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Breeding Waterfowl Populations in South Dakota

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BREEDING WATERFOWL POPULATIONS IN SOUTH DAKOTA

By

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Abstract

WAYNE G. BREWSTER

Breeding waterfowl in South Dakota were censused on 500 legal quarter sections within 125 clusters representing a proportional stratified random sample of 0.16 percent of the state area. Two breeding pair counts, one in May and a second in June, were conducted each year on the sample units in 1973 and 1974.

Densities of total breeding pairs averaged 5.58 and 2.30 pairs per km^2 in 1973 and 1974, respectively. Estimated populations based upon these densities were 1,067,500 breeding pairs in 1973 and 439,600 breeding pairs in 1974. The 58.8 percent decrease in the population occurred concurrently with intensification of drought conditions throughout South Dakota in 1974.

Blue-winged teal (Anas discors), mallard (Anas platyrhynchos), pintail (Anas acuta), and gadwall (Anas strepera) were, in that order, the most abundant species. Diving ducks constituted less than 5 percent of the population each year. Highest diving duck densities were restricted to the northern periphery of the Coteau des Prairies. Most of the remaining diving duck pairs occurred in the central Coteau des Prairies and in the Coteau du Missouri.

Highest dabbling duck densities were found in the

northern Coteau des Prairies and in the major portion of the Coteau du Missouri. Median densities occurred in the Minnesota River-Red River Lowland and the major portion of the James River Lowland. Low densities were found in the remainder of the state.

Population estimates from this method compared favorably with those obtained by aerial transect methods used by the U. S. Fish and Wildlife Service.

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INTRODUCTION

The glaciated prairie of North America, commonly called the prairie pothole region, is an area of approximately 777,000 km^2 in the north central United States and adjacent south central Canada. The glacial topography of this area has a poorly developed drainage system with abundant natural water holding depressions. Although it comprises less than 10 percent of the waterfowl breeding grounds in North America, the prairie pothole region accounts for more than 50 percent of the continental duck production in an average year (Smith et al. 1964). The future of waterfowl hunting in North America depends on maintenance of adequate wetland habitat in the prairie pothole region.

Agriculture is the economic base of the region and conflicts in land use inevitably arise. The agricultural disadvantages of wetlands create incentives for their drainage and conversion to cropland. At present probably less than half of the original wetland resource of the prairie states still remains (Allen and Leedy 1970). In the United States only North Dakota and South Dakota still retain a high proportion of their original wetlands with South Dakota retaining the greater percentage (Burwell and Sugden 1964). Because of this large natural wetland resource in South Dakota it is imperative that accurate data be available to document breeding waterfowl population densities and

distribution. This information can be used for management and as a basis for evaluating effects of future environmental changes.

Waterfowl breeding populations in South Dakota presently are estimated using data from the aerial breeding pair survey conducted by the U. S. Fish and Wildlife Service. This survey gives reliable data showing trends in population numbers, however, because of the manner in which the samples are drawn, it does not lend itself to statistical analysis. The objectives of this study were to estimate breeding waterfowl populations and determine their distribution in South Dakota by application of stratified random sampling techniques. Similar work has been performed by Stewart and Kantrud (1972, 1973, 1974) primarily in the prairie pothole region of North Dakota.

STUDY AREA

General Description

South Dakota forms part of the transition zone from the prairies of the middle west to the Rocky Mountains farther to the west. The state, approximately 595 km by 335 km with an area of 199,552 km^2 (Westin et al. 1967), is split by the upper Missouri River into two nearly equal segments referred to as "east-river" and "west-river."

Western South Dakota is primarily rangeland supporting a livestock economy. General farming practices prevail east of the Missouri River with the main reliance on wheat and other small grains in the northern part. The southern part of the state east of the Missouri River has a more diversified farming economy with mainstays of feed grains and livestock production (Westin et al. 1967). Industrial activity in South Dakota consists primarily of processing agricultural products.

Climate

South Dakota has a continental climate with extremes of summer heat and winter cold and rapid temperature fluctuations over short periods of time. Average annual temperatures range from 7C in the north to 9C in the south with a mean January temperature of -9C and a mean July temperature of 22C. Annual precipitation ranges from 64 cm in the southeastern subhumid region to 33 cm in the semi-arid western regions (Spuhler et al. 1971).

Approximately 75 percent of the precipitation falls from April to September and is important in maintaining the moisture regime throughout the growing season. Of equal importance to wetlands is the annual snowfall ranging from 64 cm to 114 cm with an average of 91 cm (Spuhler et al. 1971). The amount of snow accumulation and characteristics of the spring thaw determines to a large extent the amount of wetland basin recharge (Eisenlohr 1969). The prevailing winds are north to northwesterly in winter and south to southwesterly in summer. Average wind speed is 18 km per hour and moisture content is usually low. Evaporation exceeds precipitation in all areas of South Dakota with approximately 80 percent of the evaporation occurring from May to October (Spuhler et al. 1971).

The growing season varies from 150 days in the southeast to 120 days in the northwest. Average dates between frosts are 5 May to 5 October in the southeast and 20 May to 15 September in the northwest (Spuhler et al. 1971). The mountainous Black Hills region on the western edge of the state has increased precipitation and a shorter growing season characteristic of higher elevations.

Physiography

Elevation in South Dakota rises from 400 m in the southeast to 1040 m in the northwest. The Missouri River, separating the Central Lowland of the east from the Missouri

Plateau of the west, marks the westward limit of the Pleistocene glaciation. Glaciers entered the state from the northeast and flowed south and west. Because of this recent glaciation, eastern South Dakota is covered with glacial deposits and has abundant natural water holding depressions with a poorly developed surface drainage system. Western South Dakota is composed of older sedimentary material and has well developed surface drainage systems.

