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Waterfowl Pair and Brood Use of Dug brood Complexes in East-Central South Dakota

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WATERFOWL PAIR AND BROOD USE OF DUG BROOD COMPLEXES IN EAST-CENTRAL 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 for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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WATERFOWL PAIR AND BROOD USE OF DUG BROOD COMPLEXES

IN EAST-CENTRAL SOUTH DAKOTA

Abstract

BETH A. GIRON PENDLETON

Modification of wetlands has been a frequently employed management technique to enhance habitat for waterfowl and other wetland wildlife. One type of excavation in wetland basins is the dug brood complex; an interconnected system of pond units, channels, and islands, primarily created to provide waterfowl brood rearing habitat during drought. In 1981-82, a study was conducted to evaluate waterfowl pair and brood use of 8 pairs of Class IV wetlands in east-central South Dakota. Each pair consisted of a wetland with a dug brood complex (modified) and an unmodified basin of comparable basin size.

Under drought conditions in 1981, both modified and unmodified wetlands were dry by the brood rearing season, and therefore, produced few or no ducks. With improved water conditions in 1982, there were both greater brood densities and brood species diversities on wetlands with excavated ponds than on unmodified wetlands. This may be attributed to more open water, deeper water in excavated ponds and channels, and a greater edge effect in modified wetlands than in control wetlands. Pair and brood use of modified wetlands was found to increase as surface water area, open water area, and water depth increased.

Pheasants <u>(Phasianus colchicus),</u> mallards <u>(Anas platyrhynchos),</u> and gadwalls (A. <u>strepera)</u> most frequently used dug brood complex islands for nesting. In the event of additional dug brood pond construction, consideration should be given to creating small, rectangular islands spaced as far form one another and the basin edge as possible. Wetlands with dug brood complexes provided habitat for swimming, resting, feeding and comfort activities by ducks. Open water areas were attractive to dabbling ducks and some diving ducks, and 0W sery e as waiting sites for paired males. Edge areas were important feeding areas for ducklings. Future evaluations of modified wetlands should include pre-modification and post-modification studies to better evaluate changes in waterfowl density, diversity and production.

INTRODUCTION

A major impact on wildlife in the northern Great Plains is the loss of wetlands through drainage related to agriculture and construction activities (National Academy of Sciences 1970, Reilly 1979). Because of continued wetland loss, modification of wetlands has been a frequently employed management technique to enhance habitat for waterfowl and other wetland wildlife. One type of wetland modification is the dug brood complex; an interconnected system of pond units and channels created to provide waterfowl brood rearing habitat. Waterfowl use of stockponds (Duebbert 1972, Evrard 1975, Flake 1979, Ruwaldt et al. 1979), dugouts (Shearer 1960, Anderson 1963, Bue et al. 1964) and blasted ponds (Mathiak 1965, Hoffman 1970, Hopper 1978) has been well documented, however, little research effort has been directed to the effects of dug brood complexes on waterfowl use of wetlands.

In the mid 1970s, 9 dug brood complexes were constructed for the U. S. Fish and Wildlife Service in densely vegetated, Class IV wetlands (Stewart and Kantrud 1971) on Waterfowl Production Areas in the Madison Wetlands Management District, South Dakota. Complexes were primarily constructed to provide permanent brood rearing habitat and to reduce overland movement of ducklings during drought conditions (Gilbert, personal communication 1981, U. S. Fish and Wildlife Service, Wetlands Management Office, P.O. Box 48, Madison, South Dakota, 57042). Other benefits were considered to be greater duckling production from additional waterfowl pair use, additional nesting habitat provided by spoil banks and islands, and deep, open water habitat for diving ducks (Tribe Aythyini) where previously none existed. Comparable modifications were constructed in other wetlands management districts in South Dakota during the same time period. Since the completion of the brood complexes in the Madison Wetlands Management District in 1977, few data have been collected on pair and brood use of these modified basins. However, limited observation indicated that suitable habitat created through pond excavation had increased brood use on these wetlands (Gilbert, personal communication 1981, U. S. Fish and Wildlife Service, Wetlands Management Office, P.O. Box 48, Madison, South Dakota, 57042).

This study was initiated to evaluate waterfowl pair and brood use of wetlands with dug brood ponds in east-central South Dakota. The objectives were to:

1. compare numbers and species diversity of waterfowl pairs and broods between modified and unmodified wetlands,
2. determine waterfowl use of dug brood complex islands for nesting,
3. record waterfowl behavior on dug brood complexes, and
4. investigate factors that may be affecting waterfowl use of wetlands.

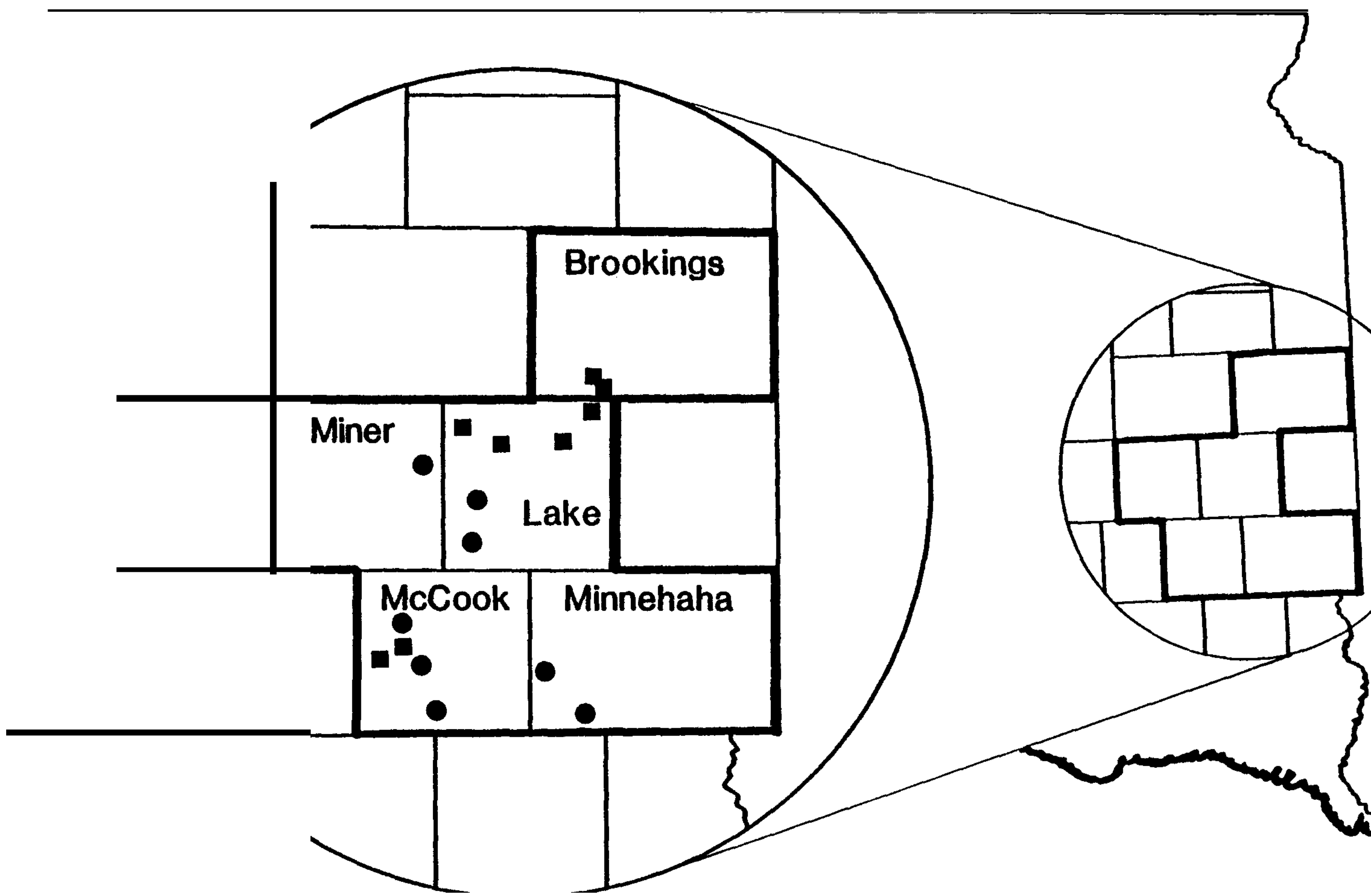
STUDY AREA

General

Study sites were located in Brookings, Lake, Miner, McCook and Minnehaha counties in east-central and southeastern South Dakota (Fig. 1). Two physiographic land forms dominate the study area, the Coteau des Prairies and the James River Lowland. Study sites in Brookings, Lake, Miner and Minnehaha counties were on the Coteau des Prairies, a highland area between the Minnesota-Red River Lowland on the east and the James River Lowland to the west (Westin and Maio 1978). Glacial wetlands in this region attract large numbers of breeding ducks and sustained breeding densities of 14.9 and 7.8 pairs per km^2 in 1973 and 1974 respectively (Brewster et al. 1976). West of the Coteau des Prairies in the James River Lowland (study sites in McCook county), wetlands are generally shallower and fluviatile areas are important to ducks. Wetlands in the lowlands sustained breeding densities of 3.4 and 1.3 pairs per km^2 in 1973 and 1974 respectively (Brewster et al. 1976). Land use in southestern South Dakota is primarily livestock production and cultivation of small grain and corn.

The region is dominated by a continental climate with annual temperature extremes ranging from -29 C during winter to 38 C in the summer (Spuhler et al. 1971). The mean annual temperature range is 9 C in the south to 7 C in the north. Subhumid conditions prevail in the east with mean annual precipitation of 63.5 cm in the southeast (Spuhler et al. 1971).

Fig. 1. Location of study sites in east-central and southeastern South Dakota. Squares indicate location of unmodified wetlands and circles indicate location of modified wetlands.



Annual precipitation in east-central and southeastern South Dakota varied between the 2 years of this study. Below average precipitation occurred in late 1980 and spring precipitation in 1981 was also below normal. Annual departures in precipitation for east-central and southeastern South Dakota in 1981 were 10.36 cm and 7.42 cm below normal, respectively (National Oceanic and Atmospheric Administration 1981). Consequently, wetland water conditions were poor during the 1981 waterfowl breeding and brood rearing seasons. Most study areas were completely dry by mid-July and few or zero broods were observed on study sites. Precipitation levels in 1982 were normal or slightly above average (National Oceanic and Atmospheric Administration 1982). All study areas had markedly improved water conditions during spring 1982, and over the course of the summer most wetland water depths remained constant due to above normal precipitation in May and July.

