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Habitat Preferences and Censusing of Waterfowl Broods On Stock Ponds In South Central South Dakota

Mark A. Rumble

HABITAT PREFERENCES AND CENSUSING OF WATERFOWL BROODS ON STOCK PONDS IN SOUTH CENTRAL SOUTH DAKOTA

BY

MARK A. RUMBLE

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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.

Lester D. Flake — Date
Thesis Adviser

Charles G. Scalet — Date
Head, Dept. of Wildlife
and Fisheries Sciences

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Abstract

MARK A. RUMBLE

Waterfowl broods on stock ponds in south central South Dakota were surveyed in 1977 and 1978 to compare flush and observation techniques for censusing broods and to determine waterfowl brood habitat preferences. Results indicated that 72-85% of the broods present were censused by either technique alone. No differences were indicated between the 2 techniques when analyzed by species. For total brood counts, a significant ($P < 0.05$) difference was indicated for 1 of the 4 sample periods. Differences were found between the 2 techniques for certain age-classes of species and age-classes overall. Visibility correction factors were calculated for each species based on the percentages of known broods censused by each technique.

Brood habitat preferences were examined using multiple regression and discriminant analyses of 33 pond and upland variables. Ponds were selected in a limited size range (0.71-2.70 ha) to reduce variation in numbers of broods per pond due to pond size. However, variables indicative of pond size were significantly and positively associated to brood use of ponds in 8 of 9 analyses. Potential brood escape cover such as *Polygonum* spp. and *Eleocharis* spp. were positively associated with mallard (*Anas platyrhynchos*),

(*A. strepera*), northern shoveler (*A. clypeata*) and class 1 broods. Large differences in numbers of broods on study ponds between the 2 years were likely due to increased nesting cover provided by yellow sweet clover (*Melilotus officinalis*). Study ponds with higher pH and more submersed aquatic vegetation had more brood use.

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INTRODUCTION

Over 88,000 stock ponds (Ruwaldt et al. 1979) have been constructed on South Dakota rangelands to improve livestock utilization of available forage (Bue et al. 1952). Production of several species of waterfowl, particularly dabbling ducks, has benefited from creation of these ponds (Bue et al. 1952, Smith 1953, Bue et al. 1964, Lokemoen 1973, Mundinger 1976, Ruwaldt et al. 1979).

Stock ponds are formed behind earthen dams across natural waterways (Bue et al. 1964). Most stock ponds were constructed in cooperation with landowners, the Agricultural Stabilization and Conservation Service (ASCS), and the Soil Conservation Service (SCS). Federal land use agencies involved in pond construction have become interested in wildlife enhancement features (Lokemoen 1973). Enhancement of stock ponds for waterfowl production requires information about habitat characteristics on ponds and adjacent areas preferred by breeding pairs and broods.

The objectives of this study were to compare 2 waterfowl brood censusing techniques (flush and observation) and to identify habitat variables important to waterfowl brood use of stock ponds. Information concerning comparisons of waterfowl censusing techniques is lacking. Anderson (1953, 1955) compared beat-outs, road counts, aerial circling, and aerial straight run techniques and reported their relative efficiencies. Hammond (1970) summarized several brood census techniques, including beat-outs and observation, and suggested that combined censusing methods might be desirable in some detailed studies. However, technique comparisons were not made.

Investigations have been conducted on the habitat factors preferred by waterfowl broods using stock ponds. Pond size was found to be more important to broods than emergent cover (Smith 1953, Berg 1956). Bue et al. (1952), Gjersing (1975), and Mundinger (1976) reported that excessive grazing of shoreline vegetation reduced the number of waterfowl broods using a pond. Turbidity and water chemistry (pH and specific conductivity) can influence brood use of a pond (Trauger 1967, Lokemoen 1973, Patterson 1976). Mack (1977) reported that shoreline distance, *Scirpus* spp., *Sagittaria* spp., and geographic location influenced dabbler brood occurrence on stock ponds. Variables used in this study were based on results of these previous studies.

Financial support was provided by the South Dakota Agriculture Experiment Station (Project 7116-615) and the Water Resources Institute (Project B-045-SDAK).

STUDY AREA

The study was conducted in eastern Jones and western Lyman counties of South Dakota. The area of approximately 1235 km^2 was bordered by the towns of Vivian and Murdo on the east and west respectively. Study ponds were located as far as 8 km south and 32 km north of Interstate 90.

Weather data averaged from Murdo and Vivian (1941-1970) indicated mean monthly temperatures for June, July, and August, when broods were on the ponds, were 19.2°, 23.4°, and 22.9°C respectively. Average annual precipitation was 44.5 cm with monthly averages for those same three months of 9.6, 4.8, and 4.3 cm respectively (National Climatic Center, Ashville, N.C., No. 81 1973). Open water evaporation averages 107 cm between May and October (Spuhler et al. 1971).

The native vegetation is characteristic of the mixed grass prairie (Johnson and Nichols 1970). The principle dominants are western wheatgrass (*Agropyron smithii*), needle and thread (*Stipa comata*), green needlegrass (*S. viridula*), buffalo grass (*Buchloe dactyloides*), and blue grama (*Bouteloua gracilis*). The 3 former grasses are cool season dominants in high range condition and the latter 2 become warm season dominants in low range condition. These warm season grasses are low in stature as compared to the cool season plants and would provide poorer nesting and brood cover, as well as poorer forage for most livestock.

