HABITAT RELATIONSHIPS OF BREEDING WATERFOWL ON STOCK PONDS IN NORTHWESTERN SOUTH DAKOTA [1]

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ABSTRACT

Twenty stock ponds ranging in surface water area from .45 ha to 9.47 ha were cover mapped and 28 habitat variables of probable or potential importance to waterfowl use were recorded. Two breeding pair counts (indicated pairs) were conducted in early to mid June of 1976 and the association of different habitat variables with breeding pairs of waterfowl analyzed by multiple regression and discriