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FACTORS INFLUENCING HABITAT USE BY BREEDING WATERFOWL IN SOUTH DAKOTA

BY

MICHAEL R. McENROE

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in Wildlife and
Fisheries Science (Wildlife Option),
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1976

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FACTORS INFLUENCING HABITAT USE BY BREEDING

WATERFOWL IN SOUTH DAKOTA

This thesis is approved as a credible 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.

Thesis Adviser Date

Head, Department of Wildlife and Fisheries Science Date

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MRM

FACTORS INFLUENCING HABITAT USE BY BREEDING WATERFOWL IN SOUTH DAKOTA

Abstract

MICHAEL R. McENROE

Wetland characteristics, adjacent upland conditions, and corresponding waterfowl populations were surveyed on 500 quarter sections in 125 clusters proportionally stratified within eight physiographic strata in South Dakota. Two surveys were conducted, one in May and a second in June, each year during 1973 and 1974.

Habitat variables of each wetland and of each quarter section, respectively, were analyzed for each species of waterfowl through multiple regression analysis. Multiple regression equations had highest coefficients of determination for mallards (*Anas platyrhynchos*), pintails (*Anas acuta*), blue-winged teal (*Anas discors*), and gadwall (*Anas strepera*). Coefficients of determination for these species were greatest in the central Coteau des Prairies, the James River Valley, and the Coteau du Missouri.

Hectares of surface water and hectares of open water per pond were most closely associated with numbers of breeding waterfowl per pond. Shoreline distance, height of emergent vegetation, and hectares of game management cover were usually positive in association with numbers of breeding waterfowl per pond.

Hectares of class IV wetlands per quarter section exhibited the most positive associations with numbers of waterfowl in the Coteau des Prairies and the James River Valley. Hectares of class II and class

III wetlands were positively associated with breeding waterfowl numbers per quarter section in the James River Valley. Shoreline distance and hectares of class III wetlands per quarter section exhibited greater positive associations with numbers of breeding waterfowl in the Coteau du Missouri than in other strata.

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INTRODUCTION

This study was initiated in the spring of 1973 to determine the importance of wetlands and associated upland habitat variables to breeding waterfowl populations in the various physiographic regions of South Dakota. Emphasis was placed on the value of temporary wetlands and the potential use of multiple regression techniques in the analysis of waterfowl habitat. With the loss of wetlands through drainage, the production of more ducks on fewer remaining wetlands (Borden and Hochbaum 1966) and the management of waterfowl by species (Crissey 1965) have become management goals of increasing importance.

The relationship between the abundance of prairie wetlands and waterfowl production is well documented, but opinion is divided as to the importance of temporary wetlands (Sanderson and Bellrose 1969). Evans and Black (1956:43) found that almost every water-containing depression in the prairie pothole region of South Dakota was used at some time during the breeding season and therefore played a part in waterfowl production. However, the degree of use by breeding waterfowl is influenced by wetland quality, waterfowl population density, weather, adjacent land use, and quite possibly several other unidentified factors (Stoudt 1971:26).

Dzubin (1955, 1969a) stated that relationships of pairs to wetlands should be determined for individual species by wetland type and on a regional basis. Wetland quality, size, distribution, associated upland cover, shoreline, and other variables related to waterfowl production should also be considered (Dzubin 1969a). This information will enable improved management of the declining wetland resource and the delineating of those wetlands and wetland characteristics of most value for maintaining the various waterfowl species. Stewart and Kantrud (1973, 1974) have related wetland classes to waterfowl populations in North Dakota. Previous studies in South Dakota have related waterfowl populations to regional wetland conditions (Bue et al. 1952, western South Dakota; Evans and Black 1956, and Drewien and Springer 1969, the Coteau des Prairies; and Wheeler 1972, the James River Valley).

STUDY AREA

South Dakota ranks sixteenth in area among the 50 states and encompasses 199,552 km^2. Production of livestock, small grains, hay, and corn ranks high among leading agricultural states (Westin et al. 1967). Corn and oats are economically most important in the southeast, wheat in the north central regions, and rangeland in the western half of the state. The beef and sheep industry is important, particularly in the portion of the state west of the Missouri River. Size of farm and ranch operations varies from small farms of less than 120 ha east of the Missouri River to ranches in excess of 2,600 ha west of the Missouri River.

Climate

South Dakota has a continental climate with cold winters and warm to hot summers (Spuhler et al. 1971). The growing season varies from 150 days in the southeast to 120 days in the northwest. Precipitation varies from 64 cm in the southeast to 33 cm in the northwest, with the majority occurring during the growing season. Winter snowfall can be extremely variable, ranging from 64 to 114 cm at the lower elevations and over 254 cm in the Black Hills.

Physiography

Two of the major physiographic regions of North America are represented in South Dakota, the Central Lowland in the east and the Great Plains from the Coteau du Missouri westward (Fig. 1) (Flint 1955). The

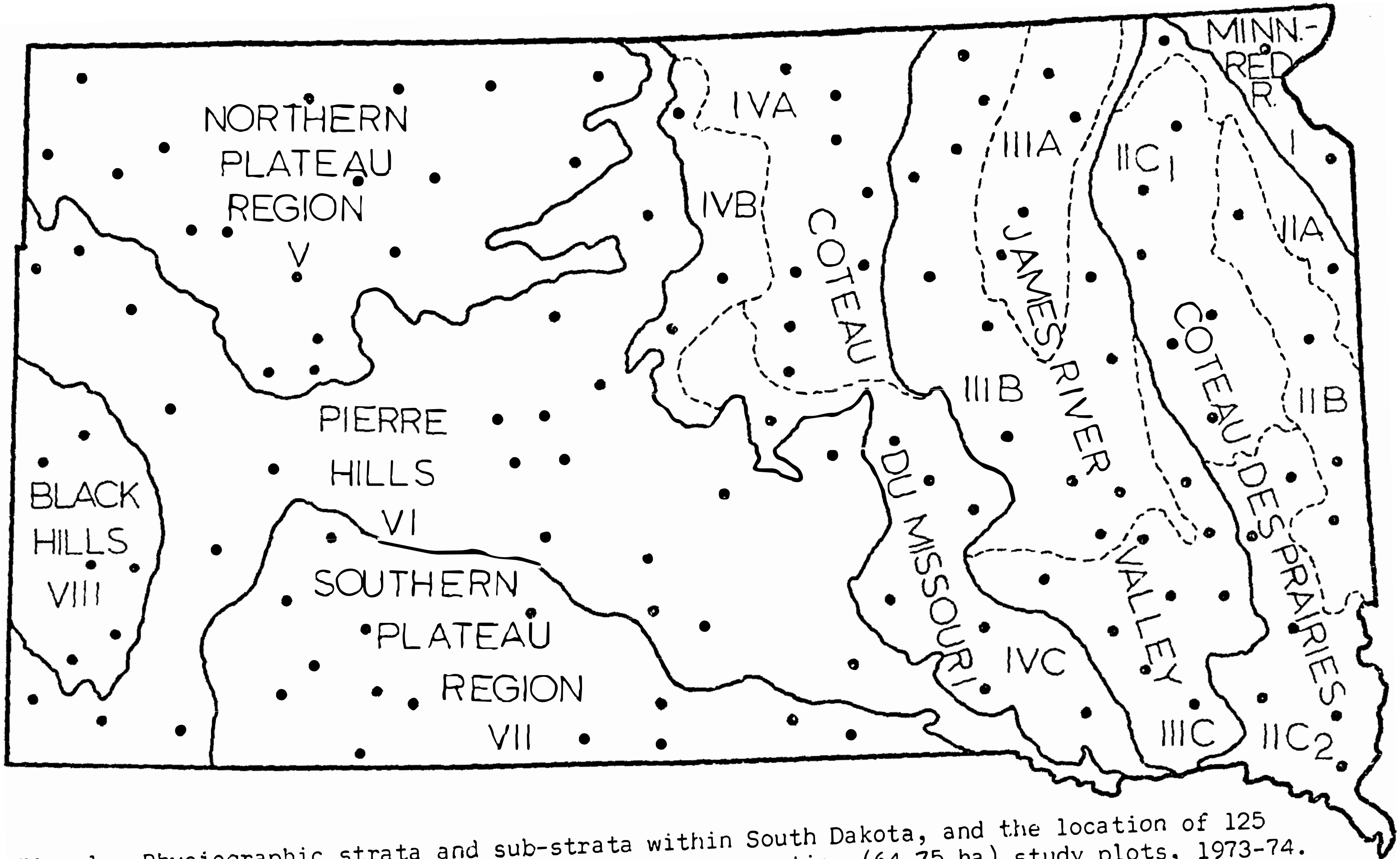

Fig. 1. Physiographic strata and sub-strata within South Dakota, and the location of 125 randomly selected clusters of four-quarter section (64.75 ha) study plots, 1973-74.

glaciated portion of South Dakota lies from the Missouri River trench to the east and is comprised of two river valleys and two coteaux (Flint 1955). The Minnesota-Red River Lowland (stratum I), a broad shallow valley 305 to 335 m above sea level, excavated by glacial action, and covered with glacial drift, lies in the northeast corner (Fig. 1). The Coteau des Prairies (stratum II) rises to the south and west to elevations of 427 to 610 m above sea level. This plateau is irregularly covered glacial drift and moraines, and is dotted with permanent and temporary lakes and marshes. The James River Valley (stratum III) is a broad lowland at 397 to 427 m with a smooth rolling topography. The Coteau du Missouri (stratum IV) at 518 to 671 m, estends to the Missouri River. This coteau is mostly drift covered and has a rolling topography.

The Great Plains have an eastward slope west of the Missouri River and have developed a mature drainage (Visher 1918). The Northern Plateau (stratum V) is a series of benches, plateaus, and buttes that rise to over 900 m. The Southern Plateau (stratum VII) is a series of plateaux and benches that vary in elevation from 610 to 915 m. The Pierre Hills (stratum VI) lying between the two plateaux, is a network of hills and ridges. The Black Hills (stratum VIII) rise more than 2,135 m above sea level and consist of mountainous, rugged terrain; exposed rock; and ponderosa pine (*Pinus ponderosa*) forest in the southwestern part of South Dakota.

Habitat

The majority of the vegetation in South Dakota is in the grassland formation of North America (Weaver and Clements 1929:458-465). The eastern third of the state is represented by the tall grass prairie association (Küchler 1964). The central and western areas of the state are in the mixed grass prairie association (Küchler 1964) although where local precipitation is low or grazing is heavy, the short grass prairie association predominates (Weaver and Clements 1929). The vegetation in the major river valleys is categorized as the northern floodplain forest association (Küchler 1964). The pine forest of the Black Hills is the montane sub-alpine forest association (Weaver and Clements 1929).

The James, Big Sioux, and Minnesota rivers drain the eastern portion of the state to the south (Flint 1955). The western portion of South Dakota is drained by the White, Cheyenne, Bad, Grand, and Moreau rivers, tributaries of the Missouri River. Natural lakes and water-filled depressions are numerous in the glaciated portion of South Dakota. Wetlands in the western portion of the state are primarily stock watering ponds and intermittent streams. Estimates of South Dakota's wetland resource vary from 304,000 ha to 426,000 ha (U. S. Department of the Interior 1954, 1957; Buller 1964; and Sanderson and Bellrose 1969). These estimates include natural wetlands (potholes), lakes, streams, stock dams, dugouts, ditches, and reservoirs.