The principle land uses of the area were pasture (71-80%) and wild hay (3-6%); agronomic crops made up the remainder (Westin and Malo 1978). Several of the study ponds were on the Fort Pierre National Grasslands, administered by the U.S. Forest Service.

METHODS AND MATERIALS

Stock Ponds

Thirty-six ponds were selected for study; all were at least 2.5 km apart to decrease the likelihood that broods would leave a pond due to disturbance from censusing and go to another study pond not yet censused. The mean number of ponds within 1.6 km of study ponds was 9.5. Ponds ranged from 0.71 ha to 2.70 ha in basin area. Ponds of this size range were selected to reduce the effect of pond size on total number of broods per pond. Data were collected from 2 sample periods each year during 1977 and 1978. Sample periods began the first week of July and August and lasted approximately 10 days. Only 35 ponds were censused during 1978 as 1 stock pond washed out.

Censusing

Two censusing techniques were used to determine brood numbers on stock ponds. Observation counts were taken during the 2.5 hour periods following sunrise and prior to sunset. These counts were to coincide with diurnal activity periods of waterfowl broods (Diem and Lu 1960, Ringelman 1977). During observation periods broods were counted from the upland using a 25X spotting scope. Camouflage netting was draped over the observer for concealment. Following morning observations, stock ponds observed that morning and the previous evening were flush censused by 2 teams of 2 men each. Each team flush censused ponds observed by members of the other team. Species, brood size, age-class (Gollop and Marshall 1954), time and date were recorded during both counts. Censusing was discontinued when temperatures exceeded 32°C or wind velocity was greater than 24 km/hr, due to low brood visibility (Ringelman 1977).

Habitat Variables

Data were collected for 33 variables from the pond and surrounding upland. Specific conductivity was collected with a Hach Kit (model 16300) water conductivity meter and pH with Hach Kit narrow range pH meters. Secchi disc disappearance was used to estimate turbidity (Beeton 1958). Pond shorelines and emergent vegetation were sketched on reproductions of ASCS aerial photographs (1:4132); shoreline development (Lind 1974), basin size, and surface-water area were obtained from the photograph reproductions and sketches. Subjective estimates were made for the percent of basin area with surface water, percent of the stock pond with emergent vegetation, and mean height of the emergent vegetation. Percent composition of emergent vegetation made up by cattail (*Typha* spp.), roundstem bulrushes (*Scirpus acutus* and *S. validus*), river bulrush (*S. fluviatilis*) and burreed (*Sparganium* spp.), spike rush (*Eleocharis* spp.), water potatoe (*Alisma* spp.) and arrowhead (*Sagittaria* spp.), and water smartweed (*Polygonum* spp.) was also estimated. This breakdown of species and species combinations of emergent plants was for similarities in height and suspected cover afforded to broods.

Weighted estimates of submersed macrophytes in the 0-61 cm depth zone were determined by multiplying the mean coverage rating (0 for 0-5%, 1 for 6-20%, 2 for 21-40%, 3 for 41-60%, 4 for 61-80%, and 5 for 81-100%) from 40 equally spaced 61 cm^2 plots around a pond times the frequency of occurrence of submersed macrophytes determined from the same plots. Percent of the pond 0-61 cm deep and percent of the pond 0-61 cm with emergent vegetation were subjectively estimated.

Upland habitat data were collected for several variables related to land use of the surrounding area. Percent of the shoreline with a band of exposed soil over 1 m wide was estimated. Land use of the immediate section surrounding the pond was sketched on aerial photographs (1:8360) and planimetered to determine the hectares of small grain, hayland, alfalfa, summer fallow, brushy draws, pasture, idle land, and row crops. Distance to the nearest road, distance to the nearest stock pond, number of stock ponds within 1.6 km, and number of wetland basins within 1.6 km were obtained from aerial photographs also. Measurements of height and density of upland vegetation were taken using the visual obstruction reading method (VOR) (Robel et al. 1970). VOR transects were started 1 m from the edge of the water and taken every 5 m for a distance of 20 m. Twelve transects, spaced equidistant, were taken on each stock pond. Presence or absence of livestock with access to the stock pond was also recorded.

Analysis

A tally of each species and total broods occurring on each pond was obtained by summing all different broods observed during the combined observation and flush counts. It was assumed that between the 2 census techniques, all or nearly all broods present on a pond were censused. For comparison of census techniques, brood tallies from each census were considered separately.

A paired t-test (Steel and Torrie 1960) was used to evaluate the 2 census techniques (observation versus flush). The subtracted differences and the resulting calculated t-values were compared to tabulated t-values to determine if any differences existed. Stock ponds in which no broods were sighted on either census were not included in the analysis.