South Dakota can be separated into eight major physical divisions (Fig. 1) as described by Westin et al. (1967). The Minnesota River-Red River Lowland (stratum I) is a broad, gently undulating, valley-like area with an elevation of about 300 m. Wetlands in this area are generally shallow depression or small, meandering streams. The continental divide separating drainage to the Arctic Ocean and the Gulf of Mexico occurs in this area with most of the streams tributary to the north-flowing Red River. The remainder of the state is drained by the Missouri River and its tributaries.

The Coteau des Prairies (stratum II) is a highland area sloping gently to the south and west. Elevations range from 610 m in the north to about 490 m in the south. The escarpment on the northeastern edge of the Coteau (substratum IIA) drops sharply to the east. Topography on the slope consists of grassland ridges and forested ravines with a glacial knob and kettle topography on the higher elevations. The central ridge of the Coteau (substratum IIB) has sharper relief with

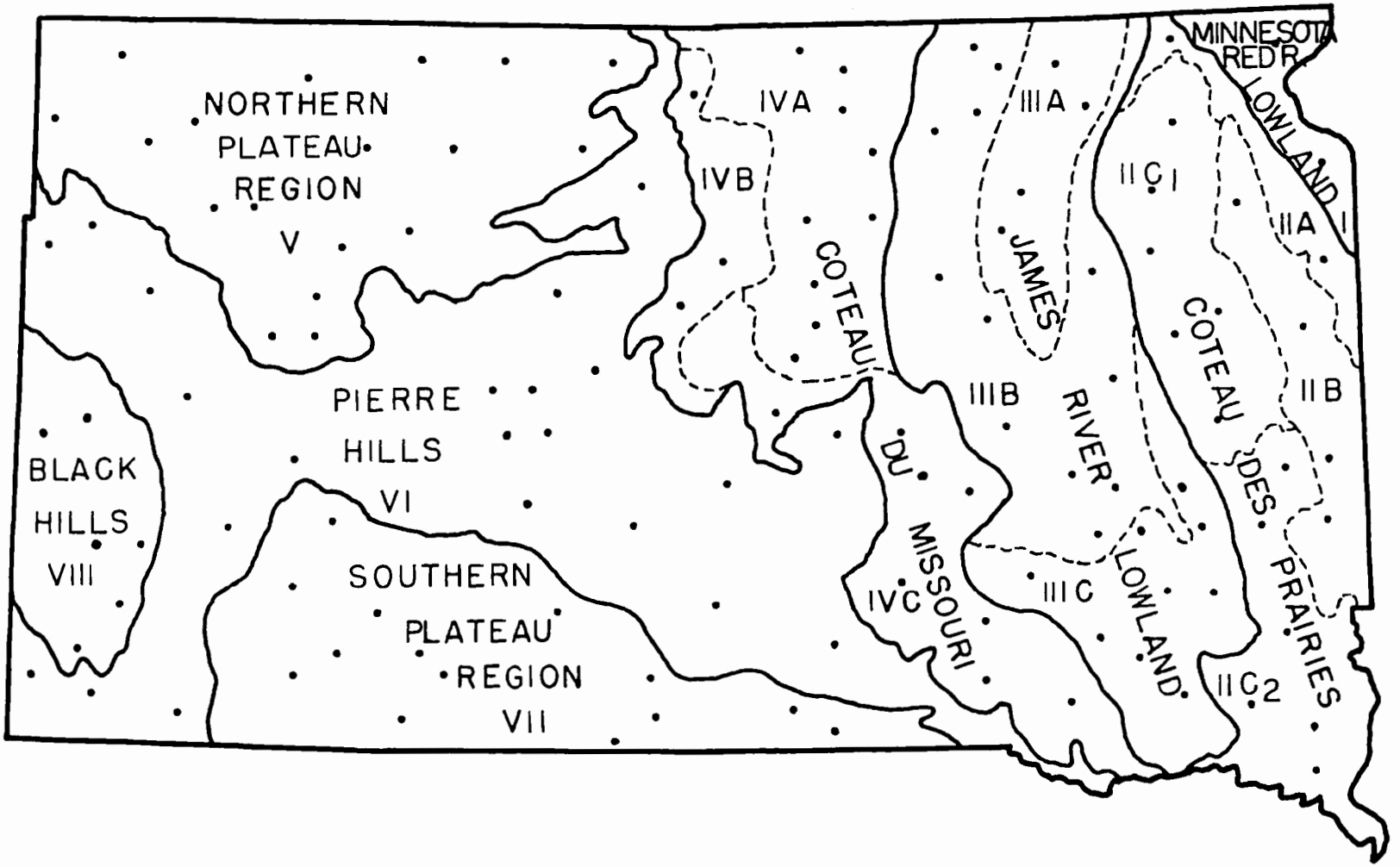

Fig. 1. Major physiographic regions, strata, and substrata within South Dakota and the location of 125 randomly selected cluster samples, 1973-74.

a more mature surface drainage system than other substrata in the Coteau des Prairies (Fenneman 1938). The eastern region of the Coteau is a series of moraines which vary from undulating in the north to gently undulating and nearly level in the south. Natural lakes and wetlands are extremely abundant, particularly in the northern part (substratum IIC_1) which has an essentially closed drainage system. Evans and Black (1956) found an average density of 13.5 wetlands per km^2 on their study area in Day County. The Big Sioux River drainage extends into the remainder of the area (substratum IIC_2) but natural wetlands are still abundant.

The James River Lowland (stratum III) is a gently undulating plain extending the width of the state and is drained by the James River. This stratum has an average elevation of 430 m. The northcentral Lake Dakota Plain (substratum IIIA) is nearly level with few natural wetland basins. The area peripheral to the Lake Dakota Plain and the central area of the James River Lowland (substratum IIIB) is gently undulating to undulating, whereas the southern area (substratum IIIC) is nearly level to gently undulating. Wetlands in these areas consist of the James River, associated oxbows and tributaries, and shallow natural wetlands of various sizes.