METHODS

Sampling Scheme

South Dakota was divided into eight major strata based on soil associations, climate, and physiography of the state according to Westin et al. (1967) (Fig. 1). Stratification by strata and sub-strata was used in an attempt to separate a heterogeneous population into relatively homogeneous subpopulations that exhibit less variation than the statewide population. Differences between strata did not contribute to the sampling error of the estimate of the mean and there was a resultant gain in precision over a simple random technique (Snedecor and Cochran 1967:520).

The legal quarter section (64.75 ha) was chosen as the sampling unit. Quarter section boundaries were usually marked by roads, fences, or changes in land use and thus could easily be located.

Two stage cluster sampling (Steel and Torrie 1960:172) allowed a reduction in travel time and cost, and an increase in number of sample plots. Selection of cluster locations within strata or sub-strata was random without replacement except for selections which fell on strata boundaries or in the Missouri River Trench. Clusters were proportionately stratified among the physiographic strata and sub-strata (Table 1). A circle with a 6.44 km radius was drawn around each cluster center and four quarter sections were randomly selected, one from each quadrant, to comprise the cluster. One hundred twenty five clusters (500 quarter sections) were selected as the number that could be counted within the time and labor limitations of the study.

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

Major physiographic region	Strata and sub-strata	Area of strata (km²)	Percent of state area	Area of sample (km²)	Percent of sample effort	Percent of area sampled
Minnesota River-Red River Lowlands	I	3,074	1.54	5.2	1.6	0.17
Coteau des Prairies	II	25,423	12.74	46.6	14.4	0.18
	A	3,033	1.52	5.2	1.6	0.17
	B	6,027	3.02	10.4	3.2	0.17
	C1	8,500	4.26	15.5	4.8	0.18
	C2	7,863	3.94	15.5	4.8	0.20
James River Valley	III	31,210	15.64	64.8	20.0	0.21
	A	5,688	2.85	10.4	3.2	0.18
	B	15,965	8.00	31.1	9.6	0.19
	C	9,557	4.79	23.3	7.2	0.24
Coteau du Missouri	IV	27,995	14.03	49.2	15.2	0.18
	A	11,134	5.58	20.7	6.4	0.19
	B	4,489	2.25	7.8	2.4	0.17
	C	12,372	6.20	20.7	6.4	0.17
Northern Plateau Region	V	30,093	15.08	46.6	14.4	0.15
Pierre Hill	VI	52,821	26.47	59.6	18.4	0.11
Southern Plateau Region	VII	20,813	10.43	36.3	11.2	0.17
Black Hills	VIII	8,122	4.07	15.5	4.8	0.19
Totals		199,552	100.00	323.8	100.0	0.16

Aerial photographs of all study plots were obtained from the South Dakota Agricultural Stabilization and Conservation Service. These photographs were enlarged to 1:3960 (one cm = 39.6 m) to aid in the location of the study plots and the delineation of the wetland basins.

Six clusters (24 study plots) were censused in the Black Hills in 1973 but not in 1974. The Black Hills stratum was eliminated from the sampling effort due to the inaccessibility of some of the plots, the presence of few wetlands other than rapidly flowing streams, and absence of waterfowl on the plots in 1973. Breeding waterfowl (mainly mallards) are present in the Black Hills but in numbers that are negligible when compared to the statewide population (letter dated 7 October 1974 from T. Kuck, South Dakota Department of Game, Fish, and Parks, Aberdeen).

Census Methods

Two two-man teams, one in eastern South Dakota and one in the western portion of the state, conducted the waterfowl study. Censuses progressed from the southern portions of the state to the north to compensate for the chronological advance of spring.

Each quarter section plot was censused by one or two observers depending on the number, size, and emergent cover of the wetlands. Observers were equipped with waders and binoculars. A walk-wade method of flushing ducks was used on wetlands exhibiting emergent vegetation, and all ducks flushed were followed visually to avoid duplication (Hammond 1969). Waterfowl on large open water wetlands were counted with a spotting scope, and the shoreline was walked to flush waterfowl loafing on shore. Ducks flushed from uplands were also recorded. Only the portion on the quarter section was censused if the wetland extended out of the sampling area. Counts were generally made from one-half hour after sunrise until one-half hour before sunset.

All waterfowl observed on each census were recorded, but numbers of breeding pairs were based on counts of indicated pairs. Indicated pairs (Hammond 1969) were comprised of segregated pairs, lone males, and males in groups of five or less. Lone females in excess of lone males and grouped males on a quarter section were also considered to represent indicated pairs (Stewart and Kantrud 1972).

Dzubin (1969b) recommended that a minimum of two censuses be conducted to count early-, mid-, and late-nesting species. Mallard (Anas platyrhynchos), pintail (Anas acuta), canvasback (Aythya valisineria), and wood duck (Aix sponsa), the early-nesting species (Hammond 1969), were censused in May. Blue-winged teal (Anas discors), gadwall (Anas strepera), American wigeon (Anas americana), northern shoveler (Anas clypeata), green-winged teal (Anas crecca), redhead (Aythya americana), lesser scaup (Aythya affinis), ring-necked duck (Aythya collaris), and ruddy duck (Oxyura jamaicensis), the mid- and late-nesting species (Hammond 1969), were censused in June. The early censuses were conducted from 10 May to 1 June 1973 and from 13 May to 27 May 1974. Late censuses were from 3 June to 21 June 1973 and from 10 June to 20 June 1974.

Habitat variables were recorded on each census. Natural basin wetlands were classified according to Stewart and Kantrud (1971) in order of increasing permanence as follows: ephemeral ponds (Class I), temporary ponds (Class II), seasonal ponds (Class III), semi-permanent ponds (Class IV), and permanent ponds and lakes (Class V). Fluviatile wetlands were classified as intermittent streams, permanent streams, and oxbows. Man-made wetlands were categorized as stock dams, dugouts, ditches, and gravel pits. Wetlands with tilled soil bottoms or without aquatic vegetation in pastures were classified as tillage ponds and pasture ponds, respectively. The type of cover (Stewart and Kantrud 1971), percentage of the basin with surface water, percentage of surface water without emergent vegetation (open water), and height of emergent vegetation were estimated for each wetland. Grazing pressure on the adjacent uplands was rated from none to heavy (0 to 3). A depth or fullness rating was estimated based on wetland zonation and surface water. Basin area and shoreline distances were measured from the aerial photographs. The upland cover and land use was mapped once during each summer. The uplands on federal waterfowl production areas and on South Dakota Department of Game, Fish, and Parks' game management areas were classified as game management cover. Areas retired from crop or hay production were classified as idle cover.

Data were coded and key-punched on standard 80-column IBM computer cards and verified. W. L. Tucker, Experiment Station Statistician, prepared the computer programs used in the statistical analysis.

Analysis of Data

The data were analyzed using stepdown multiple regression (Snedecor and Cochran 1967:413) with the numbers of indicated pairs (by species) as the dependent variables. Twenty-six independent wetland and upland variables were analyzed using indicated pairs of waterfowl per pond as the dependent variable (Table 2). Twenty-nine different habitat variables were used in the analysis of pairs per quarter section (Table 3). Multiple regression analysis was stratified on the basis of strata or sub-strata showing relatively homogeneous waterfowl densities and species distributions (Brewster 1975). Data from 1973 and 1974 were analyzed together. It was not feasible to stratify the data by wetland conditions due to variable spring run-off. Regression equations based on a single year's data may have provided more definitive equations for each year, but the regression equations may have had different independent variables or different levels of significance for the same variable from year to year (personal communication with W. L. Tucker, Experiment Station Statistician, South Dakota State University, Brookings, 7 February 1975).

Correlation coefficients between each waterfowl species and each independent habitat variable were determined. Coefficients of determination (r^2), that portion of the variation in waterfowl numbers due to variation among the habitat variables (Steel and Torrie 1960:187), were determined for each species in each strata. Densities of waterfowl pairs were determined for the various wetland classes. Wetland numbers and areas were determined for each strata.

Table 2. The 26 independent habitat variables used in the multiple regression analysis of pairs of waterfowl per pond in South Dakota, 1973-74.

Variable number	Variable description	Range of variable
1	Size of wetland basin in hectares	0.00 to 64.75
2	Hectares of surface water per pond	0.00 to 64.75
3	Hectares of open water per pond	0.00 to 64.75
4	Percentage of basin with surface water	0 to 100
5	Percentage of surface water without emergent vegetation	0 to 100
6	Depth or fullness rating (full to dry)	1 to 7
7	Tillage or pasture pond class	1 to 4
8	Natural wetland basin class[a]	1 to 5
9	Man-made or fluviatile wetland class	1 to 9
10	Type of cover[a]	1 to 4
11	Shoreline distance in meters	0 to 30,499
12	Height of emergent vegetation in centimeters	0 to 2,537
13	Percentage of shoreline grazed	0 to 100
14	Grazing intensity (none to high)	0 to 3
15	Hectares of small grain per plot	0.00 to 64.75
16	Hectares of corn per plot	0.00 to 64.75
17	Hectares of flax per plot	0.00 to 64.75
18	Hectares of alfalfa per plot	0.00 to 64.75
19	Hectares of hayland per plot	0.00 to 64.75
20	Hectares of pasture per plot	0.00 to 64.75
21	Hectares of idle cover per plot	0.00 to 64.75
22	Hectares of game management cover per plot	0.00 to 64.75
23	Hectares of roadside and ditches per plot	0.00 to 64.75
24	Hectares of farmsteads per plot	0.00 to 64.75
25	Hectares of treeland per plot	0.00 to 64.75
26	Hectares of fallow ground per plot	0.00 to 64.75

[a]follows classification system of Stewart and Kantrud (1971).

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Table 3. The 29 independent habitat variables used in the multiple regression analysis of pairs of waterfowl per quarter section study plot in South Dakota, 1973-74.

Variable number	Variable description	Range of variable
1	Number of wetland basins per plot	0 to 99
2	Number of basins with surface water	0 to 99
3	Number of basins with open water	0 to 99
4	Total basin area per plot in hectares	0.00 to 64.75
5	Surface water area per plot in hectares	0.00 to 64.75
6	Open water area per plot in hectares	0.00 to 64.75
7	Hectares of small grain per plot	0.00 to 64.75
8	Hectares of corn per plot	0.00 to 64.75
9	Hectares of flax per plot	0.00 to 64.75
10	Hectares of alfalfa per plot	0.00 to 64.75
11	Hectares of hayland per plot	0.00 to 64.75
12	Hectares of pasture per plot	0.00 to 64.75
13	Hectares of idle cover per plot	0.00 to 64.75
14	Hectares of game management cover per plot	0.00 to 64.75
15	Hectares of roadside and ditches per plot	0.00 to 64.75
16	Hectares of farmsteads per plot	0.00 to 64.75
17	Hectares of treeland per plot	0.00 to 64.75
18	Hectares of fallow ground per plot	0.00 to 64.75
19	Shoreline distance per plot in meters	0 to 30,499
20	Hectares of class I wetland[a] per plot	0.00 to 64.75
21	Hectares of class II wetland[a] per plot	0.00 to 64.75
22	Hectares of class III wetland[a] per plot	0.00 to 64.75
23	Hectares of class IV wetland[a] per plot	0.00 to 64.75
24	Number of class I wetlands[a] per plot	0 to 99
25	Number of class II wetlands[a] per plot	0 to 99
26	Number of class III wetlands[a] per plot	0 to 99
27	Number of class IV wetlands[a] per plot	0 to 99
28	Hectares of class I and II wetlands[a] combined, per plot	0.00 to 64.75
29	Number of class I and II wetlands[a] combined, per plot	0 to 99

[a]Follows classification system of Stewart and Kantrud (1971).