Sample Wetlands

Study sites consisted of 8 pairs of wetlands of which, one member of the pair contained a dug brood complex while the unmodified, or control wetland, was of comparable wetland class and basin size. All study sites were Class IV wetlands (Stewart and Kantrud 1971) on Waterfowl Production Areas. Because of the excavation of brood complexes, modified basins were characterized by a greater percentage open water and better vegetation/water interspersion than control basins. Dominant emergent vegetation on modified wetlands included river bulrush *(Scirpus fluviatilis)*, softstem bulrush *(Scirpus validus)*, hardstem bulrush (*Scirpus acutus*), smartweed (*Polygonum* spp.) and mixed grasses and forbs. Generally, unmodified wetlands were characterized by shallow water and dense stands of emergent vegetation such as cattail (*Typha* spp.), river bulrush, softstem bulrush and hardstem bulrush. During May and early June, maximum water depths on unmodified wetlands were 37.5 cm in 1981 and 48.0 cm in 1982 as compared to 57.0 cm in 1981 and 116.0 cm in 1982 on modified wetlands.

The basic brood pond unit is a 45.7 m square pond, 1.2 m deep with 3 to 1 side slopes and 6 to 1 end slopes (Fig. 2). The standard design was 4 ponds situated around a 76.2 m square island with the brood ponds interconnected by a 16.8 m channel having 3 to 1 side slopes. Some individual pond designs incorporated slight modifications of this standard configuration.

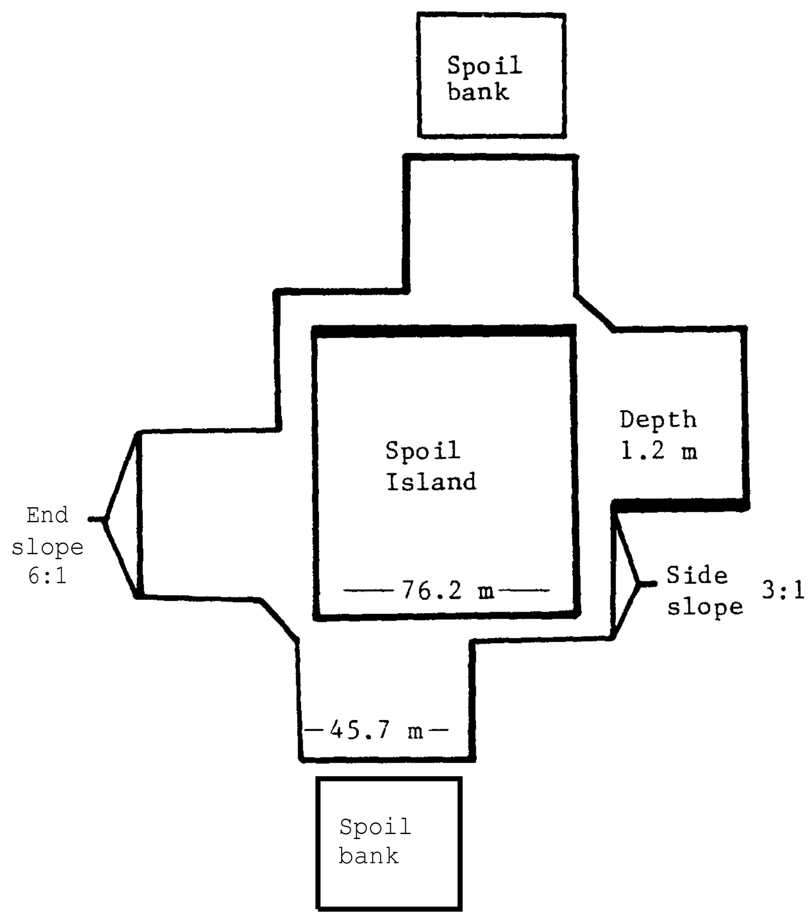


Fig. 2. Standard configuration of dug brood complexes in the Madison Wetlands Management District, South Dakota.

METHODS

Survey Methods

Waterfowl pair counts were conducted on all study areas. One count was conducted in 1981 between 18 May and 20 May. Two pair counts were made in 1982 to determine use by both early and late nesting species. The first 1982 count was from 1 May to 6 May and was intended to record use by early nesting species including mallard (Anas platyrhynchos), northern pintail (A.acuta), wood duck (Aix sponsa), and canvasback (Aythya valisneria) (Hammond 1969). The later count, from 3 June to 7 June was directed at the mid and late nesting species such as blue-winged teal (A. discors), gadwall (A. strepera), northern shoveler (A. clypeata), American wigeon (A. americana), green-winged teal (A. crecca), redhead (Aythya americana), ruddy duck (Oxyura jamaicensis), lesser scaup (Aythya affinis), and bufflehead (Bucephala albeola) (Hammond 1969).

Waterfowl observed on each study area were recorded for each count and the criteria suggested by Hammond (1969) were used to determine the number of breeding pairs. Surveys were conducted between 0900 and 1300 Central Daylight Time (CDT) as recommended by Dzubin (1969). According to Dzubin breeding pairs of most waterfowl species are least active during this time period. Wetlands were traversed by 2 observers using the walk-wade method described by Hammond (1969). Habitat data were recorded for each area during each count and included estimation of percent surface water, percent open water, and grazing intensity. Water depth (cm) and emergent vegetation height (to nearest 0.5 m) were measured. Dominant species of emergent vegetation were recorded along with temperature, percent cloud cover, and wind speed (as designated by Beaufort Scale).

In late May of 1981 and 1982, islands in dug brood complexes were searched for waterfowl nests. Two people searched transects across the islands at 2 m intervals (Glover 1956) parting the vegetation with hockey sticks. Nesting species, vegetation surrounding the nest, clutch size, vegetation composition and concealment of nest, distance of nest from shoreline, and nest fate, if presummed abandoned or predated (Poston 1974), were recorded for each nest. Dominant vegetation of island units was cover mapped.

Brood counts were conducted using hidden observation and walk-wade counts as suggested by Hammond (1970) and Rumble and Flake (1982). Two brood counts were conducted in both 1981 and 1982. The first count each year began the 3rd week of June and lasted for approximately 10 days depending on wetland water conditions. The second brood count started the 3rd week of July. With drought conditions in 1981, 75% of the study areas were dry by mid-July. Dry wetlands were assumed unused by ducks and therefore were not surveyed.

Pairs of wetlands (a dug brood complex and its control) were surveyed on consecutive days. A hidden observation count was conducted on each modified wetland prior to a flush count (Rumble and Flake 1982). Two blinds constructed from 1.9 cm PVC pipe and covered with fitted camouflage netting were erected on upland areas, spoil banks or spoil islands. One observer per blind used a tripod mounted 15X to 60X power spotting scope and binoculars to observe broods. Descriptions of duckling plummage subclasses after Gollop and Marshall (1954) were used to distinguish broods. Hidden counts were conducted from either 2.5 hours before sunset until dusk or for 2.5 hours after sunrise for each modified wetland. Observation periods coincided with peak brood activity periods (Diem and Lu 1960, Ringleman and Flake 1980). Data from both types of counts (hidden and walk-wade) were combined to yield an estimate of the number of broods using the complex. Lack of elevated vantage points (i.e., spoil banks), a predominance of tall danse vegetation, and an absence of open water on control wetlands prevented adequate visibility for use of the hidden observation count, therefore, only the walk-wade survey technique was used on control wetlands. To minimize sampling bias, not all counts for modified wetlands were conducted at the same time period (i.e., morning or evening). For each pair of wetlands a flip of the coin determined which wetland would be surveyed in the morning and which would be surveyed that evening.

Morphometric Measurements

Aerial photographs of each study wetland were taken with a 70-mm motordriven camera secured in an aircraft sidemount. Photographs were taken in the first 2 weeks of June 1981 and 1982 using color infrared film to delineate living hydrophytes and to aid in the determination of wetland boundaries and the extent of surface water. A zoom-transfer scope was used to enlarge negatives to a scale of 1:7920.

An electronic digitizer was used to measure area and/or length of study site components such as basin size (ha), surface water (ha), open water (ha), open water edge (m), exposed mud (ha), ratio of open water to basin size (ha), ratio of surface water to basin size (ha), and ratio of exposed mud to open water (ha). The most recent Agricultural Stabilization and Conservation Service 1:7920 aerial photographs were used to determine both distance to nearest semi-permanent wetland (km) and number of wetlands within a 0.75 km radius of the study basin.

Behavioral Observation

To understand the effects of wetland modifications on waterfowl, a study was initiated to determine how waterfowl use dug brood complexes. Throughout the breeding and brood rearing seasons (1 May - 1 August, 1981-1982), behavioral observations of waterfowl using dug brood complexes were made. The limits of the breeding and brood rearing seasons for each species were obtained from nesting chronology data for South Dakota breeding waterfowl (Tessman 1979). Observations were made for 197 hours from blinds located on spoil banks and islands. Generally, 2 observers on opposite ends of a brood complex recorded the behavior of ducks during the 3 time periods of 0600-1000 CDT, 1000-1700 CDT and 1700-2100 CDT. Of the 197 hours of observation, 72 hours were in period 1, 77 hours in period 2 and 48 hours in period 3. Behavioral data were recorded during the 1st 5 minutes of consecutive 15 minute intervals for 2.5 hours.

Observations were recorded by species and group category such as a pair, lone male, lone female, group of males, or brood. Activities were grouped into 9 categories: feeding, locomotor (walking, swimming and flying), resting (loafing and sleeping), comfort movements (preening, bathing and stretching), alert, courtship, agonistic (bill threats, chin lifts, chasing and biting), out of sight (broods seen at least once and assumed using peripheral vegetation), and no visible waterfowl activity. The first activity observed for each pair, bird, or group of birds observed during the 5 minute recording time was the activity recorded for the 15 minute period. The activity observed in the majority of ducklings in a brood was recorded for the entire brood.

