972, Kantrud 1982) felt justified in estimating bird populations in open habitats using single counts because many species have behavioral adaptations (e.g. elevated perches, flight songs, synchronous displays) that tend to increase their detectability compared with birds inhabiting extensive wooded areas (see Speirs and Orenstein 1967, Cody 1985).

Species were identified by sight or sound. Counts during precipitation and strong winds (>24 km/h) were avoided. Surveys of open-country birds were conducted between 0.5 h after sunrise and 0.5 h before sunset. Although some surveys occurred outside the time of peak vocal activity (i.e. early morning or late evening), Stewart and Kantrud (1972) concluded that singing and other activities of open-country birds were not appreciably affected by time of day. Quarter-sections containing extensive woodland habitats usually were covered on relatively calm (<8 km/h), sunny days between 0.5 h after sunrise and 1000 CST. These limitations were necessary because song frequencies and other activities of most woodland birds are reduced on cloudy days, in moderate or high winds, and at midday.

Counts of breeding birds were based primarily on the number of indicated breeding pairs on territories or home ranges during peak breeding periods. For most species, nearly all indicated pairs were observed as segregated pairs or as territorial males. For Wilson's Phalarope (*Phalaropus tricolor*), segregated pairs and lone females were recorded as indicated pairs. Although currently not in vogue, for consistency we based the number of indicated pairs of Brown-headed Cowbird (*Molothrus ater*) on the total number of males seen per sample unit. In the case of colonial birds that are not sexually dimorphic (e.g. Black Tern [*Chlidonias niger*] and Cliff Swallow [*Hirundo pyrrhonota*]), 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 waterfowl followed Hammond (1969) with one exception. Occasionally, the number of lone females on a given quarter-section exceeded the number of males unaccompanied by females. In this case, each excess lone female was considered to represent an indicated pair.

We excluded from our results birds that we considered to be nonbreeders. These included: (1) migrant flocks and individuals of species that are not known to breed in North Dakota (Faanes and Stewart 1982); (2) nonbreeding, vagrant waterbirds in the summer and oversummering shorebirds (i.e. transient shorebirds remaining in North Dakota during the boreal summer); (3) wide-ranging colonial waterbirds passing high overhead (e.g. pelicans and gulls); and (4) other birds passing overhead in high, direct flight. By counting birds only during their peak breeding periods, we maximized the potential for recording breeding pairs and territorial males and, at the same

time, minimized the likelihood for confounding territorial birds with migrants.

Vernacular and scientific names follow the American Ornithologists' Union (1983) and subsequent supplements, with one exception. We recorded Red-shafted (*Colaptes auratus cafer*) and Yellow-shafted (*C. auratus auratus*) subspecies of the Northern Flicker separately to reflect their species status in 1967. One obvious intergrade was recorded as a Red-shafted Flicker in 1967.

Species classification.—Based on published accounts, we classified each species into one of three groups according to its migratory behavior (Table 1): permanent resident (present in North Dakota year-round), short-distance migrant (winters primarily north of the U.S./Mexico border), and long-distance migrant (winters primarily south of the U.S./Mexico border; Faanes and Stewart 1982, AOU 1983, Harrison 1983, Rappole et al. 1983, Hayman et al. 1986, Madge and Burn 1988, Thompson et al. 1993). The migratory status of some year-round residents (e.g. Blue Jay [*Cyanocitta cristata*], American Crow [*Corvus brachyrhynchos*], European Starling [*Sturnus vulgaris*]) was difficult to determine because some wintering individuals may have originated from breeding populations north of North Dakota. We considered these species to be short-distance migrants. In addition, we categorized each species into a general breeding habitat based on the literature (Ehrlich et al. 1988, Peterjohn and Sauer 1993) and personal observations. Habitats were described as wetland (including wet meadow), grassland, open habitat with scattered trees, woodland, open or semiopen deciduous woodland and edge, shrubland, residential areas and human-made structures (hereafter, human-made structures), and "other" (mostly unvegetated habitats including clay buttes, cliffs, banks, etc.). Waterfowl were included in the wetland class, i.e. their primary foraging and brood-rearing habitat. Species using a broad range of habitats (e.g. Song Sparrow [*Melospiza melodia*], Common Yellowthroat [*Geothlypis trichas*]) were classified according to their principal habitat type.

Calculation of population estimates.—We estimated population means and totals, and their standard deviations, using standard methods for stratified random samples with proportional allocation (Cochran 1977). We calculated Bayesian confidence intervals (95% confidence limits; Box and Tiao 1973) in lieu of the usual confidence intervals using the methods described in Johnson (1977). Bayesian intervals exploit the prior knowledge that the means of bird densities and of total numbers of birds are non-negative. Population estimates are given only for species with statewide frequencies of occurrence of 10% or higher (i.e. common species). Results for 1967 in this paper may vary slightly from those given in Stewart and Kantrud (1972) due to differences in sample size (i.e. 130 vs. 128 quarter-sections).

Statewide population estimates were compared between 1967 and 1992–93 with z-tests. A significant change was claimed only if the difference between 1967 and 1992 values and the difference between 1967 and 1993 values were both significant at $P \leq 0.10$ and only if both differences were in the same direction.

Biases associated with the bird survey were not quantified (see Stewart and Kantrud 1972). In 1967, Stewart and Kantrud made efforts to minimize apparent biases in methodology through adjustments in census techniques. In the recent surveys, we endeavored to conduct our surveys as similarly as possible to the methods used in 1967. We recognize that the size of the breeding population for certain species may be over- or underestimated. For example, we assumed that all males were mated, although some territorial males may have been unmated (e.g. Dickcissel [*Spiza americana*], Fretwell and Calver 1970; Ovenbird [*Seiurus aurocapillus*], Gibbs and Faaborg 1990). Also, population estimates of wide-ranging species or species with large territories or home ranges may have been overestimated. For polygynous (e.g. Yellow-headed Blackbird [*Xanthocephalus xanthocephalus*]) and polyandrous (Wilson's Phalarope) species, the number of indicated pairs represents, in terms of breeding mates, a minimum population. Undoubtedly, biases related to differences in observers, years, weather, sampling time, etc. were present, but biases associated with methodology should be relatively consistent among years.

Breeding Bird Survey trends.—We obtained trends in abundance from the BBS for North Dakota during the period 1967–1993 (J. R. Sauer and B. G. Peterjohn pers. comm.). Trends are based on statistical methods described by Geissler and Sauer (1990) and are presented as the average percent annual change between 1967 and 1993. In North Dakota, the BBS began in 1967, the same year that Stewart and Kantrud (1972) conducted their survey.

Land use changes.—Comparable data on land use and cover were available each year for every quarter-section. To evaluate overall changes in major habitats, we digitized land use and cover by drawing vectors over scaled rasters of scanned aerial photographs using Map and Image Processing System (MIPS) software (MicroImages, Inc. 1992). Eight major land use or cover classes were delineated: (1) Cropland (all land used for the production of annual field crops and land under summer fallow); (2) Hayland (areas that have been plowed and seeded to mixtures of grasses and legumes for forage or seed production); (3) Grassland (natural grassland regardless of condition and disturbance regime [e.g. grazed, mowed, idle] and areas planted to introduced species); (4) Planted Cover (mixtures of grasses and legumes planted for wildlife cover or soil conservation [e.g. Conservation Reserve Program]); (5) Woodland and Shrubland (native and artificially stocked tree and shrub stands and plantings); (6) Wetland (areas classified as wetlands by Stewart and Kantrud [1971] as well as permanent

TABLE 1. Breeding bird populations in 128 randomly selected quarter-sections in North Dakota.