RESULTS

Wetland Conditions and Waterfowl Populations

Indicated pairs of breeding ducks and area of surface water decreased from 1973 to 1974. Early-nesting species decreased 53 percent from 640 pairs in 1973 to 299 pairs in 1974. Mid- and late-nesting species decreased 63 percent from 1,215 pairs to 445 pairs. Area of wetland surface water on study plots decreased from 559.6 ha in May 1973 to 426.9 ha in May 1974 (Appendix Tables A and C). Area of surface water was 524.8 ha in June 1973 and decreased to 370.4 ha in June 1974 (Appendix Tables B and D). Decreases in waterfowl numbers between years are similar to those from data obtained from aerial transects and reported by the U. S. Fish and Wildlife Service (Brewster 1975). Decreases in wetland area also corresponded to those reported by the U. S. Fish and Wildlife Service (1974). Numbers of wetlands increased from 1,183 basins in 1973 to 1,338 basins in 1974 (Appendix Tables E and F). This increase was largely due to an increase in tillage ponds that followed rain showers during the 1974 May census.

Results of Multiple Regression: Pairs of Waterfowl Per Pond

The multiple regression analysis of pairs of waterfowl by wetland and upland habitat variables on a pond basis was more informative when performed on the most abundant species or with species that were more selective in their habitats. Strata and sub-strata were grouped by waterfowl density and species distribution (Brewster 1975) into units for the regression analysis. Sub-strata IIA and IIC1 (Coteau des Prairies, high pair densities); sub-stratum IIC2 (Coteau des Prairies, low pair density); IIIB and IIIC (James River Valley, medium pair densities); IVA and IVC (Coteau du Missouri; high and medium pair densities, respectively); and strata V, VI, VII (western South Dakota, low pair densities) were the five units. Only significant ($p < 0.05$) habitat variables are discussed, and the variables are listed in decreasing order of contribution to the coefficient of determination.

Regression equations for mallard pairs per pond (Table 4) had from four to eight significant variables and r^2 values of 0.572 to 0.184. Hectares of surface water, hectares of game management cover, shoreline distance, and hectares of open water exhibited positive relationships with mallard pairs per pond in the high density sub-strata of the Coteau des Prairies. The variables explained 57.2 percent ($r^2 = 0.572$) of the variation in mallard numbers. Relationships of mallards to hectares of surface water, height of emergent vegetation, and the percentage of the shoreline grazed were positive and relationships of hectares of treeland and pasture surrounding a wetland were negative in relation to mallards in sub-strata IIIB and IIIC (James River Valley, medium pair densities). Hectares of surface water, height of emergent vegetation, hectares of open water, and shoreline distance were positively associated with mallards in sub-strata IVA and IVC (Coteau du Missouri, high and medium pair densities, respectively). In sub-stratum IIC2 (Coteau des Prairies, low pair density) mallards were positively associated with height of emergent vegetation, shoreline distance, and hectares of small grain, and negatively associated with hectares of roadsides and hectares of alfalfa.

Table 4. Multiple regression equations for pairs of mallards per pond and wetland and upland habitat variables by physiographic strata in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equations).

Sub-strata IIA and IIC1 (0.572)	Y = + 0.0458 + 0.0348 (hectares of surface water) + 0.2125 (hectares of game management cover) + 0.0006 (shoreline distance) + 0.0832 (hectares of open water)
Sub-stratum IIC2 (0.226)	Y = + 0.3246 + 0.0021 (vegetation height) + 0.0001 (shoreline distance) - 0.4151 (hectares of roadsides) + 0.0049 (hectares of small grain) - 0.0098 (hectares of alfalfa)
Sub-strata IIIB and IIIC (0.253)	Y = + 0.0171 + 0.2554 (hectares of surface water) + 0.0064 (vegetation height) - 0.0321 (hectares of treeland) + 0.0015 (percent of shoreline grazed) - 0.0022 (hectares of pasture)
Sub-strata IVA and IVC (0.221)	Y = + 0.0194 + 0.0765 (hectares of surface water) + 0.0120 (vegetation height) + 0.3649 (hectares of open water) + 0.0003 (shoreline distance)
Strata V, VI, and VII (0.184)	Y = - 0.0159 + 0.0035 (percent of open water) + 0.3446 (hectares of open water) + 0.0058 (vegetation height) - 0.0900 (natural basin wetland class) + 0.0074 (hectares of small grain) + 0.0001 (shoreline distance) + 0.0098 (hectares of hayland) - 0.0775 (basin size in hectares)

In western South Dakota the percentage of open water in a basin, hectares of open water, height of emergent vegetation, hectares of small grain, shoreline distance, and hectares of hayland surrounding a pond were positively associated with mallard pairs per pond while natural wetlands and size of basin were negatively related. Coefficients of determination for these sub-strata ranged from 0.253 to 0.184.

Multiple regression equations for pintail pairs per pond had from two to five significant variables and r^2 values from 0.613 to 0.053 (Table 5). The regression equation for sub-strata IIA and IIC1 had a coefficient of determination of 0.613. Hectares of game management cover, shoreline distance, and hectares of surface water per pond were positively associated with pintails. Height of emergent vegetation and hectares of open water were negatively associated with pintail pairs per pond in these sub-strata. Hectares of surface water, hectares of open water, height of emergent vegetation, and shoreline distance were positively associated with pintails and accounted for 24.7 percent of the variation in sub-strata IVA and IVC. The coefficients of determination ranged from 0.076 to 0.053 in the other sub-strata.

Three to nine habitat variables for blue-winged teal were significant and coefficients of determination ranged from 0.785 to 0.363 (Table 6). In sub-strata IIA and IIC1, 78.5 percent of the variation in blue-winged teal per pond was accounted for by the regression equation. Positive relationships occurred with hectares of surface water, hectares of game management cover, shoreline distance, the

Table 5. Multiple regression equations for pairs of pintails per pond and wetland and upland habitat variables by physiographic strata in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equations).

Sub-strata IIA and IIC1 (0.613)	Y = + 0.0210 + 0.1359 (hectares of game management cover) + 0.0003 (shoreline distance) - 0.0037 (vegetation height) + 0.0368 (hectares of surface water) - 0.0425 (hectares of open water)
Sub-stratum IIC2 (0.076)	Y = - 0.0262 + 0.0009 (percent of surface water) + 0.0261 (natural basin wetland class)
Sub-strata IIIB and IIIC (0.053)	Y = + 0.0229 + 0.0679 (hectares of surface water) + 0.0016 (vegetation height)
Sub-strata IVA and IVC (0.247)	Y = + 0.0227 + 0.2389 (hectares of surface water) + 0.6832 (hectares of open water) + 0.0074 (vegetation height) + 0.0003 (shoreline distance)
Strata V, VI, and VII (0.075)	Y = - 0.0057 + 0.0946 (hectares of open water) + 0.0008 (percent of open water) + 0.0025 (hectares of fallow)

Table 6. Multiple regression equations for pairs of blue-winged teal per pond and wetland and upland habitat variables by physiographic strata in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equation).

Sub-strata IIA and IIC1 (0.785)	Y = - 1.4200 + 0.3558 (hectares of surface water) + 0.4897 (hectares of game management cover) + 0.0029 (shoreline distance) + 0.0188 (percent of open water) - 0.1905 (hectares of open water) + 0.1768 (depth rating) + 0.0926 (hectares of idle cover) + 0.0148 (percent of shoreline grazed) - 0.5798 (grazing intensity)
Sub-stratum IIC2 (0.363)	Y = - 0.3948 + 0.0002 (shoreline distance) - 0.0049 (hectares of corn) + 3.0822 (hectares of open water) + 0.0898 (natural wetland basin class) + 0.1887 (hectares of farmsteads) + 0.0051 (vegetation height) + 0.0033 (percent of shoreline grazed)
Sub-strata IIIB and IIIC (0.523)	Y = - 0.1514 + 1.5520 (hectares of surface water) - 1.5599 (hectares of open water) + 0.0042 (percent of surface water) + 0.2362 (hectares of roadsides) - 0.0327 (man-made and fluviatile wetland class)
Sub-strata IVA and IVC (0.510)	Y = - 0.0173 + 1.9777 (hectares of surface water) + 1.2849 (hectares of open water) + 0.0134 (vegetation height)
Strata V, VI, and VII (0.400)	Y = + 0.0114 + 0.6320 (hectares of surface water) + 0.0298 (vegetation height) - 0.1991 (hectares of open water) - 0.0645 (natural basin wetland class)

percentage of open water, hectares of idle cover, and the percentage of the shoreline grazed. Negative relationships occurred with hectares of open water, depth, and high intensity of grazing. Hectares of surface water, percentage of surface water in a basin, and hectares of roadside were positively associated with blue-winged teal, while hectares of open water and man-made and fluviatile wetlands were negatively associated in sub-strata IIIB and IIIC. The coefficient of determination in these sub-strata was 0.523. In sub-strata IVA and IVC, hectares of surface water, hectares of open water, and height of emergent vegetation were positively related to blue-winged teal and had a coefficient of determination of 0.510. Shoreline distance, hectares of open water, natural wetland basins, hectares of farmsteads, height of emergent vegetation, and percentage of the shoreline grazed were positively related to blue-winged teal in sub-stratum IIC2, while hectares of corn was negatively related. These seven variables had a coefficient of determination of 0.363. Blue-winged teal were positively associated with hectares of surface water and height of emergent vegetation and negatively associated with hectares of open water and natural wetland basins in western South Dakota. The coefficient of determination was 0.400.

Multiple regression equations for gadwalls had from three to nine significant variables and coefficients of determination from 0.543 to 0.093 (Table 7). Pairs of gadwalls per pond in sub-strata IIA and IIC1 were positively related with shoreline distance, hectares of game management cover, hectares of open water, wetland basin size, hectares

Table 7. Multiple regression equations for pairs of gadwalls per pond and wetland and upland habitat variables by physiographic strata in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equations).

Sub-strata IIA and IIC1 (0.543)	Y = - 0.1627 - 0.1121 (hectares of surface water) + 0.0016 (shoreline distance) + 0.2673 (hectares of game management cover) + 0.1569 (hectares of open water) + 0.0355 (basin size in hectares) + 0.0504 (hectares of idle cover) - 0.0061 (percent of surface water) + 0.0029 (percent of shoreline grazed) + 0.0049 (percent of open water)
Sub-strata IIIB and IIIC (0.098)	Y = + 0.0038 + 0.0647 (hectares of surface water) + 0.0010 (percent of surface water) - 0.0121 (hectares of treeland)
Sub-strata IVA and IVC (0.465)	Y = + 0.0013 + 0.4680 (hectares of surface water) + 0.8781 (hectares of open water) - 0.0003 (shoreline distance) + 0.0016 (percent of open water)
Strata V, VI, and VII (0.093)	Y = - 0.0006 + 0.1413 (hectares of open water) + 0.0003 (percent of open water) - 0.0538 (hectares of surface water) + 0.0006 (vegetation height) - 0.0014 (hectares of fallow) + 0.0014 (hectares of small grain)

of idle cover, percentage of the shoreline grazed, and the percent of open water. Hectares of surface water and the percentage of basin with surface water were negatively associated with gadwalls. The coefficient of determination for these variables was 0.0543. The coefficient of determination was 0.465 in sub-strata IVA and IVC. Gadwalls in this region exhibited positive relationships with hectares of surface water, hectares of open water, and percentage of open water, and a negative relationship with shoreline distance. The coefficients of determination for gadwalls in sub-strata IIIB and IIIC and strata V, VI, and VII were 0.098 and 0.093, respectively. No gadwalls were observed on study plots in sub-stratum IIC2.