Location of activities on brood complexes was initially grouped into 3 categories. Location 1 included all excavated channels and pond units, location 2 or the edge area, extended 1 m beyond either side of the rim (natural basin's bottom contour line) of the excavation, and location 3 included spoil banks and islands excluding the area covered by location 2 (Fig. 3). Preliminary analysis showed that 69% of observed activity occurred on location 1, 30% of waterfowl activity occurred on location 2 and only 1% of all recorded activity was observed on location 3. Activity data on location 3 were not analyzed. Pair data, activity and location data, and weather information similar to that taken during pair and brood survey methods were recorded, as well as, species.

Preliminary analysis showed that blue-winged teal comprised 50% of the observations. Other dabbling ducks including mallards,

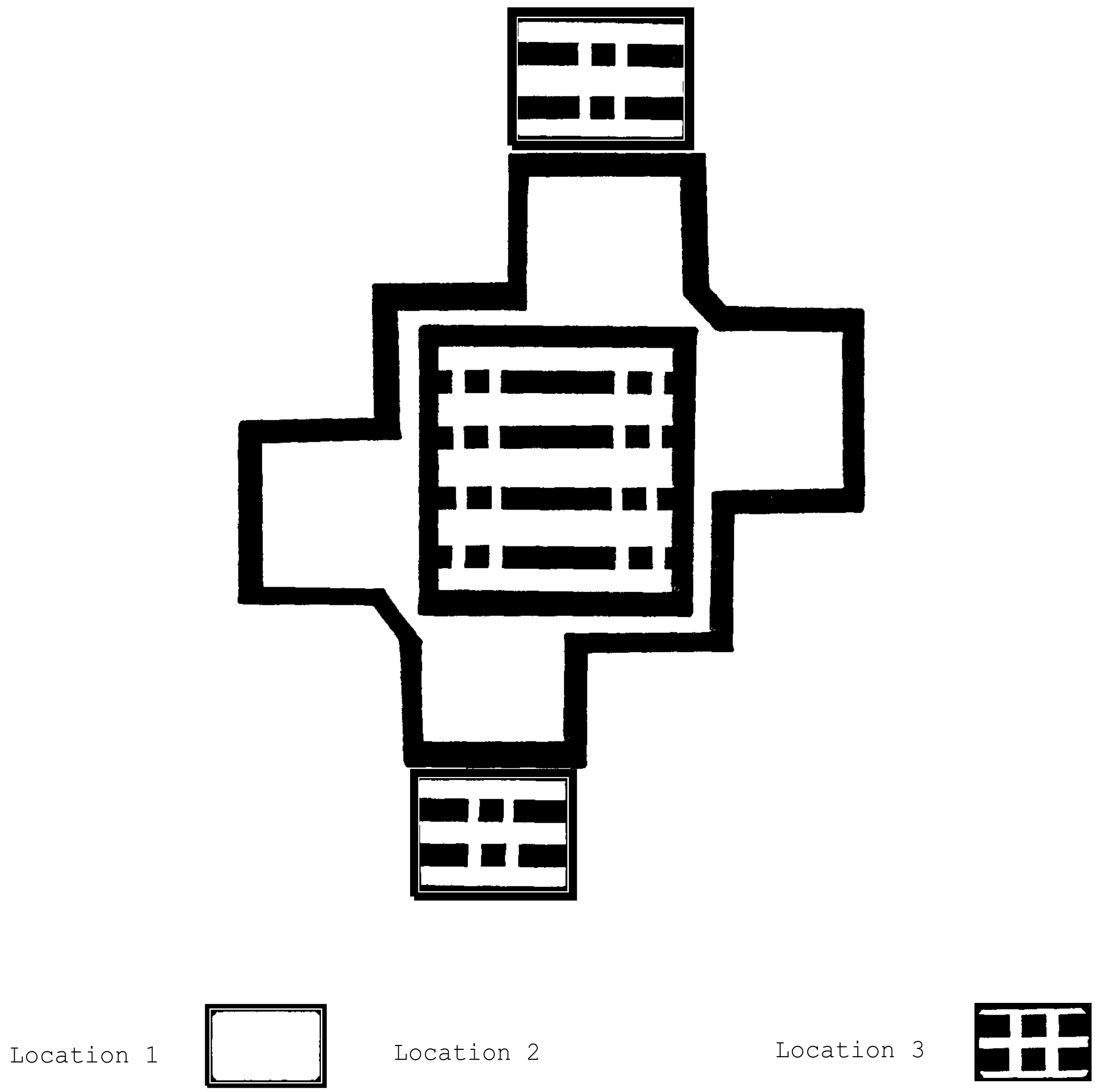


Fig. 3. Location on dug brood complexes included excavated channels and ponds (Location 1), the transition zone between excavated and unmodified portions of the wetland basin or spoil (Location 2), and spoil banks and islands (Location 3).

gadwalls, pintails, wigeon, green-winged teal, shovelers, and a perching duck, the wood duck, occurred in 37% of the observations. Diving ducks such as canvasbacks, redheads, and ruddy ducks comprised approximately 13% of the observations. For the purpose of analysis, species were grouped into 3 categories: blue-winged teal, dabblers excluding blue-winged teal (wood ducks included with other dabblers for convenience), and diving ducks. Too few observations were recorded for activities 5-9 so they were excluded from analysis.

Analysis

Analysis of variance (ANOVA) was used to distinguish differences in waterfowl density and species diversity between modified and unmodified wetland basins in 1981 and 1982. Waterfowl density was defined as pairs or broods/hectare of wetland basin. The Shannon-Weiner Index (Shannon and Weaver 1963) was used to determine the species diversity (H' $\log_2$) for each wetland. The Shannon-Weiner formula takes into consideration the relative abundance of species.

The variables listed in Table 1 were used in stepwise discriminant analysis (Cooley and Lohnes 1971:243-261) to distinguish modified wetlands from unmodified wetlands. Mack and Flake (1980) used habitat characteristics of stockponds to discriminate between stockponds with waterfowl broods and stockponds without broods in South Dakota. In my analysis, modified and unmodified wetlands were discrete dependent variables and all independent variables were continuous. Separate analyses were run for 1981 pair data, 1981 brood data, combined 1982

Table 1. Independent variables used in discriminant function analysis of modified and unmodified wetlands.

Variables	Explanation
Pair and Brood Numbers	
Number of blue-winged teal pairs or broods	Total pairs or broods according to Hammond (1969, 1970)
Number of other dabbler pairs or broods	Total pairs or broods according to Hammond (1969, 1970)
Number of diving duck pairs or broods	Total pairs or broods according to Hammond (1969, 1970)
Number of species pairs or broods	Number of waterfowl species/ wetland
Wetland Characteristics	
Basin size	Hectares of wetland basin
surface water	Percent of basin with water
Hectares of surface water	Total area of surface water
open water	Percent surface water clear of emergent vegetation
Hectares of open water	Total area of water clear of emergent vegetation
Water depth	Maximum depth to nearest 5.0 cm
Open water edge	Length (m) of open water to emergent edge
Exposed mud	Hectares exposed mud
Hectares open water : basin size	Ratio of open water to basin
Hectares surface water : basin size	Ratio of surface water to basin
Hectares exposed mud : hectares open water	Ratio of exposed mud to open water
Vegetation height	Mean emergent vegetation height to nearest 0.5 m
Associated Wetlands	
Distance to nearest semipermanent wetland	Nearest 0.01 km
Number of wetlands within 0.75 km radius	Total count of all wetland types according to Stewart and Kantrud (1971) classification scheme

pair counts, and combined 1982 brood counts. Stepwise discriminant analysis began by selecting the variable that best discriminated between modified and unmodified wetlands. A second best discriminating variable was then selected, which in combination with the first, improved the discriminatory power. Variables were added until little additional discrimination was added to the function. At each step previously selected variables may have been removed if they lowered the discriminatory power of a function (Klecka 1975).

Results of the discriminant function are interpreted as the optimal group of variables, due to interactions among variables that discriminate between wetland types (Klecka 1975). Classification of cases was based on the proportion of cases within each group that was correctly classified using only the major discriminating variables. Wilks' lambda gave an inverse measure of the discriminatory power of the variables that had not yet been removed by the function. Within-group means were examined to determine association of groups with independent variables.

Stepwise multiple regression (Snedecor and Cochran 1967) was used to determine which sets of independent variables had a statistically significant effect on explaining the variation in numbers of waterfowl pairs and broods using wetlands. Total numbers of pairs and broods were each separated into 3 dependent variable categories: (1) blue-winged teal, (2) dabbling ducks other than blue-winged teal, and (3) diving ducks. Regression analyses were used for each category using all wetlands and using only wetlands with dug brood ponds. Analyses using all wetlands indicated which set of variables were important in determining the suitability of wetlands for waterfowl pairs and broods. By using only modified wetlands, analyses indicated which habitat variables were important in determining the suitability of dug brood ponds for waterfowl pairs and broods. Drought conditions in 1981 resulted in poor brood production, therefore, analyses were run just using blue-winged teal pair data and other dabbler pair data. Regression analyses for all 3 categories of pairs and for blue-winged teal and other dabbler broods were run in 1982. Analyses of diving duck pairs (1981) and broods (1981-82) were not possible because few ponds contained any pairs or broods of diving ducks.

In stepwise multiple regression, the 1st variable entered into the equation was the single variable that explained the greatest amount of variation (the greatest reduction in the sum of squares) in the dependent variable (Snedecor and Cochran 1967). A second variable entered the model, which in combination with the first variable, increased the amount of variation explained in the dependent variable. Subsequent variables were similarly included in the model until little variation was left to be explained in the dependent variable. At each step, previously selected variables could be replaced by another variable, when the replacement in combination with other variables already in the model helped to explain a greater amount of variation than was previously explained. This procedure was repeated until all the variables were included, or the investigator terminated the analysis at a predetermined point. Independent variables entered into the analysis are listed in Table 2.

Table 2. Variables used in stepwise multiple regression.