Species[a]	No. indicated pairs 1967	1992	1993	Migratory status[b]	Breeding habitat[c]	Population change[d]	BBS trend[e]
Pied-billed Grebe (*Podilymbus podiceps*)***	11	4	7	SDM	WETL	NC	−7.55 ↓ ↓
Horned Grebe (*Podiceps auritus*)***	2	1	0	SDM	WETL	NC	−0.22
Red-necked Grebe (*Podiceps grisegena*)***	0	1	1	SDM	WETL	NC	NA
Eared Grebe (*Podiceps nigricollis*)***	40	48	22	SDM	WETL	NC	−1.28
Western Grebe (*Aechmophorus occidentalis*)***	0	2	1	SDM	WETL	NC	−28.08 ↓ ↓
American White Pelican (*Pelecanus erythrorhynchos*)**	0	0	2	SDM	WETL	NC	−6.45 ↓
Double-crested Cormorant (*Phalacrocorax auritus*)**	0	1	10	SDM	WETL	NC	−3.51
American Bittern (*Botaurus lentiginosus*)***	9	2	8	LDM	WETL	NC	−3.54 ↓ ↓ ↓
Great Blue Heron (*Ardea herodias*)**	2	1	3	SDM	WETL	NC	+1.00
Black-crowned Night-Heron (*Nycticorax nycticorax*)***	17	5	5	SDM	WETL	NC	−4.76 ↓ ↓
Canada Goose (*Branta canadensis*)*	0	11	28	SDM	WETL	NC	+9.45 ↑ ↑ ↑
Wood Duck (*Aix sponsa*)*	1	2	12	SDM	WETL	NC	+0.80
Green-winged Teal (*Anas crecca*)**	45	11	44	SDM	WETL	NC	−0.64
Mallard (*Anas platyrhynchos*)*	212	113	200	SDM	WETL	NC	+1.01
Northern Pintail (*Anas acuta*)*	171	23	58	SDM	WETL	↓	−3.68
Cinnamon Teal (*Anas cyanoptera*)**	0	1	0	LDM	WETL	NC	NA
Blue-winged Teal (*Anas discors*)**	286	99	145	LDM	WETL	↓	−3.20 ↓ ↓ ↓
Northern Shoveler (*Anas clypeata*)**	87	25	52	SDM	WETL	↓	+0.05
Gadwall (*Anas strepera*)**	96	111	118	SDM	WETL	NC	+0.36
American Wigeon (*Anas americana*)**	25	22	32	SDM	WETL	NC	−3.75 ↓ ↓
Canvasback (*Aythya valisineria*)**	10	4	5	SDM	WETL	NC	−1.58
Redhead (*Aythya americana*)***	27	19	42	SDM	WETL	NC	−2.96
Ring-necked Duck (*Aythya collaris*)**	2	0	1	SDM	WETL	NC	−10.88 ↓ ↓ ↓
Lesser Scaup (*Aythya affinis*)***	3	4	4	SDM	WETL	NC	−0.63
Bufflehead (*Bucephala albeola*)***	0	0	1	SDM	WETL	NC	−4.65 ↓ ↓
Hooded Merganser (*Lophodytes cucullatus*)*	0	0	2	SDM	WETL	NC	+0.91 ↑ ↑ ↑
Ruddy Duck (*Oxyura jamaicensis*)***	36	56	23	SDM	WETL	NC	−3.20
Turkey Vulture (*Cathartes aura*)**	2	0	1	SDM	OPWO	NC	+4.12
Northern Harrier (*Circus cyaneus*)**	15	21	34	SDM	GRAS	NC	+1.76
Sharp-shinned Hawk (*Accipiter striatus*)**	0	1	0	SDM	WOOD	NC	−1.74 ↓
Cooper's Hawk (*Accipiter cooperii*)**	3	2	8	SDM	WOOD	NC	+3.76 ↑ ↑ ↑
Broad-winged Hawk (*Buteo platypterus*)**	0	1	1	LDM	WOOD	NC	NA
Swainson's Hawk (*Buteo swainsoni*)**	7	14	25	LDM	OPTR	↑	+3.04 ↑ ↑ ↑
Red-tailed Hawk (*Buteo jamaicensis*)**	7	11	16	SDM	OPTR	NC	+1.61
Ferruginous Hawk (*Buteo regalis*)**	4	4	8	SDM	GRAS	NC	+2.51
Golden Eagle (*Aquila chrysaetos*)*	0	2	3	SDM	OTHR	↑	+0.80
American Kestrel (*Falco sparverius*)**	5	10	11	SDM	OPTR	NC	+3.37
Prairie Falcon (*Falco mexicanus*)**	0	3	3	SDM	OTHR	↑	+0.34
Gray Partridge (*Perdix perdix*)*	17	40	36	RES	GRAS	↑	+3.97 ↑ ↑ ↑

TABLE 1. Continued.

Species[a]	No. indicated pairs 1967	1992	1993	Migratory status[b]	Breeding habitat[c]	Population change[d]	BBS trend[e]
Ring-necked Pheasant (*Phasianus colchicus*)*	3	24	51	RES	GRAS	↑	+4.24 ↑ ↑ ↑
Sharp-tailed Grouse (*Tympanuchus phasianellus*)*	18	46	32	RES	GRAS	↑	+5.30 ↑ ↑
Wild Turkey (*Meleagris gallopavo*)*	0	0	3	RES	OPWO	NC	+6.66 ↑ ↑ ↑
Yellow Rail (*Coturnicops noveboracensis*)***	0	1	0	SDM	WETL	NC	+0.93 ↑
Virginia Rail (*Rallus limicola*)***	3	5	2	SDM	WETL	NC	−0.37
Sora (*Porzana carolina*)***	32	41	78	SDM	WETL	NC	−3.11 ↓ ↓ ↓
American Coot (*Fulica americana*)**	348	76	124	SDM	WETL	↓	−7.53 ↓ ↓ ↓
Piping Plover (*Charadrius melodus*)**	5	2	1	SDM	WETL	NC	NA
Killdeer (*Charadrius vociferus*)*	105	112	142	SDM	WETL	NC	−1.65 ↓
American Avocet (*Recurvirostra americana*)**	14	6	13	SDM	WETL	NC	+0.19
Willet (*Catoptrophorus semipalmatus*)**	18	16	27	LDM	WETL	NC	−0.77
Spotted Sandpiper (*Actitis macularia*)***	12	12	9	LDM	WETL	NC	−0.33
Upland Sandpiper (*Bartramia longicauda*)**	63	106	89	LDM	GRAS	↑	+4.85 ↑ ↑ ↑
Marbled Godwit (*Limosa fedoa*)*	17	8	14	SDM	GRAS	NC	+1.66
Common Snipe (*Gallinago gallinago*)**	0	2	7	SDM	WETL	↑	+5.93
Wilson's Phalarope (*Phalaropus tricolor*)**	73	30	36	LDM	WETL	↓	−6.43 ↓ ↓ ↓
Franklin's Gull (*Larus pipixcan*)**	22	79	56	LDM	WETL	NC	−9.11 ↓
Ring-billed Gull (*Larus delawarensis*)**	1	49	11	SDM	WETL	↑	−5.25
California Gull (*Larus californicus*)**	0	0	2	SDM	WETL	NC	−5.80 ↓ ↓ ↓
Forster's Tern (*Sterna forsteri*)**	3	6	4	SDM	WETL	NC	−0.20
Common Tern (*Sterna hirundo*)**	6	6	3	LDM	WETL	NC	−0.00
Black Tern (*Chlidonias niger*)***	118	39	39	LDM	WETL	↓	−5.69 ↓
Rock Dove (*Columba livia*)*	0	23	12	RES	RESI	↑	+1.60
Mourning Dove (*Zenaida macroura*)**	292	339	337	SDM	OPWO	NC	+3.70 ↑ ↑ ↑
Black-billed Cuckoo (*Coccyzus erythropthalmus*)***	7	30	10	LDM	WOOD	NC	+2.08
Great Horned Owl (*Bubo virginianus*)*	2	4	9	RES	OPWO	NC	+2.88 ↑ ↑ ↑
Burrowing Owl (*Speotyto cunicularia*)**	3	3	2	LDM	GRAS	NC	−0.86
Long-eared Owl (*Asio otus*)**	0	1	1	SDM	OPWO	NC	NA
Short-eared Owl (*Asio flammeus*)*	0	1	1	SDM	GRAS	NC	+1.65
Common Nighthawk (*Chordeiles minor*)***	10	12	16	LDM	OPWO	NC	+0.58
Chimney Swift (*Chaetura pelagica*)***	1	0	3	LDM	RESI	NC	+5.21 ↑ ↑
Ruby-throated Hummingbird (*Archilochus colubris*)***	0	4	0	LDM	OPWO	NC	NA
Belted Kingfisher (*Ceryle alcyon*)**	0	1	1	SDM	WETL	NC	−0.46
Red-headed Woodpecker (*Melanerpes erythrocephalus*)***	2	9	7	SDM	OPWO	↑	−0.70
Yellow-bellied Sapsucker (*Sphyrapicus varius*)**	0	0	2	SDM	WOOD	NC	+0.76
Downy Woodpecker (*Picoides pubescens*)**	0	9	21	RES	OPWO	↑	+1.88 ↑ ↑ ↑
Hairy Woodpecker (*Picoides villosus*)**	2	12	11	RES	OPWO	↑	+0.93
Yellow-shafted Flicker (*Colaptes auratus auratus*)**	40	25	35	SDM	OPWO	NC	−3.85 ↓ ↓ ↓
Red-shafted Flicker (*Colaptes auratus cafer*)**	12	5	4	SDM	OPWO	NC	−0.82