Northern shovelers were positively related to shoreline distance and hectares of surface water and negatively related to hectares of game management cover and hectares of open water in sub-strata IIA and IIC1 (Table 8). The coefficient of determination for northern shovelers in these sub-strata was 0.392. Hectares of surface water, hectares of open water, and height of emergent vegetation were positively related to northern shovelers per pond in sub-strata IVA and IVC. The coefficient of determination for this regression equation was only 0.200, although 50 pairs of the 82 pairs of northern shovelers observed were in these sub-strata. Multiple regression equations for pairs of northern shovelers per pond in the other strata were based on small numbers of northern shovelers and the coefficients of determination were low.

Sixty of the 74 observed pairs of redheads were in sub-strata IIA and IIC1. The coefficient of determination for the regression equation

Table 8. Multiple regression equations for pairs of northern shovelers per pond and per study plot, and wetland and upland habitat variables for sub-strata IIA and IIC1, and IVA and IVC, in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equations).

Pond basis, Sub-strata (0.392)	Y = - 0.0183 + 0.0002 (shoreline distance) + 0.0252 (hectares of surface water) - 0.0197 (hectares of game management cover) - 0.0172 (hectares of open water)
Pond basis, Sub-strata IVA and IVC (0.200)	Y = + 0.0003 + 0.1282 (hectares of surface water) + 0.2957 (hectares of open water) + 0.0024 (vegetation height)
Plot basis, Sub-strata IIA and IIC1 (0.488)	Y = - 0.0588 + 0.0001 (shoreline distance) + 0.0368 (hectares of class IV wetlands) - 0.0355 (hectares of game management cover)
Plot basis, Sub-strata IVA and IVC (0.373)	Y = - 0.0373 + 0.2705 (hectares of surface water) + 0.1479 (number of basins with open water per plot)

for this region was 0.352 (Table 9). Redheads showed positive relationships with hectares of open water, shoreline distance, hectares of game management cover, and the percentage of shoreline grazed. Percentage of a basin with surface water and high intensity of grazing were negatively related to redhead pairs per pond. Regression equations for redheads in other sub-strata provided coefficients of determination which were based on observations of only a few redhead pairs.

Ruddy ducks, although one of the less abundant species statewide, were numerous in sub-strata IIA and IIC1 (Table 10). In these sub-strata, ruddy ducks were positively associated with hectares of surface water, hectares of game management cover, shoreline distance, hectares of open water, and decreased depth rating. These five variables accounted for 49.9 percent of the variation in pairs of ruddy ducks per pond. Regression equations of ruddy ducks in the other strata were based on observations of only a few ruddy ducks.

There were no discernable habitat relationships for canvasbacks, wood ducks, American wigeon, green-winged teal, lesser scaup, and ring-necked ducks due to the low numbers of these species observed.

Results of Multiple Regression: Pairs of Waterfowl Per Plot

The multiple regression analysis of pairs of waterfowl with habitat variables on a study plot basis resulted in regression equations with higher coefficients of determination (r^2) than the regression equations by pond. The regression equations (by species) were determined on a stratified basis, using the same groupings as

Table 9. Multiple regression equations for pairs of redheads per pond and per study plot, and wetland and upland habitat variables for sub-strata IIA and IIC1 in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equations).

Pond basis, Sub-strata IIA and IIC1 (0.352)	Y = - 0.1195 + 0.2122 (hectares of open water) + 0.0018 (shoreline distance) + 0.0627 (hectares of game management cover) - 0.0056 (percent of surface water) + 0.0120 (percent of shoreline grazed) - 0.4900 (grazing intensity)
Plot basis, Sub-strata IIA and IIC1 (0.663)	Y = + 0.2378 + 0.8697 (hectares of open water) + 0.7323 (hectares of class IV wetlands) - 0.8099 (hectares of surface water) + 0.0175 (hectares of pasture) - 2.2834 (number of basins with open water per plot) + 1.7016 (number of basins with surface water per plot) - 2.5643 (hectares of class III wetlands) - 23.7484 (hectares of class I and II wetlands)

Table 10. Multiple regression equations for pairs of ruddy ducks per pond and per study plot, and wetland and upland habitat variables in sub-strata IIA and IIC1 in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equations).

Pond basis, Sub-strata IIA and IIC1 (0.499)	Y = - 0.2383 + 0.0005 (hectares of surface water) + 0.1435 (hectares of game management cover) + 0.0006 (shoreline distance) + 0.0476 (hectares of open water) + 0.0314 (depth rating)
Plot basis, Sub-strata IIA and IIC1 (0.540)	Y = - 0.0455 + 0.2900 (hectares of class IV wetlands) + 0.2236 (hectares of open water) + 0.2275 (hectares of surface water)

the regression analysis by pond. Again, only significant variables are discussed and variables are listed in decreasing order of contribution to the coefficient of determination.

Coefficients of determination for mallards (Table 11) ranged from 0.717 to 0.201. Mallards in sub-strata IIA and IIC1 were positively associated with hectares of class IV wetlands, hectares of class II wetlands, hectares of game management cover, hectares of open water, and number of class II wetlands on the plot. Hectares of surface water was negatively associated with mallards per pond. These six variables accounted for 71.7 percent of the variation in mallard pairs per plot in these sub-strata. The number and hectares of class IV wetlands and shoreline distance per plot were positively related to mallard densities in sub-strata IIIB and IIIC. The coefficient of determination was 0.446 for these two variables. In sub-strata IVA and IVC total shoreline distance and the number of class III wetlands were positively related to mallard numbers. The coefficient of determination was 0.206. In sub-stratum IIC2, seven significant variables had a coefficient of determination of 0.452. Positive relationships were demonstrated with the number of basins with open water per plot, hectares of small grain, corn, and hectares of class IV wetlands while negative relationships were demonstrated with hectares of roadsides, number of class II wetlands, and hectares of open water. In strata V, VI, and VII, mallards were positively associated with the number of basins per plot, hectares of open water, and hectares of surface water,

Table 11. Multiple regression equations for pairs of mallards per study plot and wetland and upland habitat variables by physiographic strata in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equations).

Sub-strata IIA and IIC1 (0.717)	Y = + 0.2514 + 0.3021 (hectares of class IV wetlands) + 4.5070 (hectares of class II wetlands) + 0.1174 (hectares of game management cover) + 0.3113 (hectares of open water) - 0.2836 (hectares of surface water) + 0.2247 (number of class II wetlands per plot)
Sub-stratum IIC2 (0.452)	Y = + 0.4258 + 0.2759 (number of basins with open water per plot) + 0.0150 (hectares of small grain) + 0.0074 (hectares of corn) - 0.9886 (hectares of roadsides) - 0.1895 (number of class II wetlands per plot) + 0.7919 (hectares of class IV wetlands) - 1.5021 (hectares of open water)
Sub-strata IIIB and IIIC (0.446)	Y = + 0.1651 + 0.7779 (number of class IV wetlands per plot) + 0.2648 (hectares of class IV wetlands) + 0.0001 (total shoreline distance)
Sub-strata IVA and IVC (0.206)	Y = + 0.3088 + 0.0006 (total shoreline distance) + 0.3909 (number of class III wetlands per plot)
Strata V, VI, and VII (0.201)	Y = + 0.5636 + 0.2675 (number of basins with open water per plot) + 0.1795 (number of basins with surface water per plot) - 0.0069 (hectares of pasture) - 0.1220 (total basin area in hectares)

and negatively associated with hectares of pasture and hectares of basins. The coefficient of determination was 0.201 for these variables in western South Dakota.

The regression equations for pintail pairs per plot had coefficients of determination from 0.504 to 0.099 (Table 12). Hectares of game management cover and total shoreline distance were positively related to pintails in sub-strata IIA and IIC1. The coefficient of determination was 0.504. Hectares of class IV and hectares of class III wetlands were positively associated with pintails in sub-strata IIIB and IIIC and the coefficient of determination was 0.199. In sub-strata IVA and IVC pintails were positively associated with hectares of open water, hectares of class IV wetlands, numbers of class III wetlands, and shoreline distance and negatively associated with the number of basins with open water per plot. The coefficient of determination was 0.325 for these five variables. Pintails exhibited a positive relationship with the number of basins with open water and the regression equation had a coefficient of determination of 0.250 in sub-stratum IIC2. Hectares of open water, number of basins per plot with surface water, and hectares of fallow were positively associated with pintails in strata V, VI, and VII and had a coefficient of determination of 0.099.

The coefficients of determination for the regression equations for blue-winged teal ranged from 0.844 to 0.478 for the various strata (Table 13). Hectares of class IV wetlands, hectares of class III wetlands, the number of basins with open water per plot, and hectares of

Table 12. Multiple regression equations for pairs of pintails per study plot and wetland and upland habitat variables by physiographic strata in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equations).

Sub-strata IIA and IIC1 (0.504)	Y = + 0.1089 + 0.1633 (hectares of game management cover) + 0.0002 (total shoreline distance)
Sub-stratum IIC2 (0.250)	Y = - 0.1426 + 0.1236 (number of basins with open water per plot)
Sub-strata IIIB and IIIC (0.199)	Y = + 0.1344 + 0.1868 (hectares of class IV wetlands) + 0.2636 (hectares of class III wetlands)
Sub-strata IVA and IVC (0.325)	Y = + 0.4034 + 0.3862 (hectares of open water) + 0.9542 (hectares of class IV wetlands) + 0.5837 (number of class III wetlands per plot) - 0.4877 (number of basins with open water per plot) + 0.0009 (total shoreline distance)
Strata V, VI, and VII (0.099)	Y = + 0.0170 + 0.0800 (hectares of open water) + 0.0489 (number of basins with surface water per plot) + 0.0051 (hectares of fallow)

Table 13. Multiple regression equations for pairs of blue-winged teal per study plot and wetland and upland habitat variables by physiographic strata in South Dakota, 1973-74. (Numbers in parentheses are the coefficients of determination for the multiple regression equations).