Western most of the glaciated areas is the Coteau du Missouri (stratum IV). This highland area with an elevation of 490 to 610 m is considerably higher than the James River

Lowland. The northeastern portion (substratum IVA) is rolling to undulating with abundant natural wetland basins because of the irregular landscape and lack of surface drainage patterns. The northern portion adjacent to the Missouri River (substratum IVB) is a sloping area, whereas the southern portion of the Coteau du Missouri (substratum IVC) is rolling to undulating. Both of these areas have well developed surface drainage patterns with fluviatile wetlands and stockdams becoming more important wetland types.

West of the river the unglaciated portion of the Missouri Plateau is divided into four major divisions. The Northern Plateau Region (stratum V) is a rolling to undulating series of plateaus and isolated buttes drained by the Grand, Moreau, and Cheyenne rivers. Wind and water erosion has formed striking, solitary, rock-capped buttes rising above the plains such as Slim Buttes and Cave Hills in Harding County.

The Pierre Hills (stratum VI) in the central portion of the west-river area have an undulating to steep topography. Drained by the Grand and Moreau rivers in the north, the Belle Fourche and Cheyenne rivers in the central part, and the Bad and White rivers in the southern part, this area has a heavily disected landscape, particularly near the main river courses.

The Southern Plateau Region (stratum VII), a rolling to hilly area with a diversity of topography, is drained by the Cheyenne, White, and Keya Paha rivers. The southern and

eastern portions of this region are undulating to rolling with a portion of the Nebraska sand hills extending into the extreme southern edge. Arcing through the west-central portion, the Pine Ridge is a series of conifer covered ridges and ravines with a sharper relief than the southern portion. North of the Pine Ridge along the White River is an area of steep, heavily eroded badlands with interspersed flat-topped, grass covered buttes.

The Black Hills (stratum VIII) is a mountainous region with a central area of high peaks, concentric rings of high plateaus on the north and west and steep ridges on the east and south, and a peripheral hogback rising from the surrounding plains. Major wetland types are mountain lakes and streams with some man-made reservoirs and stockdams. Throughout the remainder of the west-river area, the main wetland types are fluviatile wetlands of variable permanence, stockdams, and dugouts.

Vegetation

Potential natural vegetation in South Dakota as described in detail by Kuchler (1964) consists of tall grass prairie in the eastern third of the state, a mixed grass transition zone in the James River Lowland, and mixed grass prairie in the Coteau du Missouri and the west-river area. Northern flood plain forest occurs along most of the major water courses throughout the state. The Black Hills are

primarily Ponderosa pine (Pinus ponderosa) forest with other plant communities or seral stages dominating in areas not favorable to Ponderosa pine.

Human Disturbance

Human activity has severely altered the ecosystem in South Dakota. A vast majority of the land in the east-river area has been tilled with most of the remaining area not suited for farming being grazed by livestock with the subsequent severe alteration of the natural vegetation. Grazing in the west-river rangeland has caused a shift in the dominant vegetation types to less desirable species and has often resulted in accelerated erosion (Johnson and Nichols 1970). The abundant shelterbelts, farmsteads, roads, and municipal areas, particularly in the eastern part of the state, have further altered the prairie. Furthermore, the inundation by the large main-stem reservoirs on the Missouri River has eliminated thousands of acres of northern flood plain forest.

In the eastern portion of the state many natural wetlands have been drained or filled and increased sedimentation from agricultural activity has affected additional wetlands. New water areas, particularly in the western rangeland, have been created by construction of numerous stockdams and dugouts for stock watering.

METHODS

General

These investigations were conducted statewide in 1973 and statewide with the exception of the Black Hills stratum in 1974. The Black Hills (Fig. 1) were eliminated from the study in 1974 because waterfowl were not present on the sample areas and major wetlands were rapidly flowing streams. Census effort expended in this stratum was extremely high because of the relative inaccessibility of many of the sample units. Waterfowl in this region are mostly mallards but in numbers that are insignificant with regard to the total population (letter dated 7 October 1970 from Thomas Kuck, South Dakota Department of Game, Fish and Parks, Aberdeen, S. D.).

Field investigations were conducted by the author, two fellow graduate students, and one undergraduate summer employee. A period of orientation and training was conducted prior to actual field investigations to insure that the methods were standard for all observers and to minimize differences from individual interpretation.

Project Design

Because habitat is not homogeneous throughout the state, it was deemed necessary to stratify the sampling effort (Fig. 1) so that variation among strata means did not contribute to the sampling error of the estimate of the

population mean (Steele and Torrie 1960).

The legal quarter section (65 hectare, 0.65 km^2) was chosen as the basic sampling unit because it is easily identified in the field by recognizable terrain features, it can be thoroughly covered by two observers in a relatively short period of time, and it is small enough so that the observers can maintain communication and flushed birds can be observed or "marked down" thereby minimizing the possibility of duplicate counts. Two stage cluster sampling (Steele and Torrie 1960) was used because of the increased efficiency resulting from reduced travel time between sample units. By preliminary field trials it was determined that 500 legal quarter sections could be censused with the available manpower in the desired time period. Samples were selected randomly without replacement (Steele and Torrie 1960) by use of a random number table with sample units being allocated to each stratum and substratum in proportion to their relative size (Table 1). All townships within the state were numbered and 125 were selected (Fig. 1). The northwest corner of each selected township was designated as the center of a cluster. Within a 6.43 km (4 mile) radius of each cluster center, one quarter section was randomly selected in each quadrant of this circle. These quarter sections were plotted and the legal description recorded. The resultant 500 quarter sections within 125 clusters represented a proportional, stratified random sample of 0.16

Table 1. Distribution of sampling effort among strata and substrata in South Dakota, 1973-74.