Brood habitat preferences were determined from the 33 habitat variables collected at each pond. Stepwise forward multiple regression (Snedecor and Cochran 1967) was used for the analysis of mallard (*Anas platyrhynchos*), blue-winged teal (*A. discors*), and total broods, as there was a continuum of the dependent variable with adequate variation (0-4 for mallards, 0-7 for blue-winged teal, and 0-19 for total broods). Stepwise forward discriminant analysis (Cooley and Lohnes 1971) was used for the analysis of gadwall (*A. strepera*), pintail (*A. acuta*), wigeon (*A. americana*), and shoveler (*A. clypeata*) broods due to the low number of broods of these species occurring on ponds.

Habitat preferences for total broods, mallards, blue-winged teal, shovelers, and wigeon broods were determined using data collected during the July sample dates. August data were not included as the numbers of these species had decreased and this would have biased the results. Analysis of gadwall brood habitat preference was from August census data as there were more gadwall broods during that period. Combined data from both years were included in the analysis.

Data obtained from the Fish and Wildlife Service Migratory Bird Center, Albuquerque, New Mexico, indicated a 151.5% increase in the total breeding pairs from west river transects in South Dakota from 1977 to 1978. Therefore, a dummy variable, year, was entered into the analyses to remove variation due to year from the multiple regression equations. This variable did not contribute to the reduction of residual sums of squares and was consequently left out of the habitat analysis.

Statistical significance was determined at P 0.05 and P 0.01 for all analyses.

RESULTS AND DISCUSSION

Census Techniques

Analysis of census data indicated no difference between the observation and flush counts in 3 of the 4 sample periods (Table 1). August 1978 flush counts indicated more broods than observation counts ($P \leq 0.05$). The July 1978 sample period showed differences similar to those in August 1978 but the difference was not sufficient to be considered statistically significant ($0.20 < P < 0.10$). The increase in density of waterfowl broods, from 1.47 per ha to 3.44 per ha, may have affected the accuracy of the observation technique. Anderson (1955) reported that vegetation growth affected visibility of broods on some census techniques. Vegetational patterns did change around most ponds from 1977 to 1978; VOR measurements increased from 1.28 ± 0.17 (mean ± SE) to 2.38 ± 0.31. Inactive broods loafing in or near dense upland vegetation may have been missed on observation counts. Flush censuses often forced broods to open water and with the aid of a second observer broods were easily censused.

The number of broods from observation censuses was significantly less ($P \leq 0.01$) than the total known broods occurring on ponds (Table 2). The percentage of total known broods that were censused by the observation counts were 75%, 74%, 75%, and 72% for the 4 sample periods. Statistical comparison of flush counts versus total broods was not made due to lack of degrees of freedom for

Table 1. Observation versus flush census data for total broods.[a]

Year	Month	Number of broods		No. of ponds	Calculated t-value	Significance[b]
		Obs.	Flush			
1977	July	64	63	32	0.12	
	August	59	58	30	0.13	
1978	July	175	191	34	-1.37	
	August	101	121	32	-2.07	*

[a]Total broods is a tally of all species included.

[b]* indicates significance at $P < 0.05$.

Table 2. Observation census versus broods known to be using ponds.[a]

Year	Month	Number of broods		No. of ponds	Calculated t-value	Significance[b]
		Obs.	Total			
1977	July	64	85	32	-3.14	**
	August	59	80	30	-3.74	**
1978	July	175	232	34	-5.75	**
	August	101	141	32	-4.85	**

[a] Broods using ponds are a combined tally of both census techniques.

[b] * indicates significance at $P \leq 0.05$.

** indicates significance at $P \leq 0.01$.

tests to be made (1 minus the number of treatments). However, the percentages of total broods seen in the flush census alone were 74%, 73%, 82%, and 85% for the 4 sample periods.

Ringelman (1977) found there were greater behavioral similarities between dabbler broods of the same age-class than among species. The analysis of total brood data for class 1 and class 2 broods indicated a significant difference between the observation and flush techniques ($P < 0.01$); for class 3 broods no difference was found (Table 3). Class 1 broods were more easily seen on the observation census (Table 3). The relative lack of disturbance to the broods on ponds associated with this technique was probably the reason for this. During flush censuses, young broods were difficult to force out of the emergent vegetation or flush from the upland once they had sought out protective cover. Statistically, no differences were found between the 2 census techniques for class 1 broods analyzed by species.

Total class 2 broods, in contrast to class 1 broods, were more visible on the flush counts (Table 3). Class 2 blue-winged teal were significantly more visible on the flush censuses ($P < 0.01$). Statistically, class 2 mallard and gadwall broods had the same visibility with either census technique. The slightly larger numbers of class 2 mallard and gadwall broods censused by flush counts, when pooled with blue-winged teal and the other species, was probably the cause for the significant difference found for class 2 broods of all species.

Table 3. Observation versus flush census for age-class of broods.

Age-class	Species	Number of broods Obs.	Number of broods Flush	No. of ponds[a]	Calculated t-value	Significance[b]
Class 1	Mallard	38	22	29	1.00	
	BWT	47	46	41	0.00	
	Gadwall	28	26	28	0.57	
Total[c]	class 1	144	113	75	2.68	**
Class 2	Mallard	22	30	39	-1.43	
	BWT	64	91	72	-3.37	**
	Gadwall	19	27	31	-1.28	
Total	class 2	143	195	102	-3.38	**
Class 3	Mallard	24	14	30	2.35	*
	BWT	39	45	55	-0.72	
	Gadwall	12	11	10	0.83	
Total	class 3	93	96	75	0.00	

[a]Only ponds having broods of the age-class considered were included.