Sub-strata	Y = + 0.1832 + 0.5557 (hectares of class IV wetlands)
IIA and IIC1	+ 3.8626 (hectares of class III wetlands)
(0.844)	+ 1.1432 (number of basins with open water per plot)
	+ 0.2710 (hectares of game management cover)
	- 724.4647 (hectares of class I wetlands) - 0.1136 (hectares of hayland)
Sub-stratum	Y = + 0.4573 + 2.3622 (hectares of class IV wetlands)
IIC2	+ 0.5539 (total basin area in hectares) - 0.0074 (hectares of corn)
(0.791)	- 0.5875 (hectares of surface water) - 0.2624 (number of basins per plot)
	+ 0.0331 (hectares of pasture)
Sub-strata	Y = - 0.5753 + 1.7242 (hectares of class IV wetlands)
IIIB and IIIC	+ 1.5124 (hectares of class III wetlands) + 3.6266 (hectares of class II wetlands)
(0.684)	+ 0.0854 (total basin area in hectares) + 0.8055 (hectares of roadsides)
Sub-strata	Y = - 0.5686 + 1.8364 (hectares of surface water)
IVA and IVC	+ 1.0966 (number of basins with open water per plot)
(0.582)	+ 1.3708 (hectares of class IV wetlands)
Strata V,	Y = - 0.0064 + 0.8104 (hectares of surface water)
VI, and VII	+ 0.1323 (number of basins with open water per plot)
(0.478)	- 0.4418 (hectares of open water)

game management cover were positively associated with blue-winged teal pairs per plot in sub-strata IIA and IIC1. Hectares of class I wetlands and hayland were negatively associated with blue-winged teal. The coefficient of determination for these variables was 0.844. Blue-winged teal in sub-strata IIIB and IIIC were positively related to hectares of class IV wetlands, hectares of class III wetlands, hectares of class II wetlands, total basin area, and hectares of roadsides. These variables had a coefficient of determination of 0.684. Blue-winged teal in sub-strata IVA and IVC exhibited positive associations with hectares of surface water, number of basins with open water per plot, and hectares of class IV wetlands. The coefficient of determination was 0.582. Hectares of class IV wetlands, total basin size, and hectares of pasture were positively related to blue-winged teal in sub-strata IIC2 while negative relationships existed with hectares of corn, hectares of surface water, and number of basins per plot. These six variables had a coefficient of determination of 0.791. In strata V, VI, and VII, blue-winged teal densities were positively related to hectares of surface water and the number of basins with open water per plot, and negatively related to hectares of open water. The coefficient of determination for blue-winged teal in western South Dakota was 0.478.

Regression equations for gadwall pairs per pond ranged from 0.667 to 0.121 (Table 14). Hectares of class IV wetlands, hectares of open water, hectares of class III wetlands, and the number of class IV wetlands per plot were positively associated with gadwalls while hectares

Table 14. Multiple regression equations for pairs of gadwalls per study plot and wetland and upland habitat variables by physiographic strata in South Dakota, 1973-74. (Numbers in parentheses at the left are the coefficients of determination for the multiple regression equations).

Sub-strata IIA and IIC1 (0.667)	Y = - 0.0691 + 0.4959 (hectares of class IV wetlands)
	+ 0.4922 (hectares of open water) - 0.4593 (hectares of surface water)
	+ 2.0296 (hectares of class III wetlands)
	+ 0.5289 (number of class IV wetlands per plot)
	- 0.3636 (number of class III wetlands per plot)
Sub-strata IIIB and IIIC (0.602)	Y = + 0.0301 + 1.0259 (hectares of class III wetlands)
	- 0.1267 (number of class III wetlands per plot)
	+ 0.0107 (total basin area in hectares)
	+ 0.0746 (number of class II wetlands per plot)
	+ 0.1874 (number of basins with open water per plot)
	- 0.1559 (number of basins with surface water per plot)
	+ 0.7892 (hectares of class II wetlands) + 0.3872 (hectares of class IV wetlands)
	- 0.0182 (hectares of treeland) + 0.1610 (hectares of open water)
	- 0.3679 (hectares of surface water)
Sub-strata IVA and IVC (0.492)	Y = + 0.3299 + 0.4840 (hectares of surface water) + 1.0279 (hectares of open water)
	- 0.0006 (total shoreline distance)
	- 0.1575 (number of class I wetlands per plot)
Strata V, VI, and VII (0.121)	Y = - 0.0730 + 0.1534 (hectares of open water)
	+ 0.4620 (hectares of class II wetlands) - 0.0513 (hectares of surface water)
	+ 0.0445 (number of class IV wetlands per plot)
	+ 0.0046 (hectares of small grain) + 0.0017 (hectares of pasture)

of surface water and number of class III wetlands were negatively associated in sub-strata IIA and IIC1. The coefficient of determination for these variables was 0.667. In sub-strata IIIB and IIIC, gadwalls were positively related to hectares of class III wetlands, total basin size, number of class II wetlands, number of basins with open water, hectares of class IV wetlands, and hectares of open water. Negative relationships were demonstrated for number of class III wetlands, numbers of basins with surface water per plot, hectares of treeland, and hectares of surface water. The coefficient of determination was 0.602 in sub-strata IIIB and IIIC. Hectares of surface water and hectares of open water per plot were positively related to gadwalls in sub-strata IVA and IVC and shoreline distance and number of class I wetlands were negatively related. The coefficient of determination for these variables was 0.492. In western South Dakota, gadwalls demonstrated positive associations with hectares of open water, hectares of class II wetlands, numbers of class IV wetlands, hectares of small grain, and hectares of pasture. Gadwalls were negatively associated with hectares of surface water in western South Dakota. These six variables had a coefficient of determination of 0.121.

Northern shovelers were positively related to shoreline distance and hectares of class IV wetlands and negatively related to hectares of game management cover in sub-strata IIA and IIC1 (Table 8). The coefficient of determination was 0.488. Hectares of surface water and the number of basins with open water per plot were positively related to northern shovelers in sub-strata IVA and IVC. The two variables had a coefficient of determination of 0.373.

The regression equation for redheads per plot in IIA and IIC1 had a coefficient of determination of 0.663 percent (Table 9). Positive relationships were exhibited between density of redheads and hectares of open water, hectares of class IV wetlands, hectares of pasture, and the number of basins with surface water per plot. Negative relationships were demonstrated for hectares of surface water, number of basins with open water per plot, hectares of class III wetlands, and combined hectares of class I and II wetlands per plot.

Ruddy ducks in IIA and IIC1 were positively associated with hectares of class IV wetlands and hectares of open water and negatively associated with hectares of surface water (Table 9). The coefficient of determination for these variables was 0.540.

Use of Natural Wetlands by Breeding Waterfowl

Use by breeding pairs of class I, II, III, and IV wetlands was determined for mallard, pintail, blue-winged teal, and gadwall for each wetland class. Distribution of waterfowl pairs, pairs per wetland, and densities of pairs were determined for groups of homogeneous sub-strata in eastern South Dakota. Sub-strata analyzed were IIA and IIC1, IIIB and IIIC, and IVA and IVC. Strata in western South Dakota having few natural wetlands and sub-strata in eastern South Dakota having low waterfowl densities were not analyzed.

Class I wetlands were generally small in size and were usually dry by the May censuses. During four censuses in 1973 and 1974, 94 class I wetland basins contained 0.12 ha to 4.17 ha of surface water. Waterfowl use of class I wetlands was low in 1973 and 1974 with a total of

10 breeding pairs of the four major species counted (Tables 15, 16, 17, and 18).

Class V wetlands received little use by breeding pairs, even though they provided large and relatively constant areas of surface water. Only 49 pairs of the four major species of waterfowl were observed on seven class V wetlands censused in 1973 and 1974.

More waterfowl pairs were found on class IV wetlands than on other natural basin wetlands in eastern South Dakota. Pairs of waterfowl per wetland were generally highest for class IV wetlands. This high waterfowl use of class IV wetlands was also demonstrated in the multiple regression equations of waterfowl pairs per plot.

Although the waterfowl use per class IV wetland was high, pairs of waterfowl per hectare of class IV wetland were low (Tables 15, 16, 17, and 18).

Density of waterfowl per hectare of class IV wetlands was the lowest in sub-strata IIA and IIC1. This might have been due to the larger average size of class IV wetlands in these sub-strata (3.36 ha during the four censuses). Class IV wetlands in sub-strata IIIB and IIIC, and IVA and IVC averaged 1.37 ha and 1.11 ha, respectively.

Class II and III wetlands in sub-strata IIIB and IIIC had higher use by blue-winged teal and pintails than class II and III wetlands in sub-strata IIA and IIC1 (Tables 16, 17). The regression coefficients also demonstrate this relationship (Tables 12, 13).

Number of waterfowl pairs observed on class II and III wetlands, pairs per class II and III wetland, and pairs per hectare of Class II

Table 15. The distribution of pairs of mallards in eastern South Dakota by sub-strata and wetland class, 1973-74. (Numbers in parentheses are numbers of wetlands with surface water in each class).

	Sub-strata IIA and IIC1	Sub-strata IIIB and IIIC	Sub-strata IVA and IVC
1973			
Total mallard pairs in strata	58	72	97
Mallard pairs on:			
Class I wetlands	2 (4)	0 (1)	0 (0)
Class II wetlands	5 (28)	1 (23)	9 (16)
Class III wetlands	4 (34)	11 (31)	35 (23)
Class IV wetlands	39 (38)	30 (21)	20 (23)
Mallard pairs per:			
Class I wetland	0.50	0.00	-
Class II wetland	0.18	0.04	0.56
Class III wetland	0.12	0.35	1.52
Class IV wetland	1.03	1.43	0.87
Mallard pairs per hectare of:			
Class I wetland	6.45	0.00	-
Class II wetland	2.08	0.11	1.18
Class III wetland	0.36	0.65	1.44
Class IV wetland	0.22	0.74	0.61
1974			
Total mallard pairs in strata	46	36	35
Mallard pairs on:			
Class I wetlands	0 (1)	1 (5)	2 (9)
Class II wetlands	2 (14)	1 (15)	4 (40)
Class III wetlands	8 (24)	4 (22)	6 (23)
Class IV wetlands	34 (32)	15 (18)	9 (19)
Mallard pairs per:			
Class I wetland	0.00	0.20	0.22
Class II wetland	0.14	0.07	0.10
Class III wetland	0.33	0.18	0.26
Class IV wetland	1.06	0.83	0.47
Mallard pairs per hectare of:			
Class I wetland	0.00	0.38	1.41
Class II wetland	2.38	0.31	0.34
Class III wetland	1.95	0.34	0.25
Class IV wetland	0.35	0.66	0.48

Table 16. The distribution of pairs of pintails in eastern South Dakota by sub-strata and wetland class, 1973-74. (Numbers of wetlands with surface water are the same as in Table 15).

	Sub-strata IIA and IIC1	Sub-strata IIIB and IIIC	Sub-strata IVA and IVC
1973			
Total pintail pairs in strata	26	35	146
Pintail pairs on:			
Class I wetlands	0	0	1[a]
Class II wetlands	2	1	15
Class III wetlands	1	8	35
Class IV wetlands	18	9	41
Pintail pairs per:			
Class I wetland	0.00	0.00	-
Class II wetland	0.07	0.04	0.83
Class III wetland	0.06	0.26	1.52
Class IV wetland	0.47	0.43	1.78
Pintail pairs per hectare of:			
Class I wetland	0.00	0.00	-
Class II wetland	0.83	0.11	1.97
Class III wetland	0.18	0.47	1.44
Class IV wetland	0.10	0.22	1.24
1974			
Total pintail pairs in strata	10	6	18
Pintail pairs on:			
Class I wetlands	0	0	0
Class II wetlands	0	0	0
Class III wetlands	0	0	2
Class IV wetlands	9	4	6
Pintail pairs per:			
Class I wetland	0.00	0.00	0.00
Class II wetland	0.00	0.00	0.00
Class III wetland	0.00	0.00	0.09
Class IV wetland	0.28	0.22	0.32
Pintail pairs per hectare of:			
Class I wetland	0.00	0.00	0.00
Class II wetland	0.00	0.00	0.00
Class III wetland	0.00	0.00	0.08
Class IV wetland	0.09	0.17	0.32

[a]Pintail pair observed on dry class I wetland.