Dependent Variables	Independent Variables
Number of blue-winged teal pairs or broods	Basin size
Number of dabblers other than blue-winged teal pairs or broods	surface water
Number of diving duck pairs or broods	Hectares of surface water
	open water
	Hectares of open water
	Water depth
	Open water edge
	Exposed mud
	Hectares open water : basin size
	Hectares surface water : basin size
	Hectares exposed mud : hectares open water
	Distance to nearest semipermanent wetland
	Number of wetlands within 0.75 km radius
	Emergent vegetation height

Results of stepwise multiple regression were interpreted as the optimal set of variables, or model, that explained the greatest amount of variation in the dependent variable. The coefficient of determination (R^2) indicated the amount of variation in the dependent variable explained by the model of combined independent variables. The partial regression coefficient (b) indicated the relative importance of each independent variable within the multiple regression equation in terms of its ability to predict or estimate the dependent variable (Steel and Torrie 1980).

The direction of association between the independent variable and the dependent variable was determined by the sign (+ or -) of b. The correlation explained between a given independent variable and the dependent variable is influenced by its association with other independent variables in the model, and therefore, must be considered only within the context of the model. In the "Results" and "Discussion" sections, references to associations between variables are only valid within the context of a given model. To determine a direct association between an independent variable and the dependent variable would require an analysis using simple correlation coefficients.

Behavioral data collected on dug brood complexes were analyzed using the FUNCAT procedure as descibed in the Statistical Analysis System User's Guide: Basics (1982) Edition. FUNCAT modeled a function of categorical responses as a linear model and used weighted least squares to produce minimum chi-square estimates (Grizzle et al. 1969). For all chi-square analyses run in this study, the dependent variable was activity (i.e., feeding, resting, swimming and comfort movements). The total number of behavioral observations entered into the anlysis was 1089. Chi-square analysis tested for differences in activity by independent variables such as species, pair and brood categories, season (breeding and brood rearing), time of day, and location on brood complex. Block charts depict observation totals for the 4 activities by combinations of 2 independent variables.

RESULTS

Pair and Brood Surveys

Waterfowl pair surveys revealed that, averaged over both years, blue-winged teal comprised 42.5% and 56% of all ducks on modified and unmodified wetlands in 1981-82 (Table 3). In order of decreasing abundance, blue-winged teal, mallard, gadwall and northern pintail were the most common ducks on both types of wetlands during both years. Six percent of all ducks on modified wetlands were diving ducks, redheads and ruddy ducks, compared to 0.6% diving ducks on unmodified wetlands. Under drought conditions in 1981, there was no significant difference ($p > 0.05$) in pair density but there was a significant difference ($p < 0.05$) in pair species diversity between modified and unmodified wetlands (Table 4). The mean species diversity (H' log2) for modified wetlands was 1.84 as compared to 1.08 for natural basins. With improved water conditions in 1982, no significant differences ($p > 0.05$) were found in indices of pair use or species diversity between wetland types (Table 5).

By 15 July 1981, 75% of the study areas were dry. Water remained only in the excavated portions of four modified wetlands. Brood production in 1981 was low or zero on all study sites (Table 6) and there were no significant differences ($p > 0.05$) in brood density or brood species diversity between modified and unmodified basins (Table 4). With deeper water conditions in 1982, there was both a significantly higher ($p < 0.05$) brood density and brood species diversity on modified wetlands than on unmodified wetlands (Table 5).

Table 3. Number of pairs of waterfowl counted on 8 modified (M) and 8 unmodified (UM) wetlands in east-central South Dakota, 1981-82.

Species	1981 Single count[a] M	1981 Single count[a] UM	1982 1st count[b] M	1982 1st count[b] UM	1982 2nd count[c] M	1982 2nd count[c] UM	2 year mean[d] M	2 year mean[d] UM	Percent of mean total M	Percent of mean total UM
Blue-winged teal	45	51	54	30	40	30	42.5	40.5	42.5	55.9
Mallard	26	16	20	19	6	8	23.0	17.5	23.0	24.1
Gadwall	22	9	6	6	4	2	13.0	5.5	13.0	7.6
Northern pintail	13	3	4	7	1	3	8.5	5.0	8.5	6.9
Northern shoveler	4	5	16	3	2	0	3.0	2.5	3.0	3.4
Green-winged teal	3	1	3	3	3	0	3.0	0.5	3.0	0.7
American wigeon	1	1	2	0	0	0	0.5	0.5	0.5	0.7
Wood duck[e]	0	0	0	0	1	0	0.5	0.0	0.5	0.0
Total dabblers	114	86	105	68	57	43	94.0	72.0	94.0	99.3
Canvasback	0	0	0	0	0	0	0.0	0.0	0.0	0.0
Redhead	0	0	6	2	8	1	4.0	0.5	4.0	0.7
Lesser scaup	0	0	2	1	0	0	0.0	0.0	0.0	0.0
Ruddy duck	0	0	0	0	6	0	2.0	0.0	2.0	0.0
Bufflehead	0	0	1	0	0	0	0.0	0.0	0.0	0.0
Total divers	0	0	9	3	14	1	6.0	0.5	6.0	0.7
TOTAL	114	86	114	71	71	44	100.0	72.5	100.0	100.0

[a] 18-20 May.

[b] 1-6 May.

[c] 3-7 June.

[d] 1981 count and second count in 1982 for all species except mallard and pintail (single count 1981 and first count 1982).

[e] Wood duck included with dabblers for analysis purposes.

Table 4. Analysis of variance of numbers and species diversity of waterfowl pairs and broods between modified and natural wetland basins in drought conditions, 1981.

Source of variation	Degree of freedom	Mean square	F-value
TRT: Number of pairs	1	0.0420	0.11
Date[a]	0	0.0000	
TRT X date	0	0.0000	
Error	14	0.3746	
TRT: Pair species diversity	1	2.3562	7.56[b]
Date[a]	0	0.0000	
TRT X date	0	0.0000	
Error	14	0.3118	
TRT: Number of broods	1	0.0357	2.10
Date[c]	1	0.0003	0.02
TRT X date	1	0.0063	0.37
Error	28	0.0171	
TRT: Brood species diversity	1	0.0639	0.29
Date[c]	1	0.0770	0.35
TRT X date	1	0.0770	0.35
Error	28	0.2176	

[a] 18-20 May 1981.

[b] Significant at the 0.05 level of probability.

[c] 15-26 June and 13-16 July 1981.

Table 5. Analysis of variance of numbers and species diversity of waterfowl pairs and broods between modified and natural wetland basins, 1982.

Source of variation		Degree of freedom	Mean square	F-value
TRT:	Number of pairs	1	1.2920	3.45
Date[a]		1	0.1582	0.42
TRT X date		1	0.0001	0.00
Error		28	0.3740	
TRT:	Pair species diversity	1	2.0402	3.23
Date[a]		1	1.1026	1.74
Trt X date		1	0.0136	0.02
Error		28	0.6321	
TRT:	Number of broods	1	0.4255	10.07[b]
Date[c]		1	0.0132	0.31
TRT X date		1	0.0603	1.43
Error		28	0.0422	
TRT:	Brood species diversity	1	5.1360	11.87[b]
Date[c]		1	0.4186	0.97
TRT X date		1	0.4186	0.97
Error		28	0.4327	

[a] 1-6 May and 3-7 June 1982.

[b] Significant at the 0.01 level of probability.

[c] 23 June-3 July and 27 July-4 August 1982.

Table 6. Number of broods counted on 8 modified (M) and 8 unmodified (UM) wetlands in east-central South Dakota, 1981-82.

	1981[a]		1982	
	Total broods		Total broods	
Species	M	UM	M	UM
Blue-winged teal	5	1	24	1
Mallard	3	2	4	0
Gadwall	1	0	5	0
Northern pintail	4	1	11	2
Northern shoveler	0	0	1	0
Green-winged teal	0	0	2	0
American wigeon	0	0	1	0
Unidentified	0	0	1	1
Total dabblers	13	4	49	4
Ruddy duck	0	0	1	0
Canvasback	0	0	0	0
Lesser scaup	0	0	0	0
Redhead	0	0	0	0
Total divers	0	0	1	0
TOTAL	13	4	50	4

[a]Drought conditions existed in 1981.

Nest Searches

In 1981 there were 0.53 duck nests/ha and 0.81 pheasant nests/ha of island cover (Table 7). In 1982 there were 0.94 duck nests/ha and 1.18 pheasant nests/ha of island cover. Mallards and gadwalls were the most likely waterfowl species to nest on islands. All nests were located in mixed grasses and forbs dominated by smooth brome (*Bromus inermis*) and nests were generally well concealed. Gadwalls nested further from water than mallards. Pheasants often nested on islands where nettle (*Urtica* spp.) was a major component of the vegetative cover. Pheasant nests were very well concealed and nests were located within 16 m of water.

Differences in Morphometric Characteristics and Waterfowl Use Between Wetland Types

Stepwise discriminant analysis revealed that in spring 1981, the ratio of hectares of surface water to hectares of basin accounted for 50% of the variability between modified and unmodified wetlands (Table 8). Ninety-five percent of the variability between wetland types could be explained by the addition of variables, numbers of species, numbers of blue-winged teal pairs and water depth. The 4 variable function correctly classified 100% of the modified wetlands and 100% of the unmodifed wetlands. Based on within-group means, blue-winged teal pairs were more likely to select unmodifed basins over modified wetlands, and unmodified wetlands had a higher ratio of surface water to basin size. Within-group means for total number of species showed that

Table 7. Results of nest searches on dug brood complexes in east-central and southeastern South Dakota. In 1981 and 1982, 6 and7 islands were searched, respectively.

Species	No. nests	% abandoned	% destroyed	Dominant vegetation	$\bar{X}$ clutch size	$\bar{X}$ overall concealment[a]	$\bar{X}$ dist. shoreline (m)
1981 Results[b]							
Gadwall	1	0.0	0.0	Smooth brome	11	4	30
Blue-winged teal	1	0.0	100.0	Smooth brome	NK[c]	1	10
Pheasant	3	0.0	0.0	Smooth brome, Nettle	14	4	16
1982 Results[d]							
Gadwall	1	0.0	0.0	Smooth brome	11	3	30
Mallard	3	0.0	67.0	Smooth brome	12	2	8
Pheasant	5	0.0	40.0	Nettle, River bulrush	10	3	8

[a]Overall concealment: 1 = poor, 2 = fair, 3 = good, 4 = excellent.

[b]1981: 0.53 duck nests/ha
0.81 pheasant nests/ha

[c]NK = Not known.