Major Physiographic Region	Strata and Substrata	Area of Strata (km^2)	Percent of State Area	Area of Sample (km^2)	Percent of Sample Effort	Percent of Area Sampled
Minnesota River-Red River Lowland	I	3074	1.54	5.2	1.6	0.17
Coteau des Prairies	II	25423	12.74	46.6	14.4	0.18
	A	3033	1.52	5.2	1.6	0.17
	B	6027	3.02	10.4	3.2	0.17
	C1	8500	4.26	15.5	4.8	0.18
	C2	7863	3.94	15.5	4.8	0.20
James River Valley	III	31210	15.64	64.8	20.0	0.21
	A	5688	2.85	10.4	3.2	0.18
	B	15965	8.00	31.1	9.6	0.19
	C	9557	4.79	23.3	7.2	0.24
Coteau du Missouri	IV	27995	14.03	49.2	15.2	0.18
	A	11134	5.58	20.7	6.4	0.19
	B	4489	2.25	7.8	2.4	0.17
	C	12372	6.20	20.7	6.4	0.17
Northern Plateau Region	V	30093	15.08	46.6	14.4	0.15
Pierre Hills	VI	52821	26.47	59.6	18.4	0.11
Southern Plateau Region	VII	20813	10.43	36.3	11.2	0.17
Black Hills	VIII	8122	4.07	15.5	4.8	0.19
Totals		199552	100.00	323.8	100.0	0.16

percent of the state area.

Aerial photographs of each quarter section, obtained from the Agricultural Stabilization and Conservation Service (ASCS), were enlarged to a scale of 1:3960. Photoduplicate copies of these enlargements were used for field records and as aids in identifying the sample unit in the field.

Census Methods

Two-man teams, one east-river and one west-river, conducted the study beginning on the southern edge and proceeding northward on a broad front that followed the advance of the season.

Two separate breeding pair counts were conducted each year. All waterfowl on the sample units were recorded but only indicated pairs were used in the calculations. The first breeding pair count was conducted from 10 May to 1 June 1973 and 13 May to 27 May 1974. This count was directed at the early nesting species which include mallard (Anas platyrhynchos), pintail (Anas acuta), canvasback (Aythya vallisneria), and wood duck (Aix sponsa) (Hammond 1969). The second breeding pair count was conducted from 3 June to 21 June 1973 and 10 June to 20 June 1974. This count was directed at the mid- and late nesting species which include blue-winged teal (Anas discors), gadwall (Anas strepera), American wigeon (Anas americana), northern shoveler (Anas clypeata), green-winged teal (Anas carolinensis), redhead

(Aythya americana), ring-necked duck (Aythya collaris), lesser scaup (Aythya affinis), and ruddy duck (Oxyura jamaicensis) (Hammond 1969). In determining the number of indicated breeding pairs, our interpretation of segregated pairs, lone males, grouped males, and mixed groups of both sexes followed the criteria established by Hammond (1969). On a given sample unit excess lone females were also considered as indicated pairs as suggested by Stewart and Kantrud (1973).

All wetlands on each sample unit were censused by one or two observers using binoculars or a spotting scope depending upon the particular situation. Both the walk-wade and vehicular methods as outlined by Hammond (1969) were used as the situation dictated. If a portion of a wetland extended out of the sample unit, only the portion within the sample unit was censused. Censuses were conducted from one half hour after sunrise to one half hour before sunset.

Data Analysis

Data were coded, keypunched, and verified on 80 column IBM cards. Computer programs were developed by W. L. Tucker, Experiment Station Statistician, and analysis was performed at the Computer Center, South Dakota State University.

A least squares analysis of variance (Steele and Torrie 1960) was performed on the data. F tests were used to test significance of the sources of variation. Mean densities

of breeding pairs were calculated for each substratum and Duncan's new multiple range test (Steele and Torrie 1960) was used to test differences in mean density between substrata. These densities were expanded by species for each substrata and summed to obtain total breeding pair population estimates.

RESULTS AND DISCUSSION

Estimated Populations

Parameters calculated for waterfowl breeding pair populations in South Dakota during 1973 and 1974 include population densities, estimated populations, percentage composition by species, and percentage change from 1973 to 1974 (Table 2). Densities of total ducks in 1973 and 1974 averaged 5.58 and 2.30 pairs per km^2, respectively. Estimated populations based upon these densities were 1,007,600 dabbling duck pairs, 32,600 diving duck pairs, and 1,067,500 total breeding pairs in 1973; and 406,600 dabbling duck pairs, 22,000 diving duck pairs, and 439,600 total breeding pairs in 1974.

Decreases in the breeding populations corresponded to intensification of drought conditions throughout the state in 1974. Yearly differences were significant ($P<0.05$) for all species except canvasback and wood duck which utilize the more permanent water areas and American wigeon and green-winged teal which had low densities with a variable distribution between strata and years. The large increase of lesser scaup in 1974 may be due to sampling error because of very small sample size (N=1 and 7).

Blue-winged teal was by far the most abundant species. In decreasing order of abundance were mallard, pintail, and gadwall; these four species constituting a vast majority of

Table 2. Parameters of breeding waterfowl populations in South Dakota, 1973-74.