[b] * indicates significance at $P \leq 0.05$.

** indicates significance at $P \leq 0.01$.

[c]Totals include all species for that age-class.

The analysis of class 3 data for all species combined indicated no difference between the flush and observation censuses (Table 3). Class 3 mallard broods were, however, significantly more visible ($P \leq 0.05$) on the observation census. Hammond (1970) indicated that mallards and pintails were the most difficult ducks to census due to behavioral characteristics. On several occasions class 3 mallard broods were observed hiding in emergent vegetation during the observation census. Diem and Lu (1960) reported it was more difficult to census older broods as they often fled and scattered into cover. Diem and Lu (1960) also reported mallard broods were difficult to census. Thus, the combination of older mallard broods coupled with the additional disturbance associated with a flush census might have reduced the visibility of class 3 mallard broods. Class 3 blue-winged teal and gadwall showed no difference in their visibility to the 2 censusing techniques. These broods, with few exceptions, gathered in the open water and on stock ponds with 80-100% open water they were easily censused with either technique.

Individual species analysis, all age-classes combined, indicated no difference between the 2 censusing techniques. Visibility on the censuses was more dependent upon behavioral characteristics of the broods and here these differences were more pronounced between the age-classes than between the species.

Data here support Ringelman (1977), that greater differences exist between age-classes of dabbler broods than among species of dabblers.

Hammond (1970) reported that on ponds with 81-100% open water, all dabbler broods present could be censused. Data from this study indicated that for stock ponds (mean percent open water 85.2) 76 to 78% of the broods present over the 2 years were visible on either census (Table 4). Visibility also varied with species (Table 4). Hammond (1970) found that gadwall broods were the most visible, followed by mallard, blue-winged teal, and pintail broods respectively. Based on the average visibility correction factor (the inverse of the ratio of broods from census technique: total known to be present) blue-winged teal were the most visible followed by gadwall, mallard, and pintail broods in this study. These data vary slightly from what Hammond (1970) reported.

Habitat Evaluation

Cover for brood rearing was important in determining how much use a particular pond received. Variables indicative of potential brood cover were ranked in the top 3 in 5 of the 9 habitat analyses. Standardized partial regression coefficients indicated percent Polygonum was the most important variable of the variables in the equation determining use of stock ponds by total broods (Table 5), gadwall (Table 6), and class 1 broods (Table 7). Polygonum

Table 4. Percentage of total broods censused by observation and flush censuses and visibility correction factor.[a]

Species	Year	Percentage of total broods		Visibility correction factor	
		Obs.	Flush	Obs.	Flush
Mallard	1977	69.0	76.0	1.45	1.31
	1978	71.0	69.0	1.42	1.44
	Mean	70.0	72.5	1.44	1.38
BWT	1977	78.0	72.0	1.28	1.22
	1978	82.0	86.0	1.40	1.17
	Mean	80.0	79.0	1.34	1.20
Pintail	1977	86.0	43.0	1.16	2.33
	1978	45.0	77.0	2.20	1.29
	Mean	65.5	60.0	1.68	1.81
Gadwall	1977	65.0	71.0	1.55	1.42
	1978	75.0	86.0	1.34	1.16
	Mean	70.0	78.5	1.45	1.29
Total broods	1977	75.0	73.0	1.34	1.36
	1978	77.0	83.0	1.30	1.20
	Mean	76.0	78.0	1.32	1.28

[a] Visibility correction factor is the inverse of the ratio of broods seen on the census technique:total broods known to be present.

Table 5. Habitat variables important in determining waterfowl brood use of stock ponds as determined by stepwise forward multiple regression.

Species	Independent variables[a]	Std. part. regr. coef.[b]		Coef. of deter. (R^2)	Simple corr. coef. (r)
		$P \leq 0.05$	$P \leq 0.01$		
Total broods	Surface-water area	+0.288	+0.359	0.129	+0.359
	Frequency of submersed veg.	+0.230		0.199	+0.222
	Percent *Polygonum*	+0.316		0.253	+0.336
	Percent *Eleocharis*	+0.250		0.309	+0.192
Mallard	Frequency submersed veg.	+0.305	+0.434	0.158	+0.398
	Surface-water area	+0.369	+0.342	0.253	+0.261
	Ha small grain	+0.268	+0.303	0.344	+0.269
	VOR	+0.303		0.381	+0.317
	Percent *Eleocharis*	+0.278		0.445	+0.212
Blue-winged teal	Surface-water area	+0.368	+0.400	0.159	+0.400
	Percent river bulrush	-0.300		0.219	-0.282
	Percent mud or bare shore	-0.246		0.277	-0.183

[a]Variables are listed in order of entrance into analysis.
[b]Sign of the standard partial regression coefficient indicates the association to the variables and the absolute value indicates relative importance to variables in that analysis.

Table 6. Habitat variables important in determining presence of waterfowl broods on stock ponds as determined by stepwise forward discriminant analysis.