TABLE 1. Continued.

Species[a]	No. indicated pairs 1967	1992	1993	Migratory status[b]	Breeding habitat[c]	Population change[d]	BBS trend[e]
Pileated Woodpecker (*Dryocopus pileatus*)**	0	0	1	RES	WOOD	NC	+1.12
Eastern Wood-Pewee (*Contopus virens*)***	2	10	7	LDM	WOOD	NC	−1.46
Alder Flycatcher (*Empidonax alnorum*)***	0	0	1	LDM	SHRU	NC	+3.34
Willow Flycatcher (*Empidonax traillii*)***	30	17	37	LDM	SHRU	NC	+1.63
Least Flycatcher (*Empidonax minimus*)***	23	52	81	LDM	OPWO	↑	+1.99
Eastern Phoebe (*Sayornis phoebe*)***	2	2	3	SDM	OPWO	NC	+0.78
Say's Phoebe (*Sayornis saya*)***	6	4	17	SDM	RESI	NC	+2.51 ↑
Great Crested Flycatcher (*Myiarchus crinitus*)***	3	8	13	LDM	WOOD	NC	+1.18
Western Kingbird (*Tyrannus verticalis*)***	103	194	177	LDM	OPTR	↑	+5.99 ↑ ↑ ↑
Eastern Kingbird (*Tyrannus tyrannus*)***	167	322	245	LDM	OPTR	↑	+6.47 ↑ ↑ ↑
Horned Lark (*Eremophila alpestris*)*	1253	1093	1661	SDM	GRAS	NC	+0.30
Purple Martin (*Progne subis*)***	2	1	0	LDM	RESI	NC	−0.01
Tree Swallow (*Tachycineta bicolor*)***	3	5	12	SDM	WETL	NC	+2.64
No. Rough-winged Swallow (*Stelgidopteryx serripennis*)***	7	1	3	LDM	OTHR	NC	+0.81
Bank Swallow (*Riparia riparia*)***	77	112	61	LDM	OTHR	NC	−0.30
Cliff Swallow (*Hirundo pyrrhonota*)***	152	343	226	LDM	RESI	NC	+7.23 ↑ ↑
Barn Swallow (*Hirundo rustica*)***	96	187	194	LDM	RESI	↑	+2.31 ↑ ↑ ↑
Blue Jay (*Cyanocitta cristata*)***	14	27	31	SDM	OPWO	↑	+1.66 ↑
Black-billed Magpie (*Pica pica*)*	20	15	15	RES	OPTR	NC	−8.36 ↓ ↓
American Crow (*Corvus brachyrhynchos*)*	28	13	27	SDM	OPWO	NC	+0.26
Black-capped Chickadee (*Parus atricapillus*)***	3	28	31	RES	OPWO	↑	+1.27
White-breasted Nuthatch (*Sitta carolinensis*)***	3	7	9	RES	OPWO	NC	−0.61
Rock Wren (*Salpinctes obsoletus*)***	10	23	27	SDM	OTHR	↑	+8.64
House Wren (*Troglodytes aedon*)***	52	219	209	LDM	OPWO	↑	+3.55 ↑ ↑ ↑
Sedge Wren (*Cistothorus platensis*)***	10	20	37	SDM	GRAS	NC	+0.95
Marsh Wren (*Cistothorus palustris*)***	51	113	153	SDM	WETL	NC	+5.02
Eastern Bluebird (*Sialia sialis*)**	0	4	5	SDM	OPWO	↑	+0.48
Mountain Bluebird (*Sialia currucoides*)**	8	15	20	SDM	OPWO	NC	+3.88
Veery (*Catharus fuscescens*)***	11	5	3	LDM	WOOD	NC	−2.99
American Robin (*Turdus migratorius*)**	67	117	123	SDM	OPWO	↑	+3.51 ↑ ↑ ↑
Gray Catbird (*Dumetella carolinensis*)***	48	44	38	LDM	SHRU	NC	−1.14
Brown Thrasher (*Toxostoma rufum*)***	42	85	104	SDM	SHRU	↑	+2.19 ↑ ↑ ↑
Sprague's Pipit (*Anthus spragueii*)**	7	13	19	SDM	GRAS	NC	−2.43 ↓ ↓
Cedar Waxwing (*Bombycilla cedrorum*)***	23	129	43	SDM	OPWO	NC	+3.20 ↑
Loggerhead Shrike (*Lanius ludovicianus*)**	8	16	15	SDM	SHRU	↑	−0.41
European Starling (*Sturnus vulgaris*)*	12	47	40	SDM	RESI	NC	+0.18
Yellow-throated Vireo (*Vireo flavifrons*)***	0	0	2	LDM	WOOD	NC	+1.65
Warbling Vireo (*Vireo gilvus*)***	19	23	41	LDM	OPWO	NC	+5.06 ↑ ↑ ↑
Red-eyed Vireo (*Vireo olivaceus*)***	13	20	42	LDM	WOOD	NC	+0.19

TABLE 1. Continued.