Species	Density of breeding pairs (pairs/km^2)[a] 1973	Density of breeding pairs (pairs/km^2)[a] 1974	Estimated breeding pair population[b] 1973	Estimated breeding pair population[b] 1974	Percent change
Blue-winged teal	2.50 (1.75-3.25)	0.82 (0.49-1.15)	479300 (44.9)	156500 (35.6)	- 67.4
Mallard	1.22 (0.99-1.45)	0.70 (0.53-0.87)	233200 (21.9)	134900 (30.7)	- 40.2
Pintail	0.73 (0.49-0.97)	0.20 (0.13-0.27)	139100 (13.0)	38600 (8.8)	- 72.3
Gadwall	0.43 (0.28-0.58)	0.31 (0.16-0.46)	31500 (7.6)	58700 (13.4)	- 28.0
Northern shoveler	0.21 (0.12-0.30)	0.03 (0.01-0.05)	40700 (3.8)	5100 (1.2)	- 87.5
American wigeon	0.07 (0.04-0.10)	0.05 (0.02-0.08)	14000 (1.3)	8800 (2.0)	- 37.2
Green-winged teal	0.10 (0.03-0.17)	0.02 (0.00-0.04)	19900 (1.9)	4200 (0.9)	- 79.1
Redhead	0.14 (0.00-0.29)	0.07 (0.00-0.18)	25900 (2.4)	13700 (3.1)	- 47.2
Canvasback	0.02 (0.01-0.03)	0.02 (0.00-0.04)	2700 (0.3)	2800 (0.6)	+ 4.9
Ring-necked duck	0.02 (0.00-0.06)	0.01 (0.00-0.02)	3500 (0.3)	1200 (0.3)	- 66.7
Lesser scaup	Trace[c]	0.02 (0.00-0.04)	500 (0.1)	4300 (1.0)	+708.0
Ruddy duck	0.10 (0.01-0.19)	0.02 (0.00-0.06)	19600 (1.8)	3900 (0.9)	- 80.3
Wood duck	0.03 (0.00-0.06)	0.02 (0.00-0.04)	5800 (0.6)	2800 (0.6)	- 51.4
Unidentified			1900 (0.2)	4400 (1.0)	+131.2
Total dabbling ducks	5.27 (3.73-6.81)	2.12 (1.49-2.75)	1007600 (94.4)	406600 (92.5)	- 59.7
Total diving ducks	0.17 (0.00-0.36)	0.12 (0.00-0.24)	32600 (3.1)	22000 (5.0)	- 32.6
Total ducks	5.58 (4.23-6.93)	2.30 (1.55-3.05)	1067500(100.0)	439600(100.0)	- 58.8

[a]Values in parenthesis are 95 percent confidence intervals (T).
[b]Values in parenthesis are percentage composition.
[c]Indicates densities less than 0.005 pairs per km^2.

the breeding population. The remaining nine species made up less than 15 percent of the population in either year with the redhead, northern shoveler, American wigeon, and ruddy duck comprising the major portion. The vast majority of the population was composed of dabbling ducks with diving ducks making up less than 5 percent of the population in either year.

There was an apparent slight shift in the percentage composition by the various species between years. Blue-winged teal, pintail, northern shoveler, and green-winged teal decreased in importance while the mallard, gadwall, American wigeon, and most of the divers increased in proportion to the total population under reduced water conditions in 1974. Similar trends were noted in North Dakota by Stewart and Kantrud (1974).

Our population estimates of breeding pairs can be compared with those from the aerial transect method conducted by personnel of the U. S. Fish and Wildlife Service, (G. Pospichal and cooperators, U. S. Fish and Wildlife Service, Jamestown, N. D., Unpublished data). During 1973 our estimates of the population of each species are within 10 percent of the estimates by the U. S. Fish and Wildlife Service for the mallard, pintail, gadwall, northern shoveler, green-winged teal, total dabblers, and total ducks. During 1974 only the mallard, American wigeon, and redhead show this close agreement. The direction of the change in the

estimated populations, either increase or decrease, from 1973 to 1974 is the same for both methods. The magnitude of the percentage change between years for blue-winged teal, mallard, pintail, total dabbling ducks, total diving ducks, and total ducks is within 15 percent of the estimated changes from the aerial transect method. All other species show greater differences.

Lone Drake Index

As the reproductive season progresses, a larger percentage of the drakes are no longer closely associated with the hens and are sighted as lone drakes on waiting stations or as grouped males. The percentage of total drakes that are represented by drakes unaccompanied by a hen can be used as an index to the stage of the breeding chronology at the time of the census (Table 3). Most species were slightly more advanced at the time of the census in 1973 than 1974, particularly early nesting dabblers and redheads, and the breeding season was slightly more advanced in the east than in the west during both years. Blue-winged teal were at about the same stage of breeding chronology in both years. Small sample sizes of less abundant dabblers and most divers give less reliable comparisons than data for the more abundant species. The early nesting species and the late nesting species appear to be at about the same stage of breeding within their respective seasons. Overall, the censuses were

Table 3. Lone drake index of South Dakota breeding waterfowl populations, expressed as percentage of total drakes unaccompanied by hens, 1973-74.

Species	1973	1974
Blue-winged teal	68.4	67.4
Mallard	59.5	49.3
Pintail	63.3	58.7
Gadwall	50.0	57.8
Northern shoveler	62.0	66.7
American wigeon	59.1	50.0
Green-winged teal	85.7	71.4
Redhead	45.7	32.0
Canvasback	40.0	40.0
Ring-necked duck	83.3	100.0
Lesser scaup	0.0	71.4
Ruddy duck	66.7	42.9
Wood duck	75.0	80.0
Total dabbling ducks	64.0	59.1
Total diving ducks	47.5	43.6
Total east-river	64.0	60.0
Total west-river	59.3	50.5
Total ducks	63.2	57.6

conducted at about the same stage of the breeding chronology in 1973 and 1974.

Breeding Pair Density

Variation in mean densities of breeding pairs attributable to strata differences was significant ($P<0.05$) for all species except American wigeon, lesser scaup, and wood duck. These species had low densities and variable distributions between strata and years. Duncan's multiple range test performed on the mean density for each species further indicated that there were significant differences ($P<0.05$) between all east-river strata for one or more major species with significant differences between the east-river and the west-river strata for most species. Within each stratum there were significant differences ($P<0.05$) between substrata for one or more major species. The west-river breeding pair densities showed no significant differences ($P<0.05$) between strata. It appears valid to combine the west-river strata into one stratum.