[d]1982: 0.94 duck nests/ha
1.18 pheasant nests/ha

Table 8. Major independent variables discriminating between wetlands with dug brood complexes (modified) and unmodified wetlands as indicated by stepwise forward discriminant analysis.

Group	No. of cases	% correctly classified	Major discrim. variable[a] and Wilks' lambda ( )[b]	Within-group means Modified	Within-group means **Unmodified**
Pair Count 1981					
Modified vs.	8	100.00	Surface water : basin size (ha) (0.502686)	0.05	0.49
Unmodified	8	100.00	Total no. species (0.181924)	4.50	3.25
			No. blue-winged teal (0.076376)	5.62	9.25
			Water depth (cm) (0.044874)	56.87	37.50
Brood Count 1981					
Modified vs.	8	100.00	% open water (0.277058)	80.63	3.75
			Exposed mud (ha) (0.046979)	0.95	0.00
Unmodified	8	100.00	Water depth (cm) (0.036265)	38.75	28.75
Pair Counts 1982					
Modified vs.	8	100.00	Water depth (cm) (0.444164)	116.25	48.13
Unmodified	8	100.00	open water (0.167452)	55.31	5.63
			Open water : basin size (ha) (0.128731)	0.10	0.05
Brood Counts 1982					
Modified vs.	8	100.00	Water depth (cm) (0.410188)	109.38	44.19
Unmodified	8	100.00	Exposed mud : basin size (ha) (0.182354)	0.07	0.00
			Surface water : basin size (ha) (0.131516)	0.35	0.62

[a]Major independent discriminating variables are listed in the order of their ability to discriminate between groups. The ability of each variable is dependent on the ability of the variables listed prior to it.

[b]inverse measure of the discriminatory power of the variables which had not yet been removed by the function.

modified wetlands attracted a greater number of waterfowl species. Generally, modified basins were deeper.

As wetland water conditions deteriorated during the 1981 brood rearing season, % open water, hectares of exposed mud, and water depth explained 96% of the variability between wetland types. These factors alone correctly classified 100% of each wetland type. Water remaining in wetlands was almost exclusively confined to excavated portions of modified basins. Modified basins averaged 1 ha of exposed mud per basin.

Water conditions improved in 1982. During spring pair counts, water depth, percent open water and hectares of open water accounted for 87% of the variability between modified and unmodified wetlands (Table 8). The 3 variable function correctly classified 100% of the modified basins and 100% of the unmodified basins. Based on within-group means, wetlands with brood complexes were deeper and more open than unmodified wetlands. From the waterfowl breeding season into the brood rearing season, water depth changed very little while wetland vegetation on modified wetlands changed to favor a more densely vegetated pattern. Variables such as water depth, ratio of exposed mud to basin size and ratio of surface water to basin size explained approximately 87% of the variability between wetland types (Table 8). These variables alone correctly classified all modified and all unmodified wetlands.

Factors Influencing Waterfowl Numbers on Wetlands

In the results and discussion sections, stepwise multiple regression analysis was interpreted as the optimal set of variables, or model, that explained the greatest amount of variation in the dependent variable. The direction of association between the independent variable and the dependent variable was determined by the sign (+ or -) of b. The correlation explained between a given independent variable and the dependent variable is influenced by its association with other independent variables in the model, and therfore, the direction of association between two variables must be considered only within the context of the model.

During the 1981 pair count (Table 9), the combination of habitat variables, basin size, height of emergent vegetation, and number of wetlands within a 0.75 km radius accounted for 84% of the variation in number of blue-winged teal pairs utilizing modified wetlands ($p < 0.05$). All variables in this model were positively associated (according to sign of b) with blue-winged teal pair numbers. When all wetlands were analyzed, basin size, hectares of surface water, and ratio of open water to basin size, in combination, explained 86% of the variation in number of blue-winged teal pairs using all wetlands ($p < 0.01$). Each of these variables was positively associated with blue-winged teal pair numbers.

On modified wetlands, dabbling ducks other than blue-winged teal (predominantly mallard, gadwall, and northern pintail), were positively associated with height of emergent vegetation, open water

Table 9. Stepwise multiple regression analysis[a] of blue-winged teal pairs and habitat variables for both modified basins and all wetlands for the 1981 pair count.

Dependent variable	Prob. level	Independent variables	Partial regress. coef. (b)	Intercept	Coef. determination (R^2) for model
Modified Wetlands					
Blue-winged teal pairs	P < 0.05	Basin size (ha)	+ 0.3117	- 19.2532	.8427
		Vegetation height (m)	+ 7.8896		
No. of pairs = 45		No. wetlands within 0.75 km radius	+ 0.7383		
All Wetlands					
Blue-winged teal pairs	P < 0.01	Basin size (ha)	+ 0.3798	- 4.2070	.8640
		Surface water (ha)	+ 0.7348		
No. of pairs = 96		Open water (ha) : basin size (ha)	+42.4712		

[a] Variables listed in combination explain variation in the dependent variable.

Table 10. Stepwise multiple regression analysis [a] of dabblers (other than blue-winged teal) and habitat variables for both modified basins and all wetlands for the 1981 pair count.

Dependent variables	Prob. level	Independent variables	Partial regress. coef. (b)	Intercept	Coef. determination (R^2) for model
Modified Wetlands					
Other dabbling duck pairs	$P < 0.05$	Vegetation height (m)	+ 22.2705	- 34.7727	.8924
		Open water edge (m)	+ 0.0088		
No, pairs = 69		No. wetlands within 0.75 km radius	+ 0.9263		
All Wetlands					
Other dabbling duck pairs	$P < 0.01$	Basin size (ha)	+ 0.4035	- 18.7400	.7051
		Vegetation height (m)	+ 10.2329		
No. pairs = 104		No. wetlands within 0.75 km radius	+ 0.3497		
		Water depth (cm)	+ 0.0776		

[a]Variables listed in combination explain variation in the dependent variable.

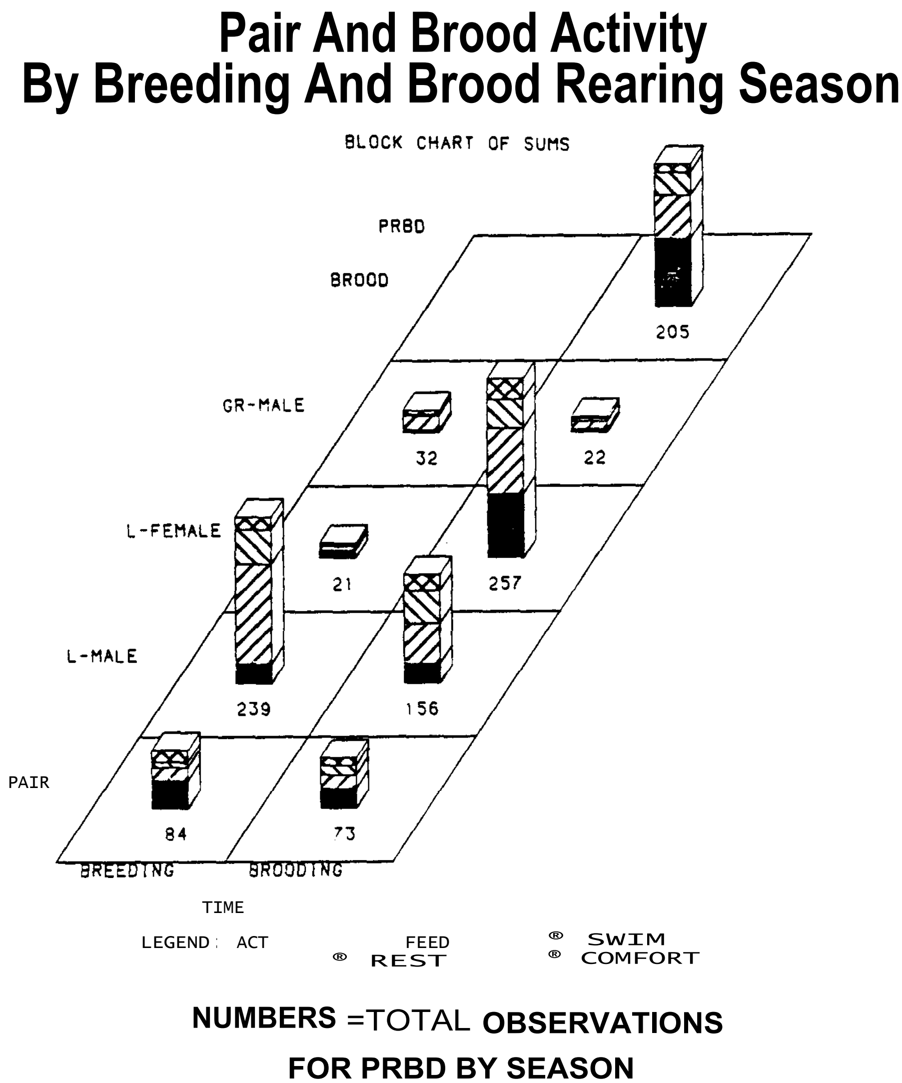


Fig. 4. Pair and brood activity by breeding and brood rearing season on dug brood complexes in east-central South Dakota. Social categories (PRBD) included broods (BROOD), group males (GR-MALE), lone females (L-FEMALE), lone males (L-MALE), and pairs (PAIR).