Species	Independent variables[a]	Standardized discrim. coef.[b]	% variation explained[c]	Within group means[d]	
				Group 1	Group 2
Gadwall	Percent *Polygonum*	+0.503	8.31	12.34	1.33
	Distance to nearest wetland basin	+0.469	5.39	0.49	0.36
	Ha fallow land	-0.336	6.19	16.39	27.32
	pH	+0.424	2.98	8.89	8.60
	Percent *Alisma* and *Sagittaria*	-0.358	3.89	11.88	22.42
	Percent mud or bare shore	+0.320	2.44	47.46	38.35
			Total 29.20		
American wigeon	pH	+1.190	8.08	9.10	8.45
	Percent surface-water area	+0.942	11.33	127.46	112.98
	Wetland basins within 1.6 km	+0.583	4.72	11.94	10.63
	Distance to nearest wetland basin	+0.445	6.11	0.50	0.38
	Ha idle land	-0.438	5.06	3.01	2.73
	Specific conductivity	-0.249	3.49	488.82	696.41
	Ha row crops	+0.294	2.67	15.16	8.82
	Ha alfalfa	-0.253	2.25	8.38	8.77
			Total 43.71		

Table 7. Habitat variables important in determining age-class (class 1, 2, 3) brood use of stock ponds as determined by stepwise forward multiple regression.

Species	Independent variables[a]	Std. part. regr. coef.[b] $P \leq 0.05$	Std. part. regr. coef.[b] $P \leq 0.01$	Coef. of deter. (R^2)	Simple corr. coef. (r)
Class 1	Percent *Polygonum*	+0.544	+0.503	0.182	+0.426
	Percent *Eleocharis*	+0.248	+0.292	0.261	+0.188
	Basin area	+0.375		0.320	+0.231
	Stock ponds within 1.6 km	-0.304		0.367	-0.135
	Ha small grain	+0.281		0.435	+0.130
Class 2	Surface-water area	+0.218	+0.296	0.076	+0.276
	Stock ponds within 1.6 km	-0.948	-0.937	0.119	-0.125
	Wetland basins within 1.6 km	+0.903	+0.847	0.300	+0.119
	Ha alfalfa	+0.227		0.355	+0.112
	Percent river bulrush	-0.275		0.392	-0.212
	VOR	+0.340		0.424	+0.162
	Percent *Typha*	-0.290		0.458	-0.122
	Ha idle land	-0.215		0.498	-0.173
Class 3	Frequency of submersed veg.	+0.317		0.071	+0.265
	Surface-water area	+0.316		0.168	+0.264

[a]Variables are listed in order of entrance into the analysis.

[b]Sign of the standardized partial regression coefficient indicates the association to the variable and the absolute value indicates relative importance to variables in that analysis.

was the first variable entered in the discriminant analysis for shoveler broods (Table 6), as it initially explained the greatest percent of variation. However, the relative importance of Polygonum was not ranked high (based on standardized discriminant coefficients) with reference to the other variables entered. In all analyses, percent Polygonum was positively associated with brood use of stock ponds. Polygonum did not occur over large areas on study ponds. However, where Polygonum occurred it provided excellent cover for broods. Broods of all species took cover in stands of Polygonum during flush counts where it was available. Broods were often extremely difficult to flush from Polygonum stands.

Beard (1953) noted the relationship between brood production and a favorable "index of interspersion" on ponds. Mack (1977) reported positive associations for several cover variables and dispersed patterns of emergent vegetation with brood use of stock ponds in South Dakota. Too much cover such as a dense band of vegetation in the 0-61 cm depth zone covering a large portion of the pond had a negative influence on brood use of stock ponds. Most ponds had scattered stands of emergent growth leaving the majority of the pond edge open.

Percent composition of emergent vegetation by Eleocharis spp. was significant ($P < 0.05$) to total broods and mallard broods (Table 5) and was important to gadwall broods (Table 6). The positive association of Eleocharis to brood use of ponds would indicate it provided suitable cover and was selected for by waterfowl broods. Berg (1956) reported Eleocharis, Alisma, and Sagittaria plant associations were important to waterfowl broods. Eleocharis stands were typical of ponds with bands of emergent vegetation along the shoreline and provided cover for broods particularly where the stand extended more than a meter from the bank. Mack (1977) also reported that stands of Eleocharis were preferred by blue-winged teal. Alisma and Sagittaria were negatively associated with gadwall broods. Alisma and Sagittaria were generally found on water saturated soil (mud) shorelines; they were found as emergents on only a few ponds. Mack (1977) reported Sagittaria was important in determining suitability of a pond for broods and Alisma and Sagittaria were associated with increased brood densities. However, Mack (1977) reported gadwall broods showed no preference for any type of emergent vegetation. Evans and Black (1956) and Gates (1962) reported gadwall broods preferred more open marshes. Flake et al. (1977) noted similar preferences for gadwall adults. This preference for open marshes or at least open shorelines may have been reflected by the negative association of gadwall broods to Alisma and Sagittaria and the positive relationship to percent mud or bare soil (Table 6).

River bulrush had a negative association to blue-winged teal (Table 5) and class 2 broods (Table 7). However, Bennett (1938) reported river bulrush to be associated with other emergent vegetation important to blue-winged teal brood use of ponds.