Table 17. The distribution of pairs of blue-winged teal in eastern South Dakota by sub-strata and wetland class, 1973-74. (Numbers in parentheses are numbers of wetlands with surface water in each class).

	Sub-strata IIA and IIC1	Sub-strata IIIB and IIIC	Sub-strata IVA and IVC
1973			
Total blue-winged teal pairs in strata	167	178	357
Blue-winged teal pairs on:			
Class I wetlands	0 (1)	1 (3)	3 (1)
Class II wetlands	4 (7)	14 (16)	45 (22)
Class III wetlands	11 (24)	27 (27)	92 (22)
Class IV wetlands	129 (34)	80 (17)	122 (21)
Blue winged teal pairs per:			
Class I wetland	0.00	0.33	3.00
Class II wetland	0.57	0.87	2.04
Class III wetland	0.46	0.90	4.18
Class IV wetland	3.79	4.70	5.81
Blue-winged teal pairs per hectare of:			
Class I wetland	0.00	16.67	60.00
Class II wetland	4.60	1.97	3.66
Class III wetland	2.52	2.02	3.60
Class IV wetland	0.84	2.46	3.82
1974			
Total blue-winged teal pairs in strata	93	35	66
Blue-winged teal pairs on:			
Class I wetlands	0 (0)	0 (1)	0 (2)
Class II wetlands	1 (5)	1 (9)	5 (19)
Class III wetlands	5 (14)	4 (18)	4 (12)
Class IV wetlands	73 (27)	16 (11)	21 (16)
Blue-winged teal pairs per:			
Class I wetland	-	0.00	0.00
Class II wetland	0.20	0.11	0.26
Class III wetland	0.36	0.22	0.33
Class IV wetland	2.70	1.45	1.31
Blue-winged teal pairs per hectare of:			
Class I wetland	-	0.00	0.00
Class II wetland	1.82	0.61	0.77
Class III wetland	2.36	0.37	0.41
Class IV wetland	0.94	0.77	0.24

Table 18. The distribution of pairs of gadwalls in eastern South Dakota by sub-strata and wetland class, 1973-74. (Numbers of wetlands with surface water are the same as in Table 17).

	Sub-strata IIA and IIC1	Sub-strata IIIB and IIIC	Sub-strata IVA and IVC
1973			
Total gadwall pairs in strata	43	21	62
Gadwall pairs on:			
Class I wetlands	0	0	0
Class II wetlands	2	1	1
Class III wetlands	1	3	17
Class IV wetlands	38	9	15
Gadwall pairs per:			
Class I wetland	0.00	0.00	0.00
Class II wetland	0.28	0.07	0.05
Class III wetland	0.04	0.10	0.77
Class IV wetland	1.12	0.53	0.71
Gadwall pairs per hectare of:			
Class I wetland	0.00	0.00	0.00
Class II wetland	2.30	0.14	0.08
Class III wetland	0.23	0.22	0.66
Class IV wetland	0.25	0.28	0.77
1974			
Total gadwall pairs in strata	41	10	28
Gadwall pairs on:			
Class I wetlands	0	0	0
Class II wetlands	1	0	0
Class III wetlands	0	2	5
Class IV wetlands	34	2	9
Gadwall pairs per:			
Class I wetland	-	0.00	0.00
Class II wetland	0.20	0.00	0.00
Class III wetland	0.00	0.11	0.42
Class IV wetland	1.26	0.22	0.56
Gadwall pairs per hectare of:			
Class I wetland	-	0.00	0.00
Class II wetland	0.82	0.00	0.00
Class III wetland	0.00	0.18	0.51
Class IV wetland	0.44	0.09	0.53

and III wetland (for mallards, pintails, blue-winged teal, and gadwalls) were the highest in sub-strata IVA and IVC (Tables 15, 16, 17, and 18). Class II and III wetlands comprised a higher proportion of both numbers and area of natural basin wetlands in sub-strata IVA and IVC. Waterfowl utilized class II and III wetlands in sub-strata IVA and IVC to a much greater extent than in other sub-strata.

More mallards, pintails, blue-winged teal, and gadwalls (71 percent) were observed on stock dams than on other wetland classes in western South Dakota (Table 19). Similar results were found in southwestern North Dakota (Stewart and Kantrud 1973). The only exception was mallards in strata V. Mallards in strata V were more frequently observed on intermittent streams than on stock dams. Study plots in strata V contained approximately twice as many intermittent streams as stock dams. Pintails, blue-winged teal, and gadwalls in strata V, however, utilized the stock dams more frequently than the more abundant streams. Stock dams comprised 64 to 79 percent of the wetland area and 30 percent of the wetland basins in 1973 and 1974. Stock dams, intermittent streams, and permanent streams, together, comprise from 88 to 97 percent of the wetland area and 64 percent of the wetland basins in western South Dakota.

The use of the various wetland classes by other species of waterfowl was difficult to examine due to the small sample size (Table 20). Northern shovelers were observed on most wetland classes, but primarily on class IV wetlands in sub-strata IIA and IIC1, class III wetlands and stock dams in sub-stratum IVA, and class II and IV western South Dakota, 1973-74.

	Pasture pond	Class I	Class II	Class III	Class IV	Dugout	Stock pond	Intermittent stream	Permanent stream	Road ditch	Total
Strata V											
Mallard	1	1			2	2	28	40	5	1	80
Pintail							10	6			16
Blue-winged teal			2		1	1	19	6	1		30
Gadwall	1			1			11	3			16
Strata VI											
Mallard					2	5	80	11			98
Pintail							22	2			24
Blue-winged teal							63	2			65
Gadwall					1		10				11
Strata VII											
Mallard	3					1	31	5	6	1	47
Pintail	2						5				7
Blue-winged teal						1	30	10			41
Gadwall							2				2
Total	7	1	2	1	6	10	311	85	12	2	437

Table 20. The distribution of the less abundant species of waterfowl by wetland class in South Dakota, 1973-74.

Wetland class	Northern shoveler	Green-winged teal	American wigeon	Redhead	Canvas-back	Ring-necked duck	Lesser scaup	Ruddy duck	Wood duck
Tillage pond	1								
Pasture pond	2	1							
Class I	1								
Class II	11	5							3
Class III	9	3	1	3	1		1		
Class IV	30	15	7	71	4	9	3	41	5
Class V			2		4			3	
Dugout	6	5	1						1
Stock dam	17	10	20		1		4	3	
Intermittent stream	4	3	2						
Permanent stream			1						8
Irrigation ditch									
Road ditch									
Gravel pit	1		1						
Total	82	42	35	74	10	9	8	47	17

wetlands in sub-stratum IVC. Green-winged teal were observed primarily on class IV wetlands and on stock dams, but used many wetland types across the state. The highest wetland use by American wigeon was on stock dams, primarily in the west-river regions. Redheads were almost exclusively observed on class IV wetlands, and 92 percent of the redheads were observed in sub-strata in the Coteau des Prairies (sub-strata IIA, IIB, and IIC1). Canvasbacks were observed primarily on class IV and V wetlands and ring-necked ducks only on class IV wetlands. Lesser scaup were seen on class III and IV wetlands in eastern South Dakota and on stock dams in western South Dakota. Stewart and Kantrud (1973) in North Dakota found high proportions of of the lesser scaup population on stock dams. Ruddy ducks were usually observed on class IV wetlands. Ruddy ducks in Alberta were limited to class IV and V wetlands (Keith 1961). Most of the wood ducks were observed on permanent streams and class IV wetlands.

DISCUSSION

Many of the variables in the regression equations by pond were similar for most species and in most regions. Hectares of surface water and hectares of open water were of major importance in influencing the numbers of waterfowl pairs per pond. One or both of these variables usually accounted for over one-half of the coefficient of variation. More pairs of waterfowl per pond were found on the larger wetlands. Similar results were found in previous studies in South Dakota which reported that a majority of the waterfowl were found on the larger wetlands and that there was a preference for wetlands with sparse or little emergent vegetation (Evans and Black 1956, Drewien and Springer 1969, and Lokemoen 1973). Exceptions to this were gadwalls, which were negatively associated with hectares of surface water per pond in IIA and IIC1 of the Coteau des Prairies and the west-river strata, and redheads, which were associated with hectares of open water but not with surface water. This may have indicated a preference for smaller wetlands by gadwalls and for larger, more open wetlands by redheads.

Shoreline distance was positively associated with all species in all strata except for gadwalls in IIA and IIC1. Large shoreline distances were found on large wetlands, small, irregularly-shaped wetlands, and streams. Drewien and Springer (1969) felt that the use of small wetlands was due to the greater shoreline-to-water area ratio these wetlands provided compared to larger wetlands.

Correlation coefficients between hectares of wetland basin, hectares of surface water, hectares of open water, and shoreline distance, although significant ($p < 0.05$), were small enough that r^2 values among the four variables indicated the variables were independent of each other. An exception was hectares of surface water and hectares of open water per pond which were strongly correlated in sub-strata IIA and IIC1 ($r^2 = 0.706$), IVA and IVC ($r^2 = 0.513$), and the west-river strata ($r^2 = 0.904$). Basin size was in some cases correlated to hectares of surface water or hectares of open water areas, but the relationship of basin size to waterfowl was seldom significant ($p < 0.05$) and always opposite in sign to hectares of surface or hectares of open water.

Height of emergent vegetation was usually positive in association with numbers of mallards, blue-winged teal, and gadwalls per pond in regions other than IIA and IIC1. Pintails in IIA and IIC1 were negatively associated with height of emergent vegetation. Sowls (1955) and Smith (1969) found that pintails in other areas of the prairie pothole region were observed more often on wetlands with open water and without tall emergent vegetation.

The percentage of the shoreline grazed was positively related to mallards, blue-winged teal, gadwalls, and redheads in some cases. Blue-winged teal and redheads were also negatively associated with grazing intensity. Grazing may open stands of emergent vegetation and create loafing sites (Keith 1961). Bue et al. (1952) and Shearer (1960) reported low densities of pairs on wetlands with intensive grazing.

Game management cover was positively related to all species except the northern shoveler in sub-strata IIA and IIC1. This positive relationship was based on observations of one excellent class IV wetland located on a South Dakota Department of Game, Fish, and Parks' public shooting area. During the two years of this study: 28, 19, 33, 20, 8, 18, and 34 percent, respectively, of the mallards, pintails, blue-winged teal, gadwalls, northern shovelers, redheads, and ruddy ducks observed in IIA and IIC1 were observed on this wetland. Heismeyer (1974) found that waterfowl densities were significantly higher ($p < 0.01$) on federal Waterfowl Production Areas than on nearby wetlands on private land. Heismeyer believed that waterfowl were attracted to these areas because of the more stable water conditions of the wetlands on Waterfowl Production Areas.