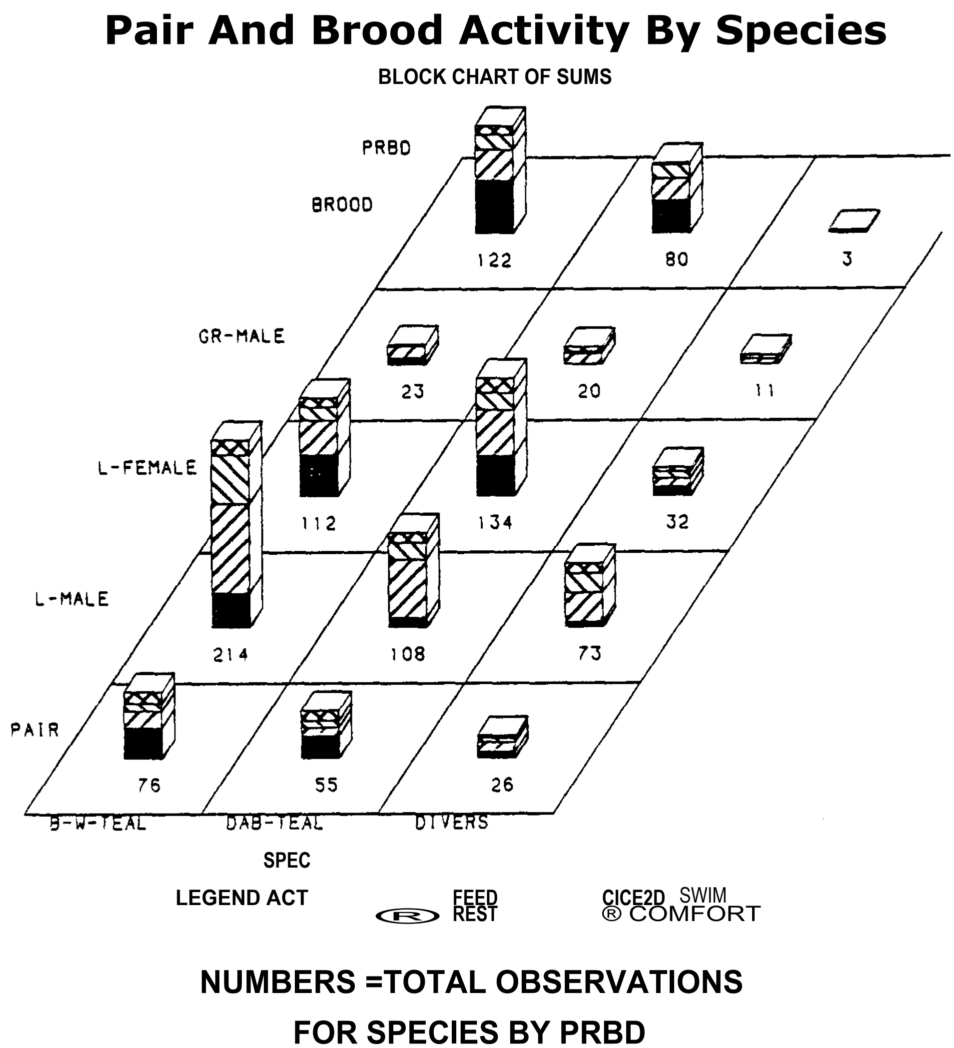


Fig. S. Pair and brood activity by season on dug brood complexes in east-central South Dakota. Social categories (PRBD) included broods (BROOD), group males (GR-MALE), lone females (L-FEMALE), lone males (L-MALE), and pairs (PAIR). Waterfowl pairs (SPEC) were grouped into 3 categories: blue-winged teal (B-W-TEAL), dabbling ducks other than blue-winged teal (DAB-TEAL), and diving ducks (DIVERS).

during the brood rearing season. Feeding was the most visible activity observed in broods while females with and without broods spent similar amounts of time feeding and swimming.

There was a significant difference ($p < 0.05$) among species activity and a highly significant difference ($p < 0.01$) in activity by pair and brood category in the 2nd analysis (Table 15). Blue-winged teal was the most common species observed on dug brood complexes (Fig. 5). In the 3rd analysis, there was a highly significant difference ($p < 0.01$) in waterfowl activity by time of day and in activity by pair or brood category (Table 15). Broods were most visible in the morning and evening (Fig. 6). Lone female activity peaked in the evening, while lone males, grouped males, and paired birds were visibly more active during mid-day. Greatest feeding activity by broods was observed from 0600-1000 CDT. Lone males were observed swimming more frequently during mid-day as compared to morning and evening. Lone females showed little change in activity pattern throughout the day (Fig. 6).

In the 4th analysis, there was a highly significant difference ($p < 0.01$) in activity by time of day and a significant difference ($p < 0.05$) in the interaction of activity by time of day and activity by species (Table 15). Activities among species varied according to the time of day. Blue-winged teal were frequently observed feeding in the morning and evening while swimming activity was most visible during mid-day (Fig. 7). A similar trend was visible in dabbling ducks other than blue-winged teal. Diving duck activity peaked during mid-day.

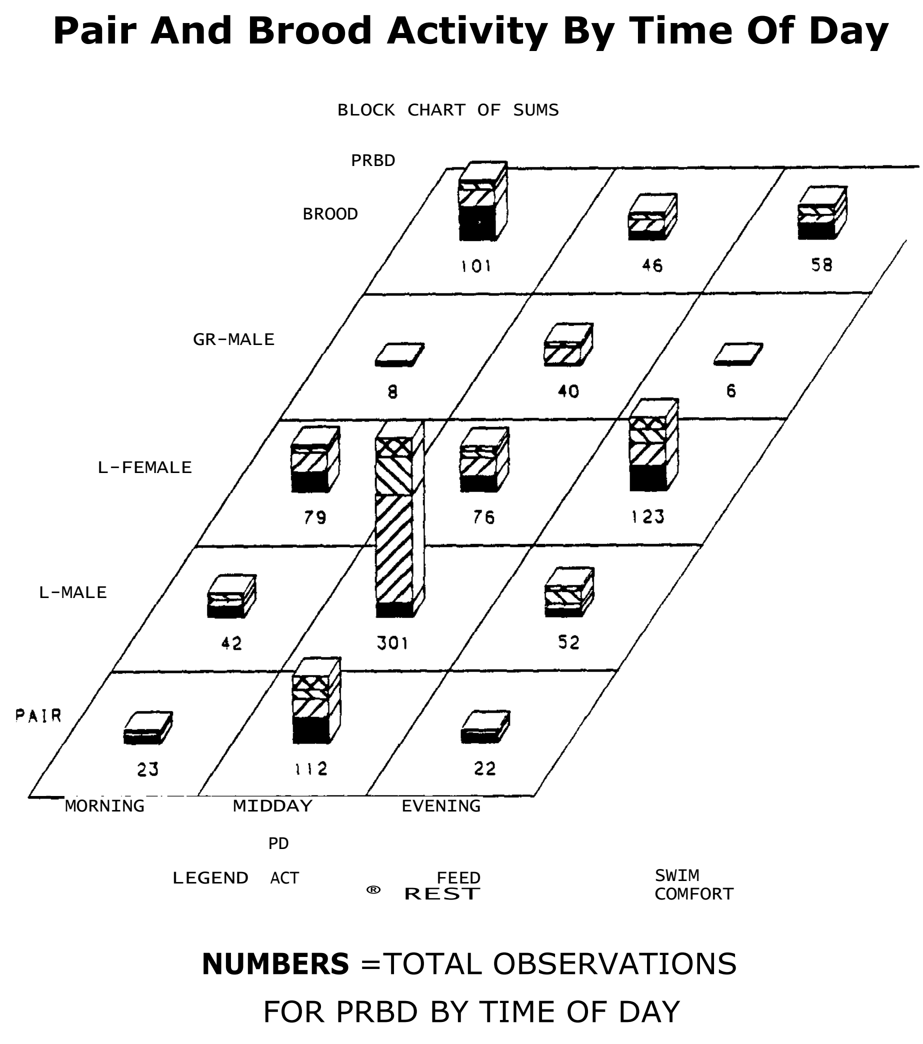
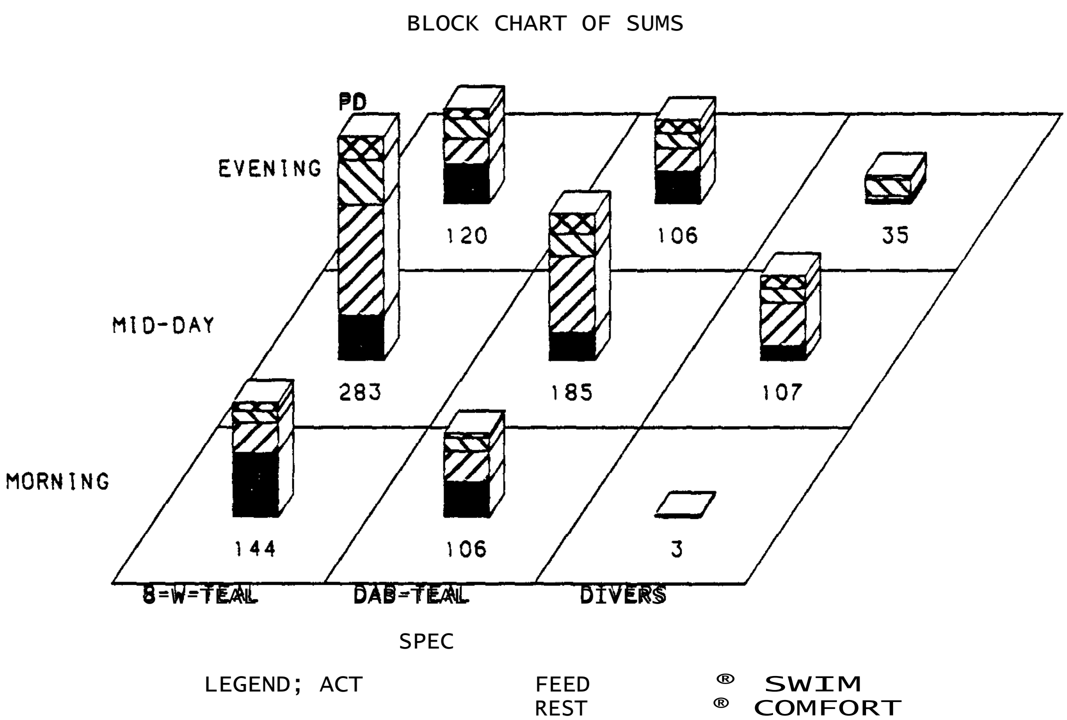


Fig. 6. Pair and brood activity by time periods 0600-1000 CDT (morning), 1000-1700 CDT (mid-day), and 1700-2100 CDT (evening), on dug brood complexes in east-central South Dakota. Social categories (PRBD) included broods (BROOD), group males (GR-MALE), lone females (L-FEMALE), lone males (L-MALE), and pairs (PAIR).

Species Activity By Time Of Day



NUMBERS = TOTAL OBSERVATIONS FOR SPECIES BY TIME OF DAY

Fig. 7. Species activity by time periods 0600-1000 CDT (morning), 1000-1700 CDT (mid-day), and 1700-2100 CDT (evening), on dug brood complexes in east-central South Dakota. Waterfowl pairs (SPEC) were grouped into 3 categories: blue-winged teal (B-W-TEAL), dabbling ducks other than blue-winged teal (DAB-TEAL), and diving ducks (DIVERS).