Mack (1977) also found Scirpus to be positively associated to blue-winged teal broods. The negative association of river bulrush resulted from larger stands of river bulrush which occurred on ponds which had substantial encroachment of emergent vegetation into the pond. In this study, these conditions resulted from removal for several years of grazing animals from the surrounding fields. Such ponds were generally unsuitable for brood use. Trauger (1967) and Stoudt (1971) reported waterfowl broods preferred ponds with at least 60% open water. Emergent vegetation on some study ponds was also quite dense further restricting brood use. Beard (1953) reported an ideal "index of interspersion" of which higher index values due to more dense vegetation would have inhibited brood movement.

Percent of the emergent cover composed of Typha spp. had a significant ($P \leq 0.05$) negative relationship to class 2 brood use of ponds (Table 7). However, the entrance of Typha into the analysis after the point of rather large variable interaction between stock ponds within 1.6 km and wetland basins within 1.6 km caused the relationship to be questionable. Surface-water area, which was positively associated to class 2 broods, was the first variable entered and was the most important variable after entrance of the second variable, stock ponds within 1.6 km. Entrance of the third variable, wetland basins within 1.6 km, caused some major changes in the relative importance of variables already entered. The importance of surface-water area was reduced while the importance of stock ponds within 1.6 km was increased by 4.3 times (based on standardized partial regression coefficients). Wetland basins within 1.6 km were ranked second in relative importance. These latter 2 variables were positively correlated (0.86) to each other yet oppositely correlated to class 2 broods. The entrance of these 2 related variables and the change in standardized partial regression coefficients indicates a classical case of variable interaction which is common to some degree in multiple regression and discriminant analyses. Due to this common interaction among variables, biological interpretation should be made with caution after the second or third variable is entered regardless of significance level.

When either of these variables was removed from analysis a large decrease in R^2 occurred. This coupled with the large contribution to R^2 by wetland basins within 1.6 km (0.18) made it difficult to remove these variables from the analysis; these 2 variables were explaining much of the variation in class 2 brood use of ponds. Therefore, a list of important variables (Table 8) and a correlation matrix (Table 9) of these variables has been made to aid in interpretation.

The negative relationship between *Typha* and class 2 broods may have resulted from interaction of variables. However, the

Table 8. List of habitat variables and corresponding number used for variables in Table 9.[a]

Variable	Number
Stock ponds within 1.6 km	1
Wetland basins within 1.6 km	2
Surface-water area	3
Frequency of submersed vegetation	4
Percent *Polygonum*	5
Percent *Eleocharis*	6
Percent *Alisma* and *Sagittaria*	7
Percent *Typha*	8
Height of emergent vegetation	9
VOR	10
pH	11
Ha small grain	12
Ha alfalfa	13
Ha idle land	14

[a]Variables listed had significant ($P \leq 0.05$) correlations to stock ponds within 1.6 km or wetland basins within 1.6 km or were consistently important in the other analyses.

Table 9. Correlation matrix between variables listed in Table 8 for interpretation of brood age-class 2 habitat analysis.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.00													
2	.86	1.00												
3	.27	.28	1.00											
4	-.26	-.32	-.16	1.00										
5	.15	.11	.38	-.08	1.00									
6	-.16	-.11	-.06	.24	-.26	1.00								
7	-.33	-.27	-.04	-.05	-.16	-.29	1.00							
8	.31	.32	-.09	-.17	-.08	-.37	-.24	1.00						
9	.29	.32	-.07	-.29	-.02	-.27	-.30	.71	1.00					
10	.19	.18	-.07	.25	.07	-.27	-.19	.43	.32	1.00				
11	-.30	-.32	.19	.19	-.02	.21	.07	-.23	-.24	-.05	1.00			
12	.21	.13	-.10	-.01	.04	-.03	-.10	.15	.15	.14	-.05	1.00		
13	.43	.35	.05	-.06	.19	-.20	-.12	.00	.15	.27	-.15	.24	1.00	
14	.20	.20	-.11	-.01	.00	.09	-.10	-.06	.00	.18	.08	.21	.18	1.00

negative simple correlation would indicate that was not the case. Ponds which had greater than 10% emergent vegetation, as with river bulrush, were no longer grazed on the shoreline. Such ponds also had very dense stands of Typha which discouraged use by broods as evidenced by the few numbers of broods using these ponds. Trauger (1967) and Stoudt (1971) reported there was a negative relationship between ponds more than 2/3 covered by emergent vegetation and waterfowl brood use of ponds. Mack (1977) found a negative relationship between Typha spp. and gadwall and pintail brood use of stock ponds.

Shoveler broods indicated a preference for more open ponds with patches of emergent cover. This was shown by the positive association to Polygonum and negative association to percent emergent vegetation (Table 6). Trauger (1967) showed negative correlations to emergent cover by shoveler broods. Wigeon broods did not exhibit a preference for a particular type of vegetation (Table 6). However, wigeon broods were difficult to flush from emergent cover and were often noted only by the presence of the broody female.

Variables indicative of pond size were entered into all the analyses except for gadwall and wigeon broods. Trauger (1967) reported significant ($P < 0.05$) positive associations of pond size to blue-winged teal and total broods which exhibited strong positive associations to surface-water area (as indicated by relative value of standardized partial regression coefficients) (Table 5).