Species[a]	No. indicated pairs 1967	1992	1993	Migratory status[b]	Breeding habitat[c]	Population change[d]	BBS trend[e]
Black-and-white Warbler (*Mniotilta varia*)***	3	7	21	LDM	OPWO	NC	−1.81
Yellow Warbler (*Dendroica petechia*)***	102	90	105	LDM	OPWO	NC	−0.08
Chestnut-sided Warbler (*Dendroica pensylvanica*)***	0	0	2	LDM	OPWO	NC	NA
American Redstart (*Setophaga ruticilla*)***	13	10	20	LDM	OPWO	NC	+0.48
Ovenbird (*Seiurus aurocapillus*)***	6	20	29	LDM	WOOD	NC	+0.47
Northern Waterthrush (*Seiurus noveboracensis*)***	2	0	0	LDM	WOOD	↓	NA
Mourning Warbler (*Oporornis philadelphia*)***	0	1	1	LDM	OPWO	NC	NA
Common Yellowthroat (*Geothlypis trichas*)***	134	91	175	LDM	WETL	NC	−1.50 ↓
Yellow-breasted Chat (*Icteria virens*)***	6	6	11	LDM	SHRU	NC	+1.76
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)***	2	3	5	LDM	OPWO	NC	+0.14
Black-headed Grosbeak (*Pheucticus melanocephalus*)**	5	5	3	LDM	OPWO	NC	+1.37
Blue Grosbeak (*Guiraca caerulea*)***	1	1	0	LDM	SHRU	NC	NA
Lazuli Bunting (*Passerina amoena*)***	8	12	17	LDM	SHRU	NC	+6.20 ↑ ↑
Indigo Bunting (*Passerina cyanea*)***	2	2	3	LDM	OPWO	NC	+3.92 ↑ ↑
Dickcissel (*Spiza americana*)***	63	34	14	LDM	GRAS	NC	−2.64
Spotted Towhee (*Pipilo maculatus*)***	94	83	118	SDM	OPWO	NC	+0.43
Chipping Sparrow (*Spizella passerina*)***	22	51	70	LDM	OPWO	↑	+5.29 ↑ ↑ ↑
Clay-colored Sparrow (*Spizella pallida*)***	364	261	289	LDM	SHRU	NC	−3.51 ↓ ↓
Brewer's Sparrow (*Spizella breweri*)***	2	1	3	LDM	SHRU	NC	+1.57
Field Sparrow (*Spizella pusilla*)***	49	65	74	SDM	SHRU	NC	+3.58
Vesper Sparrow (*Pooecetes gramineus*)***	195	224	393	SDM	GRAS	NC	+2.49 ↑ ↑ ↑
Lark Sparrow (*Chondestes grammacus*)**	40	52	41	LDM	OPTR	NC	+0.42
Lark Bunting (*Calamospiza melanocorys*)***	604	679	298	LDM	GRAS	NC	−3.40 ↓
Savannah Sparrow (*Passerculus sandwichensis*)**	516	134	276	SDM	GRAS	↓	−2.78 ↓
Baird's Sparrow (*Ammodramus bairdii*)**	170	77	125	LDM	GRAS	NC	−2.75
Grasshopper Sparrow (*Ammodramus savannarum*)***	301	402	449	LDM	GRAS	↑	−5.24 ↓ ↓ ↓
Le Conte's Sparrow (*Ammodramus leconteii*)***	6	2	14	SDM	GRAS	NC	−5.02 ↓
Nelson's Sharp-tailed Sparrow (*Ammodramus nelsoni*)***	3	3	13	SDM	WETL	NC	+1.15
Song Sparrow (*Melospiza melodia*)**	55	100	130	SDM	SHRU	↑	−1.56
McCown's Longspur (*Calcarius mccownii*)**	22	2	1	SDM	GRAS	↓	−2.27
Chestnut-collared Longspur (*Calcarius ornatus*)**	1129	602	755	SDM	GRAS	↓	−0.10
Bobolink (*Dolichonyx oryzivorus*)***	216	186	172	LDM	GRAS	NC	−0.55
Red-winged Blackbird (*Agelaius phoeniceus*)**	945	597	710	SDM	WETL	↓	−2.46 ↓ ↓ ↓
Eastern Meadowlark (*Sturnella magna*)*	0	0	1	SDM	GRAS	NC	+1.75
Western Meadowlark (*Sturnella neglecta*)*	926	487	646	SDM	GRAS	↓	+0.56
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)**	89	155	175	LDM	WETL	NC	+0.65
Brewer's Blackbird (*Euphagus cyanocephalus*)**	19	47	83	SDM	SHRU	↑	+6.49 ↑ ↑
Common Grackle (*Quiscalus quiscula*)**	140	300	299	SDM	OPTR	↑	+4.71 ↑ ↑ ↑
Brown-headed Cowbird (*Molothrus ater*)**	460	643	610	SDM	OPWO	↑	+3.09 ↑ ↑ ↑

TABLE 1. Continued.

Species[a]	No. indicated pairs 1967	1992	1993	Migratory status[b]	Breeding habitat[c]	Population change[d]	BBS trend[e]
Orchard Oriole (*Icterus spurius*)***	18	33	40	LDM	OPWO	↑	+7.99 ↑↑↑
Baltimore Oriole (*Icterus galbula*)***	21	48	38	LDM	OPWO	↑	+2.37
Bullock's Oriole (*Icterus bullockii*)***	0	0	2	LDM	OPWO	NC	+4.30 ↑↑↑
Pine Siskin (*Carduelis pinus*)*	0	0	14	SDM	WOOD	NC	−0.63 ↓↓
American Goldfinch (*Carduelis tristis*)***	106	146	132	SDM	SHRU	NC	+2.13 ↑
House Sparrow (*Passer domesticus*)*	96	181	174	RES	RESI	↑	+2.48 ↑↑

[a] Asterisks following species names indicate peak breeding period during which counts were made: * early-nesting species, peak breeding period 24 April to 7 June; ** mid-nesting species, peak breeding period 14 May to 10 July; *** late-nesting species, peak breeding period 22 May to 21 July.

[b] LDM: Long-distance migrant; SDM: Short-distance migrant; RES: Permanent resident.

[c] Breeding habitat associations defined as: GRAS: Grassland; WETL: Wetland; WOOD: Woodland; SHRU: Shrubland; OPTR: Open habitat with scattered trees or shrubs; OPWO: Open or semi-open deciduous woodland and edge; RESI: Residential (rural development, urban, human-made structures); OTHR: Other habitats (mostly unvegetated habitats including clay buttes, cliffs, banks).

[d] Population change when the difference between 1967 and 1992 estimates (Appendix B) and the difference between 1967 and 1993 estimates were both significant at $P \leq 0.10$ and only if both differences were in the same direction: ↓ = decreasing, and ↑ = increasing.

[e] Average percent annual change on Breeding Bird Survey routes in North Dakota between 1967 and 1993: ↓ (decreasing) at $P < 0.10$, ↓↓ at $P < 0.05$, and ↓↓↓ at $P < 0.01$; ↑ (increasing) at $P < 0.10$, ↑↑ at $P < 0.05$, and ↑↑↑ at $P < 0.01$; NA = not available.

and semipermanent riparian areas); (7) Human-made Structures (human-made structures, fence rows and field borders, and road and railroad rights-of-way); and (8) Clay Buttes (portions of clay buttes that are mostly unvegetated).

RESULTS

Species composition.—One hundred and sixty-one breeding bird species (not including subspecies) were recorded within the 128 quarter-sections surveyed in at least one year, including 129 species in 1967, 144 in 1992, and 153 in 1993. These 161 species represent about 72% of the 223 species of North Dakota's breeding avifauna (Faanes and Stewart 1982). Most of the remaining species that were not observed on the quarter-sections are either rare, uncommon, localized, or irregular breeders in North Dakota (Faanes and Stewart 1982, DeSante and Pyle 1986).

The composition of breeding birds in North Dakota in 1992 and 1993 was similar to that in 1967 (Table 1). One hundred twenty-two species were recorded in all three years, 21 species were observed in two of the three years, and 18 species were detected in only one of the three years (Table 1). One species was recorded only in 1967, four species only in 1992, and 13 species only in 1993. Thirty-two species were observed only in 1992 and/or 1993, but not in 1967.

Most (92%) of the 161 breeding bird species are migratory, and only a few species are considered permanent residents that show little or no seasonal movements in North Dakota (Tables 1 and 2). Of the species that migrate, 86 species are short-distance migrants and 62 are long-distance migrants. Moreover, migrants constituted over 96% of the total number of indicated pairs detected each year. Short-distance migrants composed over one-half of the observed indicated pairs each year.

Among breeding habitat associations, wetland species composed the largest proportion (32%) of species, followed by species associated with open woodland or edge and grassland habitats (Table 1 and 2). In contrast, grassland birds composed the largest proportion of observed breeding pairs, accounting for 38% or more of the indicated pairs recorded in each year.

Frequencies of occurrence on sample units.—Sixty-nine species (i.e. common species) occurred in 10% or more of the sample quarter-sections in one or more years, including 48 species in

TABLE 2. Composition of breeding birds and mean number of indicated pairs on 128 randomly selected quarter-sections in North Dakota, by year, breeding habitat, and migratory status.