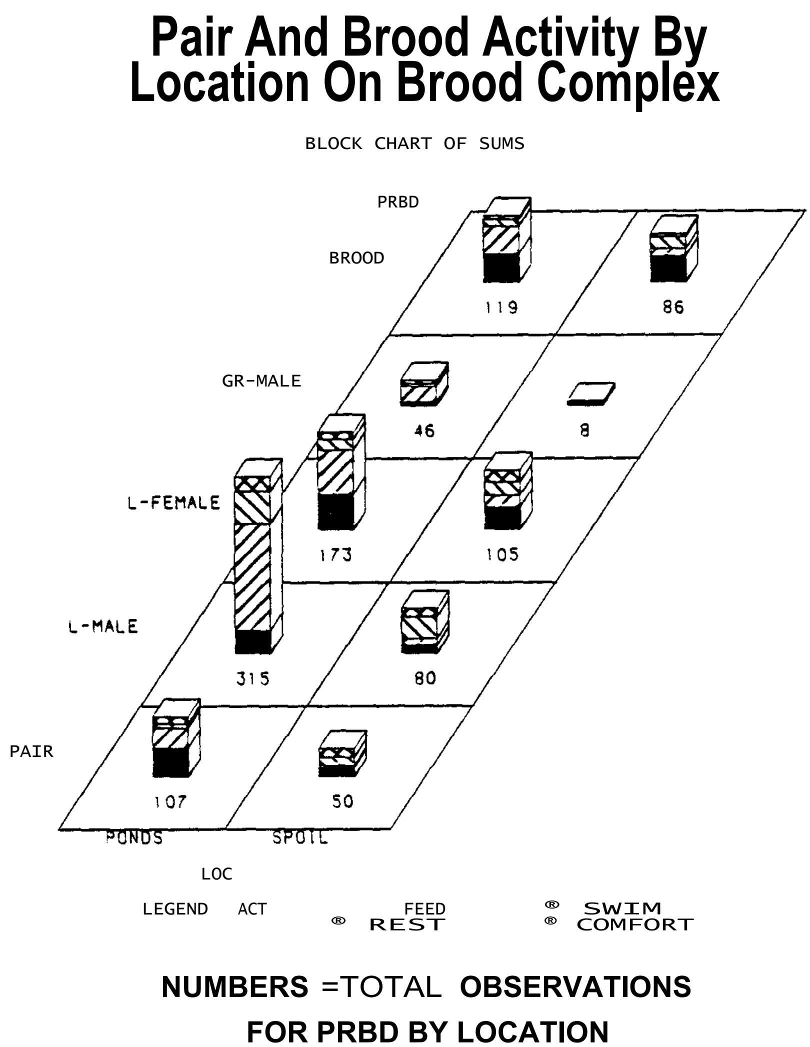


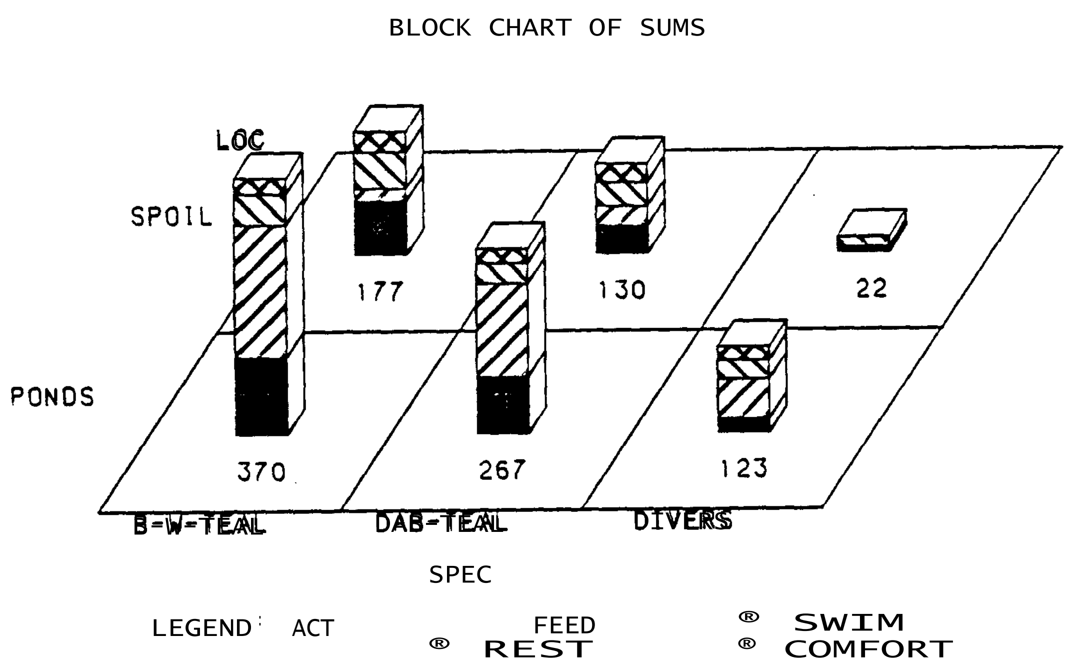
Fig. 8. Pair and brood activity by location on dug brood complexes in east-central South Dakota. Social categories (PRBD) included broods (BROOD), group males (GR-MALE), lone females (L-FEMALE), lone males (L-MALE), and pairs (PAIR). Locations on dug brood complexes (LOC) included all excavated ponds and channels (PONDS) and the edge area between excavated ponds or channels and the upland habitat of spoil islands or banks (SPOIL).

In the 5th analysis, location on brood complex was entered into the analysis to see if waterfowl activity varied by location on brood complexes A highly significant difference ($p < 0.01$) in waterfowl activity was found by location and by waterfowl age, sex and social grouping (Table 15). Generally, ponds and channels were most frequently used for feeding and locomotor activities by pairs, lone males, lone females, and grouped males. Broods used ponds, channels and edge areas equally for feeding while favoring deeper water for swimming (Fig. 8). Comfort movements by all species occurred on channels, ponds and edge areas.

Species activity by location on the brood complex, revealed a highly significant difference ($P < 0.01$) in both activity by species and activity by location. A significant difference ($p < 0.05$) in species activity by location interaction occurred (Table 15). Apparently, species activity varied according to location on the brood complex. Visible locomotor activities for the 3 species groups were more likely to occur on ponds and channels while feeding, resting and comfort movements were prevalent on both locations (Fig. 9).

A FUNCAT analysis was used to determine the effects of wind, temperature and cloud cover on waterfowl visibility. Preliminary findings suggested that waterfowl tended to be most active when wind speed was less than 24 km/hr, temperatures ranged from 24 C - 29 C, and cloud cover was 25% or less. Lowest visibility occurred when temperatures were less than 24 C, cloud cover was at or near 100% and wind speed exceeded 24 km/hr.

Species Activity By Location On Brood Complex



NUMBERS = TOTAL OBSERVATIONS FOR SPECIES BY LOCATION

Fig. 9. Species activity by location on dug brood complexes in east-central South Dakota. Locations on dug brood complexes (LOC) included all excavated ponds and channels (PONDS) and the edge area between excavated ponds or channels and the upland habitat of spoil islands or banks (SPOIL). Waterfowl pairs (SPEC) were grouped into 3 categories: blue-winged teal (B-W-TEAL), dabbling ducks other than blue-winged teal (DAB-TEAL), and diving ducks (DIVERS).

DISCUSSION

The primary reason for excavating dug brood complexes in Class IV wetlands in eastern South Dakota was to provide permanent brood rearing habitat and to lessen overland movements of ducklings during drought. Under drought conditions of 1981, few, if any duckling broods were observed using either modified or unmodified wetlands as almost all basins became dry by the brood rearing season (Table 6). However, under improved wetland water conditions in 1982, a significantly greater number of broods/ha ($p < 0.01$) was observed using modified wetlands as compared to unmodified basins (Table 5). There was also a significantly greater brood species diversity ($p < 0.01$) on dug brood complexes than on unmodified wetlands of similar basin size and wetland class (Table 5). Both stepwise discriminant analysis and stepwise multiple regression indicated that a combination of wetland characteristics, such as area of basin surface water, area of open water, and maximum water depth may have been responsible for differences in waterfowl pair and brood use between wetland types. Excavated portions of modified wetlands tended to have a greater maximum water depth than unmodified wetlands.

Stepwise multiple regression analysis for broods on unmodified wetlands in 1982 indicated that blue-winged teal and other dabbler broods increased as surface water and open water increased. Berg (1956) and Evans and Black (1956) recorded few broods on ponds less than 0.2 ha in size. Lokemoen (1973) seldom saw broods on man-made ponds with less than 0.04 ha of surface water. Lokemoen (1973) reported that as pond area increased, the number of broods per pond increased; but the highest number of broods was found on intermediate-sized ponds 0.4 - 0.8 ha in size.

Generally, broods were more numerous on the deeper modified wetlands. However, a slight, negative association of water depth with blue-winged teal brood numbers indicated that blue-winged teal appeared to be slightly more tolerant of shallower modified wetlands than other dabbling ducks. According to Evans et al. (1952), water depth was an important factor influencing the selection of wetlands by ducklings. During low water, wetland water depths greater than 60 cm were preferred to shallow areas. Berg (1956) found that waterfowl brood movements, in general, went from ponds with greater to those with less water loss. Talent et al. (1982) found that mallard broods used only semipermanent wetlands during drought in south-central North Dakota. Perhaps the more stable water conditions and open water habitat provided by modified wetlands in 1982 were attractive to waterfowl broods. Other factors, not measured in this study, such as food availability and adundance, and quality of upland nesting cover also may have had an effect on waterfowl brood use between wetland types.