Idle cover was analyzed separately from game management cover because idle cover areas were smaller and not always managed as waterfowl habitat. Idle cover near a wetland was positively associated with blue-winged teal and gadwalls in IIA and IIC1. Drewien and Springer (1969) reported higher numbers of breeding waterfowl on wetlands located in soil bank, idle cover, and hayland.

Some habitat variables influenced waterfowl numbers only in one region. The positive relationships of mallards with small grain and hayland areas in west-river, of blue-winged teal and hectares of roadsides, and of gadwalls and small grain in the west-river regions may have been responses to nesting cover within a region. Negative relationships between mallards and hectares of pasture and treeland in

IIIB and IIIC, and alfalfa fields in IIC2, blue-winged teal and corn fields in IIC2, and gadwalls and fallow areas in the west-river areas also may have been responses to a lack of nesting cover for these upland nesting species. Redheads and ruddy ducks demonstrated no significant relationships with upland cover type other than game management areas. However, redheads and ruddy ducks nest over water in emergent vegetation. Pintails exhibited a positive relationship with hectares of fallow ground in western South Dakota. Sowls (1955) and Hammond (1964) reported that pintails in Canada nested in fallow fields in greater proportions than other dabbling ducks.

Negative relationships between mallards and blue-winged teal and natural wetlands in western South Dakota may have been due to a lack of natural wetlands in this region (Appendix Tables E and F). The positive relationship of mallards, pintails, and gadwalls to the percentage of surface water without vegetation (open water) was reflective of the high utilization of stock dams. Stock dams usually had sparse emergent vegetation.

Area of surface water for each wetland class and the numbers of wetlands in each wetland class per plot most influenced the numbers of waterfowl pairs per plot. Wetland area was based on surface water area at the time of each census. Numbers of wetlands of each class included only those wetlands with surface water during the census.

Wetland classification in this study followed Stewart and Kantrud (1971) and can therefore be directly compared with their later research (1973, 1974). Earlier waterfowl research was based on the wetland classification of Martin et al. (1953) or modifications of that system (Drewien and Springer 1969). Goldstein's data (1971) from Waubay, South Dakota during the period 1955-65, utilized the system of Martin et al. (1953). Other studies not using the classification system of Stewart and Kantrud were interpreted on the basis of the wetland classification of Stewart and Kantrud (Table 21).

The area of class IV wetlands per plot was positively associated with waterfowl numbers of most species more often than any other variable in IIA and IIC1, and IIIB and IIIC. Hectares of class II and class III wetlands per plot were also positively associated with waterfowl densities, especially blue-winged teal and gadwall, in IIIB and IIIC. Mallards and pintails in IVA and IVC of the Coteau du Missouri were positively associated with hectares of class III wetlands and shoreline distance to a much greater extent than in other strata. Blue-winged teal, gadwall, and northern shoveler in that region were positively associated with hectares of surface water, hectares of open water, and numbers of basins containing open water but showed no indication of any preference for a particular wetland class.

Pintails in North Dakota were also significantly correlated with the areas of class III and IV wetlands (Stewart and Kantrud 1974). Gadwalls in North Dakota were positively correlated with the numbers of class III wetlands (Stewart and Kantrud 1974), but in South Dakota this relationship was negative (sub-strata IIIB and IIIC). Both studies demonstrated positive relationships between gadwalls and the density and area of total wetlands. Class IV wetland area was more highly

Table 21. Approximate equivalent wetland types in various wetland classifications.

Stewart and Kantrud (1971)	Drewien and Springer (1969)	Martin *et al.* (1953)
Class I		Type 1
Class II	Type IA	Type 1, 2
Class III	Type IB	Type 3, 4
Class IV	Type 3, 4, 5	Type 3, 4, 5
Class V	Type 5	Type 5

associated with blue-winged teal densities than class III wetland area, but these two variables were more highly associated with blue-winged teal densities than any other variables in eastern South Dakota. This was in agreement with studies in North Dakota (Stewart and Kantrud 1974) and in the Waubay area in South Dakota (Drewien and Springer 1969).

Redheads and ruddy ducks were most associated with hectares of open water and hectares of class IV wetlands per plot. Redheads and other diving ducks in North Dakota exhibited stronger relationships with frequency and area of class III wetlands or with class III and IV wetlands in combination (Stewart and Kantrud 1974). Regional differences in wetland classes may have been the reason for differences in waterfowl-wetland class relationships in this study.

In western South Dakota the hectares of open water and hectares of surface water and the number of basins with surface water per plot explained the greatest amount of variation. Lokemoen (1973) also found more waterfowl on larger stock dams and on dams that were near other wetlands or stock dams. Gadwalls had positive regression coefficients with the area of class II wetlands and the number of class IV wetlands per plot although only one pair of gadwalls was observed on a class IV wetland and none were observed on class II wetlands in western South Dakota (Table 19).

Numbers of type II, III, and IV wetlands per plot were in some cases a positive influence on waterfowl densities. For example, mallards were influenced by numbers of type II wetlands in sub-strata IIA and IIC1, numbers of type IV's in IIIB and IIIC, and numbers of type III's in IVA and IVC (Table 11). Stoudt (1952) felt that waterfowl populations were more dependent on numbers of wetlands than on the area of wetlands per square mile. Stewart and Kantrud (1964) reported the area of potholes containing water is a better indicator of waterfowl densities than the number of wetlands or shoreline distance. In this study, hectares of wetlands or wetland class was always more important than the number of wetlands per study plot. This effect may have been due to the influence of a single wetland on numbers of waterfowl within a quarter section study plot.

The use of temporary wetlands (class I and II) in eastern South Dakota must be discussed on a regional basis. During the study there were relatively few class I and II wetlands with surface water on study plots in the Minnesota-Red River Lowlands, the Coteau des Prairies, or the James River Valley. Consequently, there was little waterfowl use of these wetlands in these regions. The regression coefficients for hectares of class I wetlands, hectares of class I and II wetlands combined, and the number of class I wetlands were always negative for blue-winged teal in IIA and IIC1, and IVA and IVC, and very seldom significant ($p < 0.05$). This may have been because class I and II wetlands are of little value unless interspersed among class IV and V wetlands (Fredrickson 1971, P-R Proj. Rep., W-75-R-12, South Dakota Department of Game, Fish and Parks, Pierre, South Dakota).

In 1973, however, there was much waterfowl use of class II wetlands in IVA and IVC of the Coteau du Missouri where class II wetlands were the most abundant wetland class. The increased area of class II wetlands (Appendix Tables A, B, C, and D) in IVA in 1974 compared to 1973 was due to heavy spring rains during the time of the census (U. S. Department of Commerce 1974). These wetlands were dry in April and early May during the migration and attracted few waterfowl to this region. The large decrease in pintails and blue-winged teal, and to a lesser extent in mallards and gadwalls in sub-strata IVA and IVC, from 1973 to 1974 may have been attributable to the decrease in class II and III wetlands during that period. High use by pintails of class III wetlands is also shown by the regression coefficient for type III wetlands in sub-strata IVA and IVC. Total waterfowl numbers in IVA declined by 69 percent from 1973 to 1974 (339 pair to 106 pair). In this region more than any other region in South Dakota, class II wetlands were very important to breeding waterfowl. Class I wetlands, however, even in this region received little waterfowl use.

Stoudt (1971) felt that type I and II wetlands had a low waterfowl use and were unnecessary as waterfowl habitat in Saskatchewan. Drewien and Springer (1969) stated that type I and II wetlands were not essential to the breeding cycles of blue-winged teal in the Waubay area in South Dakota. However, Goldstein's multiple regression analysis (1971) of Waubay data from 1955 through 1965 indicated that waterfowl were more strongly attracted to areas with class I and II wetlands than to those areas without such wetlands. Goldstein demonstrated this relationship for both area and number of class I and II wetlands. This relationship between waterfowl and class I and II wetlands may actually have been the relationship between waterfowl and over-all favorable conditions in all classes of wetlands. The temporary wetlands and wetlands that hold water only three or four years out of 10 may be responsible for the peak waterfowl production during the very wet years (Lynch *et al.* 1963, Cooch 1969, and Crissey 1969). In periods of favorable wetland conditions, all classes of wetlands would have water levels suitable for use by breeding pairs.

CONCLUSIONS

Multiple regression analysis was used to identify habitat variables which most influenced breeding waterfowl numbers in South Dakota by species and on a pond and plot basis. The multiple regression equations were more informative for mallard, pintail, blue-winged teal and gadwall than for the less abundant species in most regions of the state. Northern shoveler were abundant in the Coteau des Prairies and the Coteau du Missouri. Redhead and ruddy duck were abundant in the Coteau des Prairies. Habitat utilization by these species could be analyzed in these regions. Regression equations comprised of different variables for the different species were determined. Regional differences in wetland habitat were reflected by the different influences of the habitat variables. This indicated different habitat preferences for the various species of waterfowl and differential utilization of the various wetland and upland habitats across the state.

Hectares of surface water and hectares of open water accounted for most of the variation in numbers of waterfowl per pond for all species and in all regions. On a plot basis, hectares of class IV wetlands, and to some extent, hectares of class II and class III wetlands were often positively associated with numbers of waterfowl in eastern South Dakota. Hectares of surface water, hectares of open water, and the number of basins with surface water per plot were the variables which accounted for most variation in waterfowl numbers in western South Dakota.

Waterfowl were positively associated with game management cover and idle cover in the Coteau des Prairies. In some cases waterfowl exhibited relationships to the presence or absence of available nesting cover.

More waterfowl of all species were found on the larger class IV wetlands in eastern South Dakota, but on a per hectare basis, the smaller and temporary wetlands were utilized more by waterfowl. Class II wetlands were more abundant and were utilized more by mallard, pintail, blue-winged teal, and gadwall in the Coteau du Missouri than in other regions. Total wetland area in the other eastern South Dakota regions was comprised primarily of class IV wetlands, and these wetlands received most of the utilization by waterfowl. Diving ducks, especially the redhead and the ruddy duck, were observed almost exclusively on class IV wetlands in the Coteau des Prairies. Stock dams and intermittent streams were the most abundant wetlands in western South Dakota, and most of the breeding waterfowl were observed on these wetlands.

Waterfowl in this study responded to habitat variables similarily to the results of other waterfowl habitat studies. However, through multiple regression an estimate of the variation in waterfowl numbers that can be attributed to these habitat variables could be determined. The multiple regression equations could be used to quantitatively estimate a particular wetland's or wetland community's value to breeding waterfowl. This quantitative evaluation could be of use to waterfowl management personnel and water resource developers in planning and mitigating water resource projects.

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Appendix Table A. Hectares of surface water in each wetland class by sub-strata in South Dakota; May, 1973.