	No. of species	Percent of observed pairs			Mean pairs/100 ha		
		1967	1992	1993	1967	1992	1993
Breeding habitat							
Wetland	51	26.2	18.3	20.9	37.0	24.3	31.6
Grassland	24	47.5	38.3	41.0	67.2	50.9	62.0
Shrubland	14	6.3	7.2	7.5	8.9	9.6	11.3
Open habitat/scattered trees	8	4.2	8.3	6.6	5.9	11.1	10.0
Open woodland/edge	37	11.5	18.5	16.8	16.1	24.3	25.2
Woodland	14	0.4	0.9	1.1	0.6	1.2	1.6
Residential/human structures	8	3.1	7.2	5.3	4.4	9.5	8.0
Other	5	0.8	1.3	0.8	1.1	1.7	1.2
Migratory status							
Long-distance migrant	62	31.2	38.6	31.7	43.8	51.1	47.7
Short-distance migrant	86	67.4	57.8	65.0	95.4	76.8	98.3
Permanent resident	13	1.4	3.6	3.3	2.0	4.7	4.9

1967, 51 in 1992, and 64 in 1993 (Appendix 1). The increase in the number of common species between 1967 and 1992–93 was related primarily to the increase in statewide frequencies of some permanent residents and some species associated with human-made structures and woody vegetation (Table 1, Appendix 1). In decreasing order, the five most frequently occurring species were Horned Lark (*Eremophila alpestris*), Brown-headed Cowbird, Western Meadowlark (*Sturnella neglecta*), Red-winged Blackbird, and Eastern Kingbird (*Tyrannus tyrannus;* Appendix 1). All but one (Downy Woodpecker [*Picoides pubescens*]) of these 69 common species occurred in all three years. Stewart and Kantrud (1972) commented that the absence of the Downy Woodpecker in 1967 was "somewhat surprising," given the species' widespread distribution in North Dakota.

Statewide population estimates.—The projected statewide population estimates for breeding birds in North Dakota were 25.5 million breeding pairs in 1967, 24.1 million in 1992, and 27.4 million in 1993. Projected statewide population estimates are given in Appendix 2 for the 69 species that had statewide frequencies of occurrence of 10% or higher in one or more years (i.e. common species). These 69 common species composed 95% of the projected statewide breeding bird populations in 1967, 92% in 1992, and 92% in 1993. By this criterion, more than one-half (92 species) of the species observed in the three years were uncommon breeders. In decreasing order of abundance, the five most common species were the Horned Lark, Chestnut-collared Longspur (*Calcarius ornatus*), Red-winged Blackbird, Western Meadowlark, and Brown-headed Cowbird. Collectively, these species accounted for 31–41% of the estimated statewide breeding populations in the three years. The Horned Lark, a species that is most characteristic of cropland and heavily grazed grassland, accounted for over 10% of the projected statewide populations in each year.

Population changes.—Annual variation in breeding bird populations was considerable (Tables 2 and 3, Appendices 1 and 2). Annual breeding bird density for all species varied from 141 indicated breeding pairs per 100 ha in 1967 to 133 in 1992 and 151 in 1993. An evaluation of population changes for each species is beyond the scope of this paper. Rather, we restrict our evaluation to two broad patterns of population change evident in our data. First, most wetland species and many grassland species occurred less frequently and were less abundant during the dry year, 1992, than during the wetter years, 1967 and 1993. This pattern appears to be most pronounced and consistent for species associated with open water, such as waterfowl and the American Coot (*Fulica americana*). Second, many permanent residents and many species associated with human-made structures and woody vegetation generally increased in frequency and abundance between 1967 and 1992–93.

Of the 161 breeding bird species observed, 46 (29%) had consistent and significant ($P \leq 0.10$) population changes between 1967 and 1992 and between 1967 and 1993 (Table 1, Appendix

TABLE 3. Land use changes on the 128 quarter-sections surveyed in 1967, 1992, and 1993, and percentage change between the two periods (1992 and 1993 averaged).

Habitat	Area (ha)			Percent change
	1967	1992	1993	
Cropland	3,870	4,113	4,093	+6.0
Grassland	2,142	2,093	2,084	−2.5
Wetland	736	529	545	−27.0
Hayland	458	214	224	−52.2
Planted cover	403	564	564	+40.0
Woodland/shrubland	268	320	320	+19.4
Human-made structures	308	349	351	+13.6
Clay buttes	83	88	88	+6.0

2). Of these 46 species, 11 long-distance migrants, 15 short-distance migrants, and 8 permanent residents exhibited increasing population changes, and 7 long-distance migrants, 5 short-distance migrants, and no permanent residents showed decreasing population changes. Twenty-four of the 34 (71%) species with significantly increasing population changes were associated with woody vegetation or human-made structures. In contrast, 11 of 12 (92%) species with significantly decreasing population changes were associated with wetlands or grasslands. Grassland species, however, had equal numbers of significantly increasing (4) and decreasing (4) population changes.

Breeding Bird Survey trends.—Sample sizes were sufficient to estimate statewide BBS trends from 1967 to 1993 for 151 of the 161 observed species. Of the 64 species with statistically significant trends, 14 long-distance migrants, 15 short-distance migrants, and 7 permanent residents exhibited increasing trends. In contrast, 9 long-distance migrants, 18 short-distance migrants, and 1 permanent resident showed significantly decreasing trends. Twenty-eight of the 36 (78%) species with significantly increasing trends were associated with human-made structures or woody vegetation. Most (23) of the 28 species with significantly decreasing trends were associated with wetlands or grasslands. Grassland species, however, had equal numbers of significantly increasing (5) and decreasing (5) population trends.

Land use changes.—Cropland and grassland were the dominant land uses in the study area, covering about three-quarters of the total area on the 128 quarter-sections in all three years (Table 3). The area of cropland increased by 2% between 1967 and 1992–93. In contrast, grassland, wetland, and hayland declined by about 3%, 27%, and 52%, respectively, from their 1967 levels; all declines reflected nationwide trends (Samson and Knopf 1994, Dahl 1990, Herkert 1991). Woodland, human-made structures, and unvegetated portions of clay buttes increased by about 19%, 13%, and 6%, respectively, between 1967 and 1992–93. Planted cover increased by 40%, which largely reflects the Conservation Reserve Program, a long-term, federal cropland retirement program that began in 1985 (Johnson and Igl 1995). Land use changes between 1992 and 1993 were relatively small.

DISCUSSION

Species composition.—Compared with other ecological regions, the breeding avifauna of grasslands is relatively simple (Risser et al. 1981). A characteristic of grassland bird communities is low species diversity and numerical domination by a few species (Cody 1985). Although North Dakota is situated in the grassland biome of North America, the breeding avifauna of North Dakota is enriched by a diverse assemblage of birds with eastern, western, central, and northern North American affinities (Table 1; Stewart 1975). Nonetheless, the predominance of grassland birds is evident from our data. Collectively, eight species—Horned Lark, Western Meadowlark, Red-winged Blackbird, Brown-headed Cowbird, Lark Bunting (*Calamospiza melanocorys*), Savannah Sparrow (*Passerculus sandwichensis*), Grasshopper Sparrow (*Ammodramus savannarum*), and Chestnut-collared Longspur—accounted for 43–53% of the breeding birds in North Dakota each year. All but two of these species (Brown-headed Cowbird and Red-winged Blackbird) are considered endemic or secondary grassland species in North America (Mengel 1970; Knopf 1988, 1994).

Another characteristic of grassland bird assemblages in North America is the prevalence of short-distance migrants (MacArthur 1959, Willson 1976). In this study, short-distance migrants composed more than one-half of the observed species and indicated pairs in each year. These patterns are comparable to those of other grasslands in North America but contrast greatly with northeastern deciduous forests, where long-distance migrants and permanent residents dominate the breeding avifauna (MacArthur 1959, Willson 1976).

One species, Northern Waterthrush (*Seiurus noveboracensis*), was recorded only in 1967, compared with 32 species detected only in 1992 and/or 1993. Although differences in observer abilities between 1967 and 1992–93 may account for the increased number of species between the two periods (Table 1), many other recent or irregular events may have contributed to this increase. These include food-based nomadism (Pine Siskin [*Carduelis pinus*], DuBowy 1983; Short-eared Owl [*Asio flammeus*], Stewart 1975; Long-eared Owl [*Asio otus*], Marks et al. 1994), increased nest box availability (Hooded Merganser [*Lophodytes cucullatus*], Doty et al. 1984; Eastern Bluebird [*Sialia sialis*], Sauer and Droege 1990), successful reintroduction and management programs (Wild Turkey [*Meleagris gallopavo*], Johnson and Knue 1989; Canada Goose [*Branta canadensis*], Lee et al. 1984), and increased habitat availability (species associated with woody vegetation, see below). Nonetheless, most of the 32 species that were not observed in 1967 are considered rare, uncommon, localized, or irregular breeders in North Dakota (Faanes and Stewart 1982, DeSante and Pyle 1986).