Breeding pair densities in 1973 (Table 4) and 1974 (Table 5) show striking differences between the various substrata. In the east-river portion of the state highest densities occurred in the northern periphery of the Coteau des Prairies (substrata IIA and IIC_1) and in the major portion of the Coteau du Missouri (substrata IVA and IVC). These substrata had total breeding pair densities that were

Table 4. Estimated waterfowl breeding pair density per km^2 in South Dakota, 1973.

Species	Minnesota River-Red River Lowland	Coteau des Prairies				James River Lowland			Coteau du Missouri			Northern Plateau Region	Pierre Hills	Southern Plateau Region
		II				III			IV					
	I	A	B	C_1	C_2	A	B	C	A	B	C	V	VI	VII
Blue-winged teal	3.48	9.85	1.26	7.46	1.29	0.00	2.81	3.73	5.79	0.00	11.44	0.43	0.77	0.75
Mallard	0.39	4.63	0.10	2.12	0.39	0.29	1.38	1.46	2.56	0.51	2.12	0.86	1.11	0.83
Pintail	0.19	1.74	0.10	1.09	0.26	0.10	0.58	0.82	4.15	0.26	2.85	0.19	0.24	0.14
Gadwall	0.39	6.56	0.29	1.87	0.07	0.10	0.26	0.56	2.03	0.13	0.97	0.13	0.09	0.03
Northern shoveler	0.00	0.77	0.00	0.45	0.07	0.00	0.07	0.26	0.87	0.00	1.31	0.02	0.07	0.03
American wigeon	0.00	0.00	0.00	0.19	0.00	0.00	0.03	0.04	0.29	0.00	0.05	0.09	0.09	0.03
Green-winged teal	0.00	0.00	0.00	0.58	0.07	0.00	0.16	0.17	0.39	0.00	0.15	0.00	0.07	0.03
Redhead	0.00	3.86	0.68	0.90	0.00	0.00	0.00	0.09	0.15	0.00	0.00	0.00	0.00	0.00
Canvasback	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.04	0.10	0.00	0.00	0.00	0.00	0.00
Ring-necked duck	0.00	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lesser scaup	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Ruddy duck	0.00	0.39	0.39	1.42	0.00	0.00	0.03	0.17	0.17	0.00	0.00	0.07	0.00	0.00
Wood duck	0.00	0.77	0.00	0.00	0.00	0.00	0.07	0.26	0.00	0.00	0.00	0.00	0.00	0.00
Unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.00	0.00
Total dabbling ducks	4.44	19.69	1.74	13.66	2.12	0.48	5.41	7.04	16.07	0.90	18.87	1.71	2.42	1.82
Total diving ducks	0.00	5.41	0.68	0.90	0.00	0.00	0.00	0.13	0.29	0.00	0.00	0.00	0.00	0.00
Total pairs	4.44	26.26	2.80	16.09	2.12	0.48	5.50	7.60	16.36	0.90	18.92	1.82	2.42	1.82

Table 5. Estimated waterfowl breeding pair density per km^2 in South Dakota, 1974.

Species	Minnesota River-Red River Lowland	Coteau des Prairies II				James River Lowland III			Coteau du Missouri IV			Northern Plateau Region	Pierre Hills	Southern Plateau Region
	I	A	B	C_1	C_2	A	B	C	A	B	C	V	VI	VII
Blue-winged teal	0.58	4.44	1.35	4.57	0.77	0.10	0.58	0.73	1.88	0.51	1.31	0.24	0.32	0.39
Mallard	1.35	3.86	0.39	1.67	0.13	0.29	0.42	0.77	1.16	0.26	0.58	0.86	0.54	0.50
Pintail	0.00	0.00	0.39	0.65	0.07	0.39	0.10	0.09	0.58	0.39	0.24	0.15	0.17	0.05
Gadwall	0.00	0.58	0.48	2.44	0.00	0.00	0.19	0.17	0.92	0.13	0.44	0.22	0.10	0.03
Northern shoveler	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.04	0.24	0.13	0.00	0.00	0.02	0.00
American wigeon	0.00	0.19	0.00	0.07	0.00	0.00	0.00	0.09	0.05	0.00	0.00	0.15	0.04	0.00
Green-winged teal	0.00	0.19	0.00	0.07	0.00	0.00	0.03	0.00	0.15	0.00	0.00	0.00	0.02	0.00
Redhead	0.00	0.00	0.00	1.54	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Canvasback	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Ring-necked duck	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lesser scaup	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.15	0.00	0.02	0.00
Ruddy duck	0.00	0.19	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood duck	0.39	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.07	0.02	0.00
Total dabbling ducks	1.93	9.27	2.61	9.53	0.97	0.77	1.32	1.89	4.97	1.42	2.56	1.61	1.19	0.97
Total diving ducks	0.00	0.58	0.00	1.80	0.00	0.00	0.00	0.00	0.15	0.00	0.20	0.00	0.02	0.00
Total pairs	2.32	10.04	2.61	11.71	0.97	1.06	1.41	1.89	5.12	1.42	2.75	1.68	1.22	0.97

significantly different ($P<0.05$) from all other substrata. Drewien and Springer (1968) reported an average density for the years 1950-55 and 1957-66 of 17.5 pairs per km^2 on their study area near Waubay, South Dakota, in the Coteau des Prairies (substratum IIC_1). This compares to the densities of 16.09 and 11.71 pairs per km^2 found during this study.