Shoveler broods also exhibited a positive relationship to surface-water area (Table 6). Ponds on this study were selected to reduce the effect of pond size on brood usage, but pond size variables still remained relatively important. Pond size was found to influence brood use more than cover (Smith 1953). Lokemoen (1973) suggested pond size was the most important variable affecting waterfowl use of stock ponds. Patterson (1976) and Mack (1977) found that shoreline distance (highly correlated to pond size) was important in determining duck brood usage of ponds.

Surface-water area had high simple correlations to class 2 and class 3 broods and was thus entered first and second into the equations respectively (Table 7). The relative importance of surface-water area to class 2 broods was reduced following the entrance of other variables. For class 3 broods surface-water area was as important as the first variable entered (based on standardized partial regression coefficients). Evans et al. (1952) and Berg (1956) reported movement by older broods to larger and more permanent ponds. Basin area, ranked second in relative importance to class 1 broods (Table 7), may reflect preferences by nesting hens. Lokemoen (1973), McEnroe (1976), and Patterson (1976) reported more use of larger ponds by breeding pairs. The relationship between class 2 broods and surface-water area would reflect a combination of the 2 previously discussed situations.

Wigeon broods were positively associated with percent surface-water area, an indicator of basin fullness and water depth. Lokemoen (1973) reported water depth was positively correlated to wigeon brood use of ponds. Water depth on stock ponds generally increases with size of the pond.

Submersed aquatic vegetation was important in determining mallard and total brood use of stock ponds (Table 5), as well as class 3 broods (Table 7). Aquatic vegetation provides both living space and food for aquatic invertebrates (Klugh 1926) which are a potential food source for ducklings (Moyle 1961). Patterson (1976) found brood use was correlated to submersed macrophytes but indicated overall pond productivity was the most important factor determining waterfowl use of ponds. Specific conductivity, pH, and turbidity are also related to productivity. American wigeon and gadwall broods were positively associated to pH (Table 6). Pond productivity is related to total alkalinity (Moyle 1961); therefore, higher pH was indicative of more productive ponds. Trauger (1967) reported a significant ($P \leq 0.01$) positive correlation of pH to dabbler broods. Significant ($P \leq 0.05$) contribution of pH to multiple regression analysis was also found for gadwall, blue-winged teal, and shoveler broods (Trauger 1967). Turbidity as measured by Secchi disc disappearance was negatively associated with shoveler broods. Secchi disc disappearance depth was decreased by suspended silt and phytoplankton.

Moyle (1961) reported an inverse relationship between phytoplankton and aquatic macrophytes. Aquatic macrophytes have been found to be positively associated with brood use of ponds (Patterson 1976). Also, Secchi disc readings less than 2.3 dm were associated with unproductive waters (Moyle 1961). Lokemoen (1973) found mallard broods were negatively correlated to turbidity. The negative association to specific conductivity by wigeon broods (Table 6) was not substantiated in the literature. Trauger (1967) and Patterson (1976) found specific conductivity and water hardness were positively associated to waterfowl brood use of ponds. Moyle (1961) reported general water fertility was related to carbonate hardness, total dissolved salts, and conductivity. Trauger (1967) reported the optimum conductivity of ponds with waterfowl broods was 800-1100 umhos.

Specific conductivities of some study ponds decreased slightly from 1977 to 1978 due to higher water levels. This slight decrease with a corresponding increase in brood use of ponds led to the negative relationship found. The range of specific conductivity (137-3500) and mean ± SE (646 ± 70.1) for the 2 years was not a determining factor influencing brood use of stock ponds in this particular area.

Upland land use conditions and vegetation patterns influenced the use of ponds by waterfowl broods. Bare soil or mud areas over 1 m wide due to trampling by livestock or drawdown were negatively associated to blue-winged teal broods (Table 5) and shoveler broods (Table 6). These exposed areas may have reduced the accessibility of upland escape cover. Mack (1977) suggested that younger broods sought out upland cover during the hot periods of the day when cover was lacking over water. Bue et al. (1952) noted increased usage of ponds which had grassy shorelines and Lokemoen (1973) found greater brood use of ponds with brushy shorelines.

Vegetation surrounding the pond as indicated by VOR measurements had a significant ($P \leq 0.05$) positive association with mallard and class 2 brood use of stock ponds. VOR was also the next variable entered after the P=0.05 level for class 1 broods. VOR values from 1977 to 1978 were more than doubled, in response to better rainfall and soil moisture conditions. While VOR measurements were only taken out to 20 m from the pond, earlier more lengthy transects indicated they were representative of conditions throughout pasture vegetation types which made up 64.5% of the land use of this area.

The primary difference between 1977 and 1978 vegetative conditions was the dominance of stands of yellow sweet clover (Melilotus officinalis) in pastures. Yellow sweet clover is a biennial plant and was responding to conditions of the second year following several years of drought. During the first year, plants are usually small; second year plants mature and flower (Johnson and Nichols 1970). Established yellow sweet clover plants with good root reserves are capable of rapid early spring growth if conditions are suitable. By mid May 1978 sweet clover plants were tall and dense enough to provide excellent cover for nesting hens. Duebbert and Lokemoen (1976) reported tall dense stands of grasses and legumes provided attractive and secure nesting cover for breeding dabbler hens.