Patterns of population changes.—Current evidence indicates that populations of some endemic grassland birds and many other species have declined in grassland regions in North America in recent decades (Knopf 1988, 1994; Finch 1992; Droege and Sauer 1994; USFWS 1995). Despite early indications of population declines in some breeding birds in the Midwest and Great Plains (Anonymous 1983, Robbins et al. 1986, Knopf 1988), birds in the midcontinent have not received the attention accorded other bird groups, such as Neotropical migrants in eastern forests (Hagan and Johnston 1992, Finch and Stangel 1993). In part, this may due to the inherent variability of bird populations in the Great Plains, making it difficult to detect long-term population changes. Species that breed in this region are believed to have evolved mechanisms in response to a naturally dynamic environment, including a high degree of behavioral plasticity in locating available habitat opportunistically (Cody 1985). Accordingly, many grassland and wetland birds undergo considerable annual changes in distribution and abundance in the Great Plains (Henny 1973, Trapp et al. 1981, Johnson and Grier 1988, Mulvihill 1989, Droege and Sauer 1989, Goosen et al. 1993, Igl and Johnson 1995).

Our results (Tables 1 and 2; Appendices 1 and 2) are consistent with earlier reports showing that breeding bird populations in grassland ecosystems are tremendously dynamic, exhibiting considerable annual variation in abundance and frequency of occurrence (Graber and Graber 1963, George et al. 1992, Zimmerman 1992). Within breeding habitat associations, our observed patterns of population change were remarkably similar and consistent among species with different migratory behaviors. First, many species associated with woody vegetation (e.g. House Wren [*Troglodytes aedon*]) and human-made structures (e.g. Barn Swallow [*Hirundo rustica*]) generally increased between 1967 and 1992–93 (Appendices 1 and 2). Second, many grassland (e.g. Savannah Sparrow) and wetland (e.g. Wilson's Phalarope) species declined between 1967 and 1992–93, though many exhibited slight (e.g. American Coot), moderate (e.g. Western Meadowlark), or dramatic (e.g. Common Yellowthroat) increases between 1992 and 1993.

The two patterns of long-term population change evident in our data were consistent with trends from the BBS. For both surveys, most species with significantly increasing population changes were associated with human-made structures or woody vegetation, and most species with significantly decreasing population changes were associated with wetlands or grasslands. This concordance illustrates that both independently derived measures of population change likely were recording the same phenomena. Moreover, of the 46 and 64 species that had significant population changes in our survey and the BBS, respectively, 26 species had significant trends in both data sets; all 26 species were considered common species in North Dakota (Appendices 1 and 2). Only one of the 26 species, Grasshopper Sparrow, had a population change that was opposite in sign. This discrep-

ancy could be attributed to many factors, including differences in survey methodology or trend analysis. However, the long-term trend from the BBS may have masked the recent population increase in Grasshopper Sparrows in the Great Plains; these increases have been associated with the increased availability of perennial grassland habitat established by the Conservation Reserve Program (Reynolds et al. 1994, Johnson and Igl 1995).

The causes of the above patterns may involve conditions in the breeding, migration, or wintering seasons (Sherry and Holmes 1992). The prevalence of parallel patterns of population change among habitat associations, but not among migratory behaviors, suggests that these population changes may be caused, at least in part, by conditions on the breeding grounds (Finch 1991). A common feature of breeding birds observed in this study is their dependence on habitats on the breeding grounds; most of these species breed in the northern Great Plains but winter elsewhere. For example, if breeding-ground conditions are primary influences on bird population dynamics, then populations of long-distance migrants should show similar patterns of change as short-distance migrants. The examples of Blue-winged Teal (*Anas discors*) and American Coot for wetlands, Baird's Sparrow (*Ammodramus bairdii*) and Savannah Sparrow for grasslands, and House Wren and Blue Jay for open woodlands are illustrative (Appendices 1 and 2).

What conditions or factors might limit populations on the breeding grounds in the northern Great Plains? Habitat loss and changes in land use have been viewed as major potential causes of population change for many breeding birds in the Great Plains (Knopf 1988, 1994; McNicholl 1988). Within the last century, the landscape of the Great Plains has been greatly modified by a number of human-induced changes. The once abundant grasslands and wetlands of the Great Plains have been drastically reduced, altered, and fragmented by intensive agriculture, roads, tree plantings, encroachment by woody vegetation, invasion of exotic plants, and other human activities. Knopf (1994) described several historic, contemporary, and continuing influences on breeding birds and their habitats in the Great Plains, including: (1) removal of native grazers and transformation to intensive, domestic livestock grazing; (2) cultivation of native grasslands; (3) loss of wetlands; and (4) woody development in the form of tree plantings and ecological invasions. The first three influences were implicated in the recent declines of grassland bird populations, as well as wetland associates. The fourth provided increased nesting opportunities for species associated with woody vegetation that generally were lacking or were limited in presettlement times. Likewise, Herkert (1994), Vickery et al. (1994), and Warner (1994) implicated fragmentation of grasslands in the recent declines of breeding birds in eastern and midwestern grasslands.

Before European settlement, the landscape of North Dakota included vast expanses of grassland, consisting primarily of northern mixed-grass prairie with some tallgrass prairie on the extreme eastern edge of the state (Risser et al. 1981). Moreover, the grasslands of the prairie pothole region (i.e. Drift Plains and the Missouri Coteau; Fig. 1) were dotted by millions of shallow wetland basins. Since settlement, North Dakota has lost about 49% of its wetlands (Dahl 1990) and 75% of its native grasslands (Samson and Knopf 1994), much of this before 1967. We compared the statewide changes in bird populations (Tables 1 and 2, Appendices 1 and 2) with the overall changes in land use area (Table 3) between 1967 and 1992–93. Long-term population changes in our study and BBS were consistent with the notion that these changes were, in part, caused by changes in land use on the breeding grounds (e.g. Knopf 1994). Declines in wetland species were commensurate with declines in wetland area. The increases in species associated with human-made structures and woody vegetation were consistent with the overall increases in area of those habitats. The declines in grassland birds paralleled the decrease in the combined total area of grassland and secondary grasslands (hayland and planted cover). Bernstein et al. (1990) repeated the historic survey of Kendeigh (1941) in northwestern Iowa and found similar declines in grassland birds and increases in species associated with woody vegetation.

Land use area, however, changed very little between 1992 and 1993, but our results suggest that many grassland and wetland species, as well as several other species, shifted similarly by increases in frequency and abundance between the two recent years (Tables 1 and 2, Appendices 1 and 2). Droege and Sauer (1989) and Peterjohn and Sauer (1993) suggested that breeding bird population declines on BBS routes in the late 1980s and increases in the early 1990s

reflect extreme drought conditions and amelioration of drought conditions, respectively. Extended periods of below-average rainfall are known to affect populations of grassland and wetland birds (e.g. Johnson and Grier 1988). In this study, the increases between 1992 and 1993 corresponded with the amelioration of the long-term drought conditions and are consistent with observations of behavioral flexibility and opportunism in habitat selection (Cody 1985) and weather-related shifts in distribution and abundance by grassland (Wiens 1974) and wetland (Johnson and Grier 1988) species. George et al. (1992) also noted rapid recoveries of grassland bird densities after drought. Reproductive success of grassland birds varies annually, with very poor productivity during some drought years (George et al. 1992).