Median densities occurred in the Minnesota River-Red River Lowland (stratum I), the central portion of the Coteau des Prairies (substratum IIB), and in the major portion of the James River Lowland (substrata IIIB and IIIC). Wheeler (1972) reported a mean density of 13.5 pairs per km^2 on a study area in Miner County in the James River Lowland (substratum IIIB) during 1971-72. However, the latter study area was selected for high wetland density and does not represent average densities throughout the James River Lowland.

Low densities occurred in the southern Coteau des Prairies (substratum IIC_2), in the Lake Dakota Plain (substratum IIIA), and in the northern portion of the Coteau du Missouri adjacent to the Missouri River (substratum IVB).

Breeding pair densities were low throughout the west-river strata. Bue et al. (1952) reported a density of 2.5 and 3.0 pairs per km^2 in 1950 and 1951, respectively, on a study area in Stanley County in the Pierre Hills (stratum VI) compared to densities of 2.42 and 1.22 pair per km^2 during this study.

The west-river area contained 21 percent of the total breeding pairs in 1973 and 31 percent in 1974. The decrease in total breeding pairs in the west-river area was 39 percent between 1973 and 1974, whereas, the decrease in the east-river area was 64 percent. The west-river area, while having low densities of breeding waterfowl, may be important in maintaining dabbling duck populations because of its large area and comparatively stable populations even during dry years.

Species Distribution

Examination of the percentage of each species occurring in the various strata in 1973 (Table 6) and in 1974 (Table 7) reveals important differences in species distribution between the various strata. In each year more than 95 percent of the total diving ducks occurred in the east-river strata. High diving duck densities were restricted to the northern periphery of the Coteau des Prairies (substrata IIA and IIC_1) containing more than 70 percent of the total diving ducks in each year. Diving duck densities in these two substrata were significantly different ($P<0.05$) from all other substrata. The Coteau des Prairies (stratum II) contained over 90 percent of the redheads, more than 75 percent of the ruddy ducks, and 100 percent of the ring-necked ducks during each year of the study. Combined with the Coteau du Missouri (stratum IV) these two strata contained over 95 percent of the total diving duck pairs. No divers were observed in

Table 6. Percentage of estimated waterfowl breeding pair populations within each stratum in South Dakota, 1973.

Species	Minnesota River-Red River Lowland I	Coteau des Prairies II	James River Lowland III	Coteau du Missouri IV	Total east-river	Northern Plateau Region V	Pierre Hills VI	Southern Plateau Region VII	Total west-river
Blue-winged teal	2.2	23.2	17.2	43.0	85.6	2.7	8.5	3.2	14.4
Mallard	0.5	15.8	16.2	24.5	56.4	11.1	25.1	7.4	43.6
Pintail	0.4	12.4	12.6	59.4	84.8	4.2	8.9	2.1	15.2
Gadwall	1.5	32.3	12.3	43.1	89.1	4.8	5.4	0.7	10.9
Northern shoveler	0.0	16.4	8.6	63.3	88.3	1.6	8.7	1.4	11.7
American wigeon	0.0	11.7	6.6	27.3	45.7	18.5	31.7	4.1	54.3
Green-winged teal	0.0	27.4	21.2	30.7	79.2	0.0	17.9	2.9	20.8
Redhead	0.0	90.6	3.2	6.2	100.0	0.0	0.0	0.0	0.0
Canvasback	0.0	44.1	15.4	40.5	100.0	0.0	0.0	0.0	0.0
Ring-necked duck	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Lesser scaup	0.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0
Ruddy duck	0.0	79.2	11.0	0.0	90.2	9.8	0.0	0.0	9.8
Wood duck	0.0	40.2	59.8	0.0	100.0	0.0	0.0	0.0	0.0
Total dabbling ducks	1.4	20.3	15.5	41.3	78.4	5.1	12.7	3.8	21.6
Total diving ducks	0.0	86.3	3.8	9.9	100.0	0.0	0.0	0.0	0.0
Total pairs	1.3	23.4	15.3	39.4	79.3	5.1	12.0	3.6	20.7

Table 7. Percentage of estimated waterfowl breeding pair populations within each stratum in South Dakota, 1974.

Species	Minnesota River-Red River Lowland I	Coteau des Prairies II	James River Lowland III	Coteau du Missouri IV	Total east-river	Northern Plateau Region V	Pierre Hills VI	Southern Plateau Region VII	Total west-river
Blue-winged teal	1.1	42.5	10.7	25.2	79.5	4.5	10.8	5.1	20.5
Mallard	3.1	21.7	11.6	15.7	52.2	19.1	21.0	7.7	47.8
Pintail	0.0	21.5	11.8	29.0	62.3	11.7	23.0	3.0	37.7
Gadwall	0.5	42.4	8.0	27.5	78.9	11.0	9.1	1.0	21.1
Northern shoveler	0.0	10.7	8.0	63.9	82.6	0.0	17.4	0.0	17.4
American wigeon	0.0	12.9	9.3	6.1	28.3	51.5	20.2	0.0	71.7
Green-winged teal	0.0	14.1	13.2	12.4	39.7	38.9	0.0	21.4	60.3
Redhead	0.0	96.1	0.0	3.9	100.0	0.0	0.0	0.0	0.0
Canvasback	0.0	78.6	0.0	21.4	100.0	0.0	0.0	0.0	0.0
Ring-necked duck	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Lesser scaup	0.0	13.5	0.0	66.1	79.6	0.0	20.4	0.0	20.4
Ruddy duck	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Wood duck	41.9	0.0	58.1	0.0	100.0	0.0	0.0	0.0	0.0
Total dabbling ducks	1.5	33.6	10.7	23.0	67.7	11.9	15.5	4.9	32.3
Total diving ducks	0.0	77.8	0.0	18.2	96.0	0.0	4.0	0.0	4.0
Total pairs	1.6	34.9	10.6	22.2	69.2	11.5	14.7	4.6	30.8

several strata.