Wetland Class	Physiographic Sub-strata													
	I	IIA	IIB	IIC1	IIC2	IIIA	IIIB	IIIC	IVA	IVB	IVC	V	VI	VII
Tillage pond	3.89	0.00	0.00	0.13	0.02	0.00	0.01	4.93	0.00	0.00	0.00	0.00	-	0.00
Pasture pond	1.23	0.01	-	0.22	-	0.00	0.05	0.01	0.31	-	0.00	0.82	-	0.07
Class I	0.10	0.13	-	0.18	-	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.03
Class II	-	2.63	0.01	0.77	0.78	0.00	4.09	4.75	1.82	-	5.81	0.42	0.01	0.02
Class III	2.45	5.42	0.38	5.35	10.01	0.00	6.56	10.46	14.46	-	9.78	8.88	0.04	-
Class IV	16.14	25.69	18.86	147.12	3.84	-	15.34	24.96	9.71	-	23.29	0.40	0.11	-
Class V	-	10.26	-	22.10	-	-	7.61	4.47	-	-	-	-	-	-
Dugout	-	0.17	0.23	0.47	0.48	0.39	1.53	1.47	0.65	0.13	1.02	0.05	0.39	0.21
Stock dam	-	-	0.17	-	0.24	-	-	-	7.36	0.61	4.05	15.07	46.48	15.05
Intermittent stream	0.38	0.02	0.82	0.46	0.89	0.92	1.40	0.68	0.57	-	0.37	15.04	1.30	0.60
Permanent stream	-	-	4.68	-	-	3.73	10.25	6.04	-	-	-	3.67	6.11	2.25
Irrigation ditch	-	-	-	0.43	0.00	-	-	1.19	-	0.00	0.00	0.02	-	-
Road ditch	0.33	0.34	-	0.07	0.10	-	0.47	0.27	0.00	0.02	0.09	0.40	0.00	0.08
Other wetlands	-	-	-	-	-	-	-	-	0.12	-	-	1.30	-	0.10
Total	24.52	44.67	25.15	177.30	16.36	5.04	47.31	59.23	35.00	0.76	44.41	46.96	54.44	18.41

Appendix Table B. Hectares of surface water in each wetland class by sub-strata in South Dakota; June, 1973.

Wetland Class	Physiographic Sub-strata													
	I	IIA	IIB	IIC1	IIC2	IIIA	IIIB	IIIC	IVA	IVB	IVC	V	VI	VII
Tillage pond	0.25	0.00	0.00	0.14	0.13	0.00	0.00	3.16	0.00	0.00	1.49	0.38	-	0.00
Pasture pond	0.00	0.00	-	0.16	-	0.00	0.43	0.71	0.00	-	0.10	0.23	-	0.35
Class I	0.00	0.01	-	0.00	-	0.00	0.06	0.00	0.00	0.00	0.05	0.00	0.00	0.00
Class II	-	0.87	0.00	0.00	0.44	0.00	5.91	1.17	1.89	-	10.41	2.48	0.02	0.01
Class III	0.93	3.59	0.07	0.74	2.03	0.00	4.06	9.26	12.38	-	13.21	1.21	0.00	-
Class IV	13.43	22.77	17.33	131.46	2.36	-	11.40	21.12	6.14	-	25.73	0.42	0.23	-
Class V	-	10.26	-	19.89	-	-	7.61	4.47	-	-	-	-	-	-
Dugout	-	0.17	0.23	0.38	0.64	0.35	1.43	1.42	0.63	0.16	0.81	0.07	0.39	0.23
Stock dam	-	-	0.14	-	0.23	-	-	-	7.21	1.83	4.95	13.70	42.87	15.38
Intermittent stream	0.00	0.03	0.27	0.00	0.63	0.46	2.28	1.77	0.37	0.02	0.44	10.83	1.09	1.49
Permanent stream	-	-	4.52	-	-	2.33	10.85	5.56	-	-	-	5.39	6.11	2.44
Irrigation ditch	-	-	-	0.09	0.00	-	-	0.00	-	0.00	0.00	0.00	0.00	-
Road ditch	0.00	0.05	-	0.00	0.02	0.00	0.32	0.13	-	-	0.19	0.28	0.02	0.17
Other wetlands	-	-	-	-	-	-	-	-	0.09	-	-	0.27	-	0.10
Total	14.61	37.75	22.56	152.86	6.48	3.14	44.35	48.77	28.71	2.01	57.38	35.26	50.73	20.17

Appendix Table C. Hectares of surface water in each wetland class by sub-strata in South Dakota; May 1974.

Wetland Class	Physiographic Sub-strata													
	I	IIA	IIB	IIC1	IIC2	IIIA	IIIB	IIIC	IVA	IVB	IVC	V	VI	VII
Tillage pond	0.15	0.00	0.00	0.07	0.58	0.23	3.85	3.30	1.89	0.00	0.10	0.00	-	0.00
Pasture pond	0.73	0.00	-	0.00	-	0.01	2.82	0.17	1.22	-	0.00	0.42	-	0.09
Class I	0.06	0.03	-	0.00	-	0.00	2.66	0.00	1.42	0.00	0.00	0.00	-	0.00
Class II	-	0.84	0.00	0.00	3.63	-	2.82	0.36	16.03	-	0.07	0.00	0.00	0.00
Class III	0.06	3.33	0.00	0.77	7.69	0.00	7.43	4.25	18.85	-	5.45	0.15	0.00	0.02
Class IV	7.24	22.83	13.68	74.17	2.74	-	10.71	11.99	8.49	-	10.04	0.48	0.16	-
Class V	-	9.23	-	21.78	-	-	6.85	3.58	-	-	-	-	-	-
Dugout	0.00	0.16	0.23	0.26	0.47	0.42	1.70	1.44	0.53	0.00	1.04	0.15	0.23	0.18
Stock dam	-	-	0.11	-	0.22	-	-	-	5.92	0.92	3.42	9.70	34.74	11.47
Intermittent stream	0.00	0.06	0.60	0.00	1.59	0.00	2.00	1.01	2.91	0.02	0.42	6.59	0.45	1.18
Permanent stream	-	-	4.48	-	-	5.62	11.46	6.04	-	-	-	4.16	3.06	2.28
Irrigation ditch	-	0.00	-	0.09	0.00	-	-	1.19	-	0.00	0.00	0.00	-	-
Road ditch	0.02	0.25	-	0.00	0.15	0.02	1.25	0.62	0.15	0.00	0.02	0.15	0.00	0.04
Other wetlands	-	-	-	-	-	-	-	-	0.00	-	-	0.13	-	0.11
Total	8.26	36.73	19.10	97.14	17.07	6.30	53.55	33.95	57.41	0.94	20.56	21.93	38.64	15.37

Appendix Table D. Hectares of surface water in each wetland class by sub-strata in South Dakota; June, 1974.

Wetland Class	Physiographic Sub-strata													
	I	IIA	IIB	IIC1	IIC2	IIIA	IIIB	IIIC	IVA	IVB	IVC	V	VI	VII
Tillage pond	0.00	0.00	0.00	0.09	1.72	0.00	0.25	6.45	0.00	0.00	0.70	0.00	-	0.20
Pasture pond	0.00	0.00	-	0.00	-	0.00	0.47	0.19	0.17	-	0.07	0.00	-	0.15
Class I	0.00	0.00	-	0.00	0.33	0.00	0.30	0.00	0.00	0.00	0.44	0.00	-	0.00
Class II	-	0.55	0.00	0.00	3.79	-	0.34	0.81	1.15	-	5.39	0.00	0.02	0.06
Class III	0.00	2.11	0.00	0.00	6.25	0.00	5.82	4.97	6.23	-	3.57	0.08	0.00	0.02
Class IV	3.58	20.43	12.30	57.43	3.72	-	9.33	11.55	4.58	-	16.95	0.42	0.49	-
Class V	-	9.23	-	21.79	-	-	7.04	4.47	-	-	-	-	-	-
Dugout	0.09	0.15	0.23	0.31	0.47	0.34	1.51	1.59	0.51	0.11	1.04	0.25	0.34	0.24
Stock dam	-	-	0.10	-	0.31	-	-	-	4.63	3.06	4.54	9.21	39.45	12.21
Intermittent stream	0.00	0.02	0.95	0.00	1.67	0.00	2.01	2.15	1.42	0.10	0.79	4.51	0.32	1.14
Permanent stream	-	-	4.48	-	-	5.62	11.99	6.04	-	-	-	4.02	1.53	1.60
Irrigation ditch	-	0.00	-	0.09	0.00	-	-	1.19	-	0.00	0.00	0.00	-	-
Road ditch	0.00	0.21	-	0.00	0.15	0.00	0.20	0.38	0.02	0.01	0.14	0.06	0.02	0.18
Other wetlands	-	-	-	-	-	-	-	-	0.00	-	-	0.13	-	0.05
Total	3.67	32.70	18.06	79.71	18.41	5.96	39.84	39.71	18.71	3.28	33.63	18.68	42.17	15.85

Appendix Table E. Number of wetland basins of each class by sub-strata in South Dakota in 1973.

Wetland Class	Physiographic Sub-strata													
	I	IIA	IIB	IIC1	IIC2	IIIA	IIIB	IIIC	IVA	IVB	IVC	V	VI	VII
Tillage pond	6	4	2	6	7	1	3	11	3	1	13	3	1	1
Pasture pond	1	1	0	4	0	2	4	3	2	0	2	33	0	13
Class I	1	3	0	6	0	1	19	9	27	1	14	5	1	4
Class II	0	27	1	3	11	1	30	20	59	0	23	4	3	2
Class III	5	28	3	10	9	3	30	19	27	0	12	1	1	0
Class IV	4	19	3	20	6	0	13	8	12	0	12	9	3	0
Class V	0	2	0	2	0	0	2	1	0	0	0	0	0	0
Dugout	0	2	5	5	6	5	21	21	7	2	9	1	4	3
Stock dam	0	0	2	0	2	0	0	0	7	1	8	25	58	16
Intermittent stream	1	5	4	2	9	2	12	6	5	1	8	58	30	11
Permanent stream	0	0	3	0	0	2	3	3	0	0	0	7	1	7
Irrigation ditch	0	0	0	1	1	0	0	2	0	1	1	2	0	0
Road ditch	3	5	0	9	8	1	31	14	4	1	17	10	1	10
Other wetlands	0	0	0	0	0	0	0	0	1	0	0	4	0	1
Total	21	96	23	68	59	18	168	117	154	8	119	162	102	68

Appendix Table F. Number of wetland basins of each class by sub-strata in South Dakota in 1974.

Wetland Class	Physiographic Sub-strata													
	I	IIA	IIB	IIC1	IIC2	IIIA	IIIB	IIIC	IVA	IVB	IVC	V	VI	VII
Tillage pond	7	4	1	8	16	5	41	22	19	1	23	3	0	1
Pasture pond	1	1	0	5	0	2	17	6	11	0	3	32	0	11
Class I	1	6	0	5	4	1	25	3	27	1	10	7	0	4
Class II	0	29	1	4	7	0	29	20	64	0	24	1	3	1
Class III	4	27	3	9	7	3	28	19	26	0	11	2	1	1
Class IV	4	18	3	20	7	0	14	7	13	0	11	9	4	0
Class V	0	2	0	2	0	0	2	1	0	0	0	0	0	0
Dugout	1	2	5	5	6	5	23	23	7	2	10	2	4	3
Stock dam	0	0	2	0	3	0	0	0	7	1	8	26	58	16
Intermittent stream	1	5	5	2	9	2	13	6	5	1	10	56	32	15
Permanent stream	0	0	3	0	0	2	3	3	0	0	0	5	1	6
Irrigation ditch	0	1	0	1	1	0	0	2	0	1	1	2	0	0
Road ditch	3	6	0	9	11	2	47	20	8	1	15	10	2	10
Other wetlands	0	0	0	0	0	0	0	0	1	0	0	4	0	5
Total	22	101	23	70	71	22	242	132	188	8	126	159	105	69