In conclusion, our results indicate that BBS data reflect real population changes for many common species in North Dakota. The increase in species associated with human-made structures and woody vegetation and decreases in wetland and grassland species in agricultural landscapes have been reported previously, both in North America (McNicholl 1988, Knopf 1994, Herkert 1995) and elsewhere (Böhning-Gause and Bauer 1996). Our data suggest that land use changes, and probably drought conditions, influenced some breeding bird population changes in North Dakota between 1967 and 1992–93. Although these factors would not necessarily affect different species to the same extent, the fact that our surveys detected significant population changes for several common species (e.g. Northern Shoveler [*Anas clypeata*]) that the BBS did not detect and vice versa (e.g. Sora [*Porzana carolina*]) deserves further investigation. Furthermore, we cannot attribute all population changes to conditions on the breeding grounds. However, because many birds in the Great Plains are short-distance migrants, many of the factors driving population changes on the Great Plains are likely North American processes (Knopf 1994, Herkert 1995). Nonetheless, our data indicate that factors on the breeding grounds are having a major effect on breeding bird populations in the northern Great Plains.

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APPENDIX 1. Statewide frequencies of occurrence (confidence interval) of common bird species (i.e. species with frequencies greater than 10%) in North Dakota.

Species	Year		
	1967	1992	1993
Green-winged Teal	18.0 (11.8–24.9)	3.1 (0.8–6.5)	11.7 (6.6–17.8)
Mallard	60.9 (52.3–69.3)	35.9 (27.9–44.3)	53.9 (45.3–62.4)
Northern Pintail	52.3 (43.7–60.9)	13.3 (7.9–19.6)	24.2 (17.1–32.0)
Blue-winged Teal	38.3 (29.9–47.0)	18.8 (12.4–25.9)	25.0 (17.6–33.1)
Northern Shoveler	28.1 (20.6–36.2)	9.4 (4.9–14.8)	17.2 (11.2–23.9)
Gadwall	28.1 (20.6–36.2)	14.1 (8.5–20.5)	25.8 (18.5–33.7)
American Wigeon	11.7 (6.6–17.8)	7.0 (3.2–11.9)	7.8 (3.9–12.6)
Northern Harrier	11.7 (6.6–17.8)	16.4 (10.5–23.1)	25.0 (17.6–33.1)
Swainson's Hawk	5.5 (2.1–10.0)	10.9 (6.1–16.7)	19.5 (13.1–26.7)
Red-tailed Hawk	5.5 (2.1–10.0)	8.6 (4.2–14.1)	12.5 (7.3–18.6)
Gray Partridge	11.7 (6.6–17.8)	20.3 (13.9–27.4)	20.3 (13.9–27.4)
Ring-necked Pheasant	2.3 (0.4–5.5)	11.7 (6.6–17.8)	17.2 (11.2–23.9)
Sharp-tailed Grouse	7.8 (3.9–12.6)	12.5 (7.3–18.6)	11.7 (6.6–17.8)
Sora	13.3 (7.9–19.6)	7.8 (3.9–12.6)	23.4 (16.3–31.3)
American Coot	23.4 (16.3–31.3)	6.3 (2.7–10.8)	14.1 (8.5–20.5)
Killdeer	49.2 (40.7–57.8)	43.0 (34.6–51.5)	56.3 (47.6–64.7)
Willet	13.3 (7.9–19.6)	7.8 (3.9–12.6)	8.6 (4.2–14.1)
Upland Sandpiper	28.1 (20.6–36.2)	38.3 (29.9–47.0)	37.5 (29.3–46.0)
Marbled Godwit	11.7 (6.6–17.8)	5.5 (2.1–10.0)	9.4 (4.9–14.8)
Wilson's Phalarope	22.7 (15.7–30.3)	6.3 (2.7–10.8)	10.2 (5.5–15.8)
Black Tern	21.1 (14.4–28.5)	3.9 (1.1–8.1)	10.2 (5.5–15.8)
Mourning Dove	54.7 (46.1–63.2)	53.9 (45.3–62.4)	60.2 (51.6–68.5)
Common Nighthawk	5.5 (2.1–10.0)	7.0 (3.2–11.9)	10.2 (5.5–15.8)
Black-billed Cuckoo	4.7 (1.6–9.0)	16.4 (10.5–23.1)	7.0 (3.2–11.9)
Downy Woodpecker	0	6.3 (2.7–10.8)	10.9 (6.1–16.7)
Yellow-shafted Flicker	16.4 (10.5–23.1)	14.1 (8.5–20.5)	18.8 (12.4–25.9)
Willow Flycatcher	12.5 (7.3–18.6)	5.5 (2.1–10.0)	19.5 (13.1–26.7)
Least Flycatcher	7.0 (3.2–11.9)	11.7 (6.6–17.8)	15.6 (9.8–22.3)
Say's Phoebe	3.1 (0.8–6.5)	3.1 (0.8–6.5)	12.5 (7.3–18.6)
Western Kingbird	38.3 (29.9–47.0)	64.1 (55.7–72.1)	60.9 (52.3–69.3)
Eastern Kingbird	54.7 (46.1–63.2)	76.6 (68.7–83.7)	74.2 (66.3–81.5)
Horned Lark	85.9 (79.5–91.5)	86.7 (80.4–92.1)	85.2 (78.5–90.9)

APPENDIX 1. Continued.

Species	Year		
	1967	1992	1993
Bank Swallow	7.8 (3.9-12.6)	10.2 (5.5-15.8)	12.5 (7.3-18.6)
Cliff Swallow	5.5 (2.1-10.0)	14.8 (9.1-21.5)	18.0 (11.8-24.9)
Barn Swallow	39.8 (31.5-48.4)	57.0 (48.5-65.4)	58.6 (50.1-66.9)
Blue Jay	7.0 (3.2-11.9)	11.7 (6.6-17.8)	10.9 (6.1-16.7)
American Crow	18.8 (12.4-25.9)	9.4 (4.9-14.8)	19.5 (13.1-26.7)
Black-capped Chickadee	2.3 (0.4-5.5)	12.5 (7.3-18.6)	15.6 (9.8-22.3)
House Wren	15.6 (9.8-22.3)	35.9 (27.9-44.3)	32.8 (25.1-40.9)
Marsh Wren	6.3 (2.7-10.8)	9.4 (4.9-14.8)	12.5 (7.3-18.6)
American Robin	15.6 (9.8-22.3)	33.6 (25.7-41.9)	35.9 (27.9-44.3)
Gray Catbird	10.9 (6.1-16.7)	14.8 (9.1-21.5)	14.1 (8.5-20.5)
Brown Thrasher	18.8 (12.4-25.9)	34.4 (26.5-42.6)	41.4 (33.1-49.9)
Cedar Waxwing	7.0 (3.2-11.9)	14.1 (8.5-20.5)	10.2 (5.5-15.8)
Loggerhead Shrike	6.3 (2.7-10.8)	10.9 (6.1-16.7)	11.7 (6.6-17.8)
Warbling Vireo	6.3 (2.7-10.8)	9.4 (4.9-14.8)	14.8 (9.1-21.5)
Yellow Warbler	22.7 (15.7-30.3)	19.5 (13.1-26.7)	21.1 (14.4-28.5)
Common Yellowthroat	29.7 (22.1-37.8)	28.9 (21.5-36.8)	39.1 (30.7-47.7)
Chipping Sparrow	5.5 (2.1-10.0)	14.8 (9.1-21.5)	14.8 (9.1-21.5)
Clay-colored Sparrow	39.8 (31.5-48.4)	35.9 (27.9-44.3)	35.2 (27.1-43.6)
Vesper Sparrow	52.3 (43.7-60.9)	50.0 (41.4-58.6)	52.3 (43.7-60.9)
Lark Sparrow	8.6 (4.2-14.1)	11.7 (6.6-17.8)	9.4 (4.9-14.8)
Lark Bunting	41.4 (33.1-49.9)	40.6 (32.1-49.4)	25.0 (17.6-33.1)
Savannah Sparrow	63.3 (54.7-71.5)	28.1 (20.6-36.2)	44.5 (36.1-53.1)
Baird's Sparrow	24.2 (17.1-32.0)	18.0 (11.8-24.9)	20.3 (13.9-27.4)
Grasshopper Sparrow	48.4 (39.9-57.0)	50.0 (41.4-58.6)	46.1 (37.6-54.7)
Song Sparrow	20.3 (13.9-27.4)	25.8 (18.5-33.7)	32.8 (25.1-40.9)
Chestnut-collared Longspur	47.7 (39.1-56.3)	39.1 (30.7-47.7)	39.8 (31.5-48.4)
Bobolink	44.5 (36.1-53.1)	36.7 (28.5-45.3)	43.8 (35.3-52.4)
Red-winged Blackbird	80.5 (73.3-86.9)	67.2 (59.1-74.9)	67.2 (59.1-74.9)
Western Meadowlark	94.5 (90.0-97.9)	77.3 (69.7-84.3)	82.0 (75.1-88.2)
Yellow-headed Blackbird	11.7 (6.6-17.8)	16.4 (10.5-23.1)	18.0 (11.8-24.9)
Brewer's Blackbird	7.8 (3.9-12.6)	9.4 (4.9-14.8)	17.2 (11.2-23.9)
Common Grackle	25.8 (18.5-33.7)	39.1 (30.7-47.7)	34.4 (26.5-42.6)
Brown-headed Cowbird	81.3 (74.1-87.6)	83.6 (76.9-89.5)	89.1 (83.3-93.9)
Orchard Oriole	9.4 (4.9-14.8)	18.0 (11.8-24.9)	18.8 (12.4-25.9)
Baltimore Oriole	11.7 (6.6-17.8)	21.1 (14.4-28.5)	14.8 (9.1-21.5)
American Goldfinch	38.3 (29.9-47.0)	34.4 (26.5-42.6)	43.0 (34.6-51.5)
House Sparrow	17.2 (11.2-23.9)	21.9 (14.9-29.6)	22.7 (15.7-30.3)