Added benefits of dug brood complexes were speculated to be higher production from additional waterfowl pair use, additional nesting habitat provided by spoil banks and islands, and deep, open water habitat for diving ducks where previously none existed. In both 1981 and 1982, blue-winged teal comprised approximately 50% of all waterfowl observed on each type of wetland. Mallards, gadwalls and northern pintails, in order of decreasing abundance, were the next most frequently observed waterfowl species on both modified and unmodified wetlands (Table 3). Brewster et al. (1976) determined breeding waterfowl populations and their distribution in South Dakota and found a similar trend with the exception of northern pintails which were slightly more common than gadwalls. Gadwalls have been found to heavily colonize impounded areas in eastern North America (Henny and Holgersen 1974). In my study, the high incidence of gadwall pairs on modified wetlands in 1981, may have been a response by gadwalls to persisting water on dug brood ponds in early spring.

Although there was no significant difference in pair densities between wetland types in either 1981 or 1982, there was a significantly greater pair species diversity on modified wetlands under poor water conditions in 1981 (Table 4). In spite of the 1981 drought, total number of pairs for all study areas exceeded total number of pairs on all study areas in 1982 (Table 3). With drought on the prairie pothole region, waterfowl may home to natal areas and quickly fill the suitable habitat (Smith 1971), pioneer to more northern latitudes (Smith 1970, Pospahala et al. 1974), or immigrate to areas where water persists (Kaminski and Prince 1981). Most semipermanent wetlands held some water in spring 1981, whereas, most temporary and seasonal wetlands in the region were dry. It is likely then, that waterfowl were attracted to shallow semipermanent basins in 1981, because water in semipermanent wetlands was the only water available.

In May and early June 1981, field observations revealed that shallow, open excavations on modified wetlands and shallow unmodified basins with little new vegetative growth had large concentrations of invertebrates. According to Krapu (1974) and Swanson et al. (1974), shallow water was of critical value to the nutritional and breeding status of pintails and blue-winged teals, respectively. It is possible that the large numbers of waterfowl pairs in 1981 on shallow wetlands were attracted to the temporary, but abundant food supply.

Construction of islands may enhance productivity of wetlands for waterfowl in areas where nesting ccver is limited. Nesting waterfowl have been known to be attracted to islands (Johnson et al. 1978, Duebbert 1966, Vermeer 1970). In this study, mallards and gadwalls were most likely to nest on dug brood complex islands in east-central South Dakota. Giroux (1981) found that mallards and gadwalls were the most common dabbling duck nesters on artificial islands in southeastern Alberta. In Giroux's study, the mean density of nests was from 1.8 to 29.1 nests/ha. Johnson et al. (1978) found that waterfowl nests/hectare averaged 135 nests on small man-made islands in North Dakota. Densities of nesting ducks observed in my study were somewhat lower than other densities reported on islands in the prairie pothole region (Drewien and Fredrickson 1970, Hines 1975). Several factors, however, distinguish dug brood complex islands from the above mentioned artificial islands. Dug brood complex islands tended to be considerably larger (0.7 ha as compared to 0.003 ha in Johnson et al. 1978), water levels could not be manipulated, and generally, islands were separated from dry land by narrow channels along portions of each island. Poor water conditions in 1981 and inadequate nesting cover may have been partially responsible for low nesting densities on dug brood complex islands.

Nesting density and success may be improved on brood complexes if islands are constructed substantially smaller (Johnson et al. 1978) and further from the basin edge (Hammond and Mann 1956). Giroux (1981) recommended small, rectangular islands about 0.1 ha, 25 m wide and 40 m long. Rectangular islands provide a greater ratio of water-land edge to land mass than circular, elliptical or square islands. Hammond and Mann (1956) suggested close spacing of islands to serve as a break from wind and wave action. However, clustering of islands can increase vulnerability to predation (Sherwood 1968, Giroux 1981). Though distances of greater than 100 m between islands and upland are recommended by Hammond and Mann (1956) and Giroux (1981), this is not practical on most densely vegetated wetlands such as those selected for modification in the Madison Wetlands Management District. However, in the event of further construction of modified wetlands, serious consideration should be given to creating smaller islands, to island shape, and to the spacing of islands from one another and the basin edge.

Combined pair count data for 1981 and 1982, revealed that 6% of all paired ducks on modified wetlands included redheads and ruddy ducks as compared to 0.6% diving ducks on unmodified wetlands (Table 3). It appeared that under suitable water conditions, diving ducks were attracted to the deep, open water habitat provided by dug brood ponds. Stepwise multiple regression revealed that diving duck pair numbers on modified wetlands increased as percent surface water and hectares of open water increased. Number of diving duck pairs decreased on larger modified basins. The larger brood complex wetlands tended to have less surface water to basin acreage and less open water as compared to smaller modified wetlands. Regression analysis also indicated that as distance to the nearest semipermanent wetland increased, number of diving duck pairs decreased which may indicate that diving duck home ranges require a complex of semipermanent wetlands.

For both blue-winged teal and other dabbler pairs on modified wetlands in 1981, regression analysis revealed that height of emergent vegetation was positively associated with pair numbers. Generally, new vegetation growth indicated the presence of at least some moisture in a wetland basin during drought. Wetlands that were dry in early spring showed little new emergent growth. Waterfowl may have been attracted to the surface water and available food supply in wetlands with new emergent growth. Number of wetlands within a 0.75 km radius also was positively associated with pair numbers on all wetlands in 1981. According to Stewart and Kantrud (1974), populations of dabbling ducks, as a group, show a high correlation with densities of wetlands of all types. Basin characteristics, such as basin size, area of open water and area of surface water were frequently associated with pair numbers. Basin size was positively associated with blue-winged teal pair numbers on all wetlands in 1981 and 1982 and with other dabbler pair numbers on all wetlands in 1981. Basin size was negatively correlated with diving duck pairs in 1982. Diving ducks were most frequently observed on the smaller, deeper modified basins. Surface water area and ratio of open water to basin size were generally, positively associated with waterfowl pair numbers (except diving ducks) on all wetlands. According to Lokemoen (1973), as man-made pond size increased, total waterfowl pairs per pond increased in western North Dakota. Flake et al. (1977) found that gadwalls and mallards were positively associated with surface water area in their study of breeding waterfowl on South Dakota stockponds in northwestern South Dakota.

Unlike 1981, emergent vegetation height in 1982 was negatively associated with blue-winged teal and other dabbling duck pair numbers on all wetlands. Apparently, waterfowl were more likely to select wetlands with low vegetation growth over wetlands with tall emergent growth. Generally, vegetation responded to the drawdown and subsequent reflooding with tall, dense new growth in 1982. Hubbard (1979) suggested that lone males on waiting sites require good visibility and may select low vegetation so that they are more visible to hens coming off nests.

The behavioral study revealed greatest use of dug brood ponds by lone males in the breeding season. Brood complexes appear to be important to paired males as waiting sites while hens are on the nest. Brewster et al. (1976) indicated that as the breeding season progresses, lone males less frequently associate with hens and appear solitarily on waiting stations. Few observations made on lone females during the breeding season indicated that females associated with dug brood complex wetlands were either observed within a pair or already on the nest.

In the brood rearing season, females accompanied by broods were most frequently observed on brood ponds. Broods were most visible in the morning and evening and peaks in feeding activity corresponded with peaks in visibility. Chura (1963) observed diurnal peaks in mallard brood activity which correlated with feeding activity. He found greater amounts of food in duckling stomachs in morning and evening than during afternoon. Swanson and Sargeant (1972) also speculated that brood movements and habitat use patterns were largely influenced by the emergence and activity patterns of insect food resources.

Blue-winged teal were the most common species observed on dug brood complexes. These observations corresponded to the predominance of blue-winged teal in pair and brood counts in 1981-82 and to work done by Brewster et al. (1976). Waterfowl used ponds and channels most frequently for feeding and locomotor activities. Broods tended to favor shallow, flooded emergents (edge areas) for feeding while selecting open channels and ponds for swimming. Collias and Collias (1963) found that the distribution of age-class I broods was correlated with the abundance of invertebrate food. Invertebrates were found in and out of emergent plant cover. In contrast, vegetative food items were usually in submergent vegetation which grow most abundantly in open areas. As duckling age increased, Sugden (1973) observed that the consumption of vegetative matter increased while consumption of invertebrate matter decreased. The majority of observations in my study were made on younger broods, in part, because behavioral observation was terminated 1 August 1981-82. Thus, it appears that the food resource in edge areas on dug brood ponds are especially important to young broods. Furthermore, young ducklings are physically limited in their ability to use deep water food resources (Ringelman and Flake 1980) and may depend on easily obtained food items associated with flooded edge areas of dug brood ponds.

In this study I observed decreases in waterfowl visibility when wind speed exceeded 24 km/hr and temperatures exceeded 29 C or dropped below 24 C. Diem and Lu (1960) observed that broods moved into dense emergents when temperatures were between 26.7 C and 32.2 C while at moderate temperatures, broods selected more open areas. They also noticed that fewer broods were observed when wind speeds were greater than 24 km/hr.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

1. With severe drought conditions in 1981, Class IV wetlands with dug brood complexes and control wetlands in east-central South Dakota did not maintain adequate water levels for duck use, and therefore, produced few or no ducks.
2. With improved water conditions in 1982, there were greater brood densities and brood species diversities on wetlands with excavated ponds than on unmodifed wetlands of similar class and size. This may be attributed to more open water, deeper water in excavated ponds and channels, and a greater edge effect in modified wetlands than in control wetlands.
3. Generally, pair and brood use of modified wetlands increased as surface water area, open water area and water depth increased. In the event of additional modifications to prairie pothole wetlands, consideration should be given to maximizing the ratios of surface water to basin size and open water to basin size, as well as, to creating pond and channel depths of at least 1.2 m.
4. Though islands provide some nesting habitat, easy predator access may limit nest success. By planting dense nesting cover on islands, island use by nesting waterfowl may increase. Islands appear attractive to nesting pheasants. In the event of additional dug brood pond construction, consideration should be given to creating small, rectangular islands spaced as far from one another and the basin edge as possible.

5. Wetlands with dug brood complexes provide habitat for feeding, swimming, resting and comfort activities by ducks. Open water areas are attractive to dabbling ducks and some diving ducks, and may serve as waiting sites for paired males and brood rearing habitat for ducklings. Edge areas may be important feeding areas for ducklings. Spoil banks and island shorelines were used by ducks as loafing and preening sites as well as for other activities.
6. Future evaluations of modified wetlands should include a 5-year study prior to modification and a 5-year study after modification to better evaluate changes in waterfowl density, diversity and production. A benefit/cost analysis should also be an integral part of the study.

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