Breeding pair counts (Fish and Wildlife Service Migratory Bird Center, Alberquerque, New Mexico) indicated breeding pairs in western South Dakota increased 1.5 times from 1977 to 1978. However, numbers of broods increased 4.3 times on study ponds which would indicate better nesting success. Furthermore, the 1977 August census indicated 80 broods using study ponds, 5 less than the July cersus. The August 1978 census however indicated 141 broods, 91 less than the corresponding July census. This 39% reduction in the numbers of broods would indicate greater nesting success on initial attempts, thus fewer renests than in 1977.

The positive relationship of VOR to mallard and class 2 broods might have resulted from this increased nesting success of early spring breeders such as mallards. By July these broods would have been about age-class 2. Gates (1965), Kirsch (1969), and Gjersing (1975) reported nesting success of ducks was affected by available cover in early spring.

The presence of livestock in the same pasture decreased shoveler brood use of stock ponds (Table 6). Kirsch (1969) and Gjersing (1975) suggested that livestock disturbed waterfowl resulting in decreased use of ponds. Fields that were grazed also had lower VOR measurements. In 1978 there appeared to be a general decrease in the influence of cattle due to available forage conditions and higher cattle prices which may have led to selling by ranchers.

Sayler (1962) reported agricultural land use was inversely proportional to waterfowl brood use of ponds. Stoudt (1971) suggested broods preferred ponds in pastures over cropland. However, hectares of small grain were positively associated to mallard (Table 5), shoveler (Table 6), and class 1 (Table 7) brood use of stock ponds. Land planted to small grains increased in 1978 due to better growing conditions, due to higher ground moisture than 1977 (the first year following drought conditions). Thus, with the increased numbers of broods, small grain was positively associated to broods. Hectares of idle land decreased from 1977 to 1978 due to the use of these areas for hayland and cropland. Thus, with the increase in numbers of broods over the same period, negative associations with American wigeon, shoveler (Table 6), and class 3 broods (Table 7) were found. Sayler (1962) reported that nesting pairs preferred idle land. Hectares of fallow land were negatively associated to gadwall broods (Table 6) for the same reasons as caused the negative association of idle land to brood use. Mack (1977) found mallard and blue-winged teal broods were positively associated with fallow land. Hectares of row crops (corn, milo, cane, and sunflowers) increased in 1978 and were positively associated to American wigeon brood use of ponds (Table 6). Alfalfa was negatively associated to American wigeon broods. Cutting of alfalfa fields for hay may have discouraged use for nesting. Gates (1965) showed avoidance by mallards of alfalfa and grass fields which were cut for hay. However, Mack (1977) reported a positive association between mallard and blue-winged teal broods and alfalfa in western South Dakota. Sayler (1962) indicated alfalfa fields were important to nesting blue-winged teal.

Distance to the nearest wetland was positively associated to gadwall and American wigeon broods (Table 6). Flake et al. (1977) reported mallard breeding pairs were positively associated to distance to other water and explained this by the larger home range of mallards and their use of isolated ponds; wigeon, however, were negatively associated to distance to other wetlands. Negative relationships were found between mallard, wigeon, teal, and pintail broods and distance to other water by Lokemoen (1973). Stock ponds within 1.6 km were negatively associated to class 1 and class 2 broods (Table 7). However, wetlands within 1.6 km were positively associated to wigeon (Table 6) and class 3 (Table 7) brood use of stock ponds. Flake et al. (1977) indicated that ponds within 1.6 km were negatively associated with wigeon and positively associated with blue-winged teal breeding pairs. However, Mack (1977) reported gadwall and blue-winged teal were positively associated with wetland density. The positive association to wetlands within 1.6 km in my study may have represented movement to permanent ponds from temporary wetlands as summer progressed (Mack 1977).

MANAGEMENT RECOMMENDATIONS

1. Neither flush counts nor observation counts account for all broods present; to obtain total counts the two techniques should be used in combination.
2. Over 72% of the broods were censused by either technique used alone.
3. The flush census technique is recommended where time and manpower are limited.
4. Presence of emergent vegetation is important to brood use of stock ponds; gadwall broods may be an exception to this.
5. Specific types of emergent vegetation such as *Eleocharis* spp. and *Polygonum* spp. are particularly important to broods. Construction and management of ponds to encourage these emergents is recommended to improve waterfowl production. Several other emergent species may also be important.
6. Extensive stands of *Typha* spp. and *Scirpus fluviatilis* should not be allowed to obliterate shoreline and open water areas. Periodic or moderate livestock use will encourage emergent-open water interspersion on ponds that tend to become overcrowded with emergents.
7. Excessive grazing and trampling of pond edges increases turbidity and reduces pond productivity. Emergent vegetation is also

destroyed by heavy livestock use. Good pond dispersal and moderate grazing are recommended on lands managed for livestock if duck production is desired.

8. Upland vegetative conditions are extremely important to nesting ducks and thus to waterfowl production. Thus, on lands managed primarily for livestock, grazing practices that encourage residual vegetation and moderate use of pastures is recommended.

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