Dabbling ducks comprised more than 90 percent of the total population in the east-river strata during each year. Blue-winged teal and mallards were the primary species in this area and made up 64 percent of the population in each year. There was, however, a shift in the relative importance between these two species because of the different rates of decrease. The blue-winged teal made up 48 percent and the mallard comprised 16 percent of the total east-river population in 1973 while in 1974 the blue-winged teal and mallard made up 41 and 23 percent, respectively. This proportional decrease in blue-winged teal and increase in mallards was noted in all strata, both east- and west-river.

Because of low pair density and small total area, the Minnesota River-Red River Lowland (stratum I) was relatively insignificant with regard to the total breeding population.

The Coteau des Prairies (stratum II) was the most important stratum in the state because of its large area, high proportion of the total divers occurring there, and abundant dabbler populations. This stratum had a sizeable proportion of the total breeding pair population for each species within the state, particularly in 1974.

Intermediate proportions of all dabbler species and low diver densities characterize the James River Lowland (stratum III). This stratum, however, contained about 60 percent of the total wood ducks in each year.

Second in importance for breeding populations is the Coteau du Missouri (stratum IV), especially the northeastern portion (substratum IVA). This stratum contained a large portion of the dabbler pairs including blue-winged teal, pintail, gadwall, northern shoveler, and American wigeon. It also contained a sizeable portion of the diver pairs, particularly lesser scaup and canvasback. However, in contrast to the Coteau des Prairies, this area showed marked declines in the percentage of almost all species occurring in that area with the intensification of drought conditions in 1974.

Dabbling ducks represented more than 97 percent of the west-river population during each year. Species composition was essentially the same throughout all three west-river strata. Mallard was the most abundant species and blue-winged teal was second most abundant; these two species comprised more than 70 percent of the west-river population. This large west-river area contained a considerable proportion of the mallard and pintail populations and a majority of the American wigeon population in each year. Also, the proportion of the total population of these species occurring in the west-river area increased in 1974 when water conditions were less favorable statewide.

Census Effort

The census effort expended through this random sampling

method in South Dakota (Table 8) depended on several factors. Initially much time was spent finding the desired sample units and obtaining permission of landowners to enter the land; hence, the large number of man-days during the initial pair count in 1973. Familiarity with the location and physical features of each sample unit reduced effort expended during subsequent counts.

All sample units were visited during the first pair count each year, while, only those with wetland basins were visited on subsequent counts. Fewer man-days were required during the second counts. Census effort in the west-river area was lower because of lower wetland abundance and ability to census many of the wetlands from a vehicle. Location and searching of plots in the Black Hills (stratum VIII) and heavy rains encountered in the Northern Plateau Region (stratum V), which hampered travel, greatly increased the effort expended in the west-river area during the initial count in 1973.

Finally, the number of wetland basins containing water in 1974 was considerably reduced from 1973 so the man-days expended in actual census work was greatly reduced in 1974. If this random sample census was conducted by regional personnel of the conservation agencies or conservation officers, it would allow an almost instantaneous statewide census.

Table 8. Man-days expended in field census work in South Dakota, 1973-74.

Census	1973	1974
First pair count		
East-river	37	28
West-river	38	22
Total	75	50
Second pair count		
East-river	30	22
West-river	20	16
Total	50	38
Complete census		
East-river	67	50
West-river	58	38
Grand total	125	88

CONCLUSIONS

Extreme variability in wetland conditions on the prairie was evident during the two years of this study. Breeding waterfowl populations exhibited a marked decline concurrent with intensification of drought conditions in 1974 which was characteristic of waterfowl populations in the prairie pothole region.

A detailed picture of species composition and regional distribution was obtained for breeding waterfowl in South Dakota. Differential rates of decline which affect total species composition were observed between regional populations of total breeding waterfowl and particular species. This would indicate that particular species and certain regional populations are affected by drought to a greater extent.

Populations in the eastern and western halves of the state differed both in density and species composition. The east-river portion of the state, that area included in the prairie pothole region, had a majority of all species except the American wigeon and contained virtually all of the diving ducks. Blue-winged teal, mallard, pintail, gadwall, northern shoveler, and redhead were the six most abundant species in that order.

The two major physiographic regions having the highest breeding pair densities were the Coteau des Prairies and the Coteau du Missouri. Within these regions there were certain

areas, particularly the northern edge of the Coteau des Prairies and the northeastern Coteau du Missouri, which had the highest densities. These areas also contained essentially all of the diving ducks.

These results emphasize the great diversity in waterfowl production value of various areas within the major region broadly classified as the prairie pothole region. Continued economic pressure for more intensive land use and wetland drainage make it essential to catalog more exactly how valuable particular regions are in terms of overall breeding waterfowl and for specific species.

In the west-river area, where wetlands are almost exclusively stockdams, dugouts, and streams, populations consisted almost entirely of dabbling ducks. Mallard, blue-winged teal, pintail, gadwall, American wigeon, and northern shoveler were the most abundant species in that order. The relative importance of certain species is different than the eastern population where natural wetlands are more prevalent. This would indicate that even though man-made wetlands contribute to the total habitat, they favor certain species and thereby alter the species composition of the total population.

Population declines were less severe in the west-river area as compared to the east-river portion. Though a low waterfowl density area, this region contained a substantially larger percentage of the population in 1974 and may be

important in maintaining certain species when water conditions are less favorable.

Population estimates obtained by stratified random sampling techniques agreed favorably with those obtained by aerial transect methods. The results obtained through this random sampling method, because of the experimental design, can be analyzed by standard statistical procedures thereby giving an estimate of the precision of the method.

The information obtained from these censuses can be used to evaluate the impact of environmental changes on waterfowl populations in the various areas. Additionally, this method potentially can be used to evaluate some wetland non-game species, wetland habitat, and associated upland habitat.

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