APPENDIX 2. Statewide breeding population estimates (1,000s of pairs, with confidence intervals) of common species of birds (i.e. species with statewide frequencies greater than 10%) in North Dakota.

Species	Year		
	1967	1992	1993
Green-winged Teal	96 (54-139)	24 (0-47)	96 (30-161)
Mallard	457 (373-541)	249 (148-349)	439 (294-585)
Northern Pintail	371 (295-448)	50 (26-75)	127 (79-176)
Blue-winged Teal	612 (425-799)	216 (113-319)	312 (177-448)
Northern Shoveler	189 (108-269)	55 (20-90)	112 (55-170)
Gadwall	208 (101-315)	246 (55-437)	259 (126-393)
American Wigeon	53 (20-87)	49 (0-102)	71 (0-132)
Northern Harrier	33 (17-49)	46 (28-64)	75 (53-98)
Swainson's Hawk	16 (5-27)	31 (16-47)	55 (35-75)
Red-tailed Hawk	15 (4-25)	24 (10-38)	34 (19-49)
Gray Partridge	38 (19-56)	89 (49-128)	79 (47-112)
Ring-necked Pheasant	7 (0-13)	53 (24-83)	114 (49-179)

APPENDIX 2. Continued.

Species	Year		
	1967	1992	1993
Sharp-tailed Grouse	39 (12–67)	102 (23–182)	72 (32–112)
Sora	68 (34–102)	90 (0–173)	167 (100–235)
American Coot	761 (206–1,315)	169 (0–414)	271 (37–504)
Killdeer	227 (176–277)	248 (178–318)	312 (226–397)
Willet	39 (22–56)	35 (10–61)	60 (12–108)
Upland Sandpiper	139 (93–185)	236 (166–307)	198 (138–258)
Marbled Godwit	37 (19–55)	18 (5–31)	31 (14–49)
Wilson's Phalarope	157 (97–218)	66 (8–125)	79 (31–128)
Black Tern	254 (101–408)	86 (0–192)	83 (28–139)
Mourning Dove	628 (478–777)	742 (538–945)	733 (542–923)
Common Nighthawk	23 (5–40)	27 (8–45)	35 (15–54)
Black-billed Cuckoo	15 (3–27)	65 (36–94)	22 (8–36)
Downy Woodpecker	0	19 (6–33)	45 (19–71)
Yellow-shafted Flicker	87 (45–128)	55 (28–81)	76 (43–110)
Willow Flycatcher	63 (27–98)	37 (6–69)	79 (46–113)
Least Flycatcher	48 (12–85)	112 (35–189)	169 (77–260)
Western Kingbird	221 (160–282)	427 (342–512)	390 (291–488)
Eastern Kingbird	360 (276–444)	706 (586–827)	536 (432–641)
Say's Phoebe	12 (1–24)	8 (1–16)	37 (20–54)
Horned Lark	2,772 (2,407–3,136)	2,412 (2,082–2,742)	3,672 (3,164–4,179)
Bank Swallow	161 (0–300)	246 (0–473)	131 (48–213)
Cliff Swallow	308 (0–629)	743 (173–1,313)	477 (111–842)
Barn Swallow	206 (155–257)	408 (305–510)	420 (323–516)
Blue Jay	29 (7–51)	58 (25–92)	66 (26–107)
American Crow	60 (37–83)	28 (13–42)	58 (38–78)
Black-capped Chickadee	6 (0–12)	59 (26–93)	66 (38–94)
House Wren	111 (52–170)	473 (306–641)	449 (287–611)
Marsh Wren	112 (0–218)	250 (0–526)	336 (0–649)
American Robin	144 (66–221)	254 (163–345)	267 (167–367)
Gray Catbird	103 (38–168)	94 (47–142)	82 (37–126)
Brown Thrasher	93 (48–138)	187 (130–244)	229 (165–293)
Cedar Waxwing	49 (8–89)	279 (68–489)	90 (28–152)
Loggerhead Shrike	18 (6–30)	36 (18–54)	34 (19–49)
Warbling Vireo	40 (7–73)	50 (16–84)	86 (43–130)
Yellow Warbler	216 (110–322)	193 (107–279)	226 (114–337)
Common Yellowthroat	285 (173–398)	196 (121–271)	375 (235–516)
Chipping Sparrow	45 (6–83)	105 (37–174)	150 (44–256)
Clay-colored Sparrow	786 (523–1,050)	564 (334–793)	622 (369–875)
Vesper Sparrow	414 (328–500)	479 (374–584)	844 (654–1,034)
Lark Sparrow	83 (16–151)	107 (35–178)	89 (32–146)
Lark Bunting	1,368 (974–1,762)	1,541 (1,151–1,931)	686 (412–960)
Savannah Sparrow	1,120 (859–1,381)	295 (189–400)	596 (392–800)
Baird's Sparrow	376 (208–543)	171 (90–251)	279 (140–418)
Grasshopper Sparrow	661 (478–844)	890 (648–1,132)	1,001 (737–1,265)
Song Sparrow	116 (64–168)	216 (134–298)	274 (186–363)
Chestnut-collared Longspur	2,544 (1,987–3,101)	1,351 (913–1,789)	1,707 (1,183–2,232)
Bobolink	464 (313–616)	405 (287–523)	371 (262–480)
Red-winged Blackbird	2,038 (1,690–2,386)	1,306 (1,021–1,591)	1,536 (1,224–1,848)
Western Meadowlark	2,034 (1,802–2,267)	1,080 (911–1,248)	1,441 (1,231–1,651)
Yellow-headed Blackbird	193 (37–350)	340 (114–566)	373 (183–563)
Brewer's Blackbird	43 (12–73)	102 (22–182)	187 (89–285)
Common Grackle	302 (193–412)	658 (400–916)	651 (346–957)
Brown-headed Cowbird	1,005 (794–1,217)	1,425 (1,080–1,771)	1,335 (1,116–1,554)
Orchard Oriole	39 (15–64)	73 (40–105)	87 (51–122)
Baltimore Oriole	44 (18–71)	105 (63–146)	86 (45–128)
American Goldfinch	227 (156–297)	316 (193–438)	282 (203–361)
House Sparrow	214 (88–339)	397 (208–586)	380 (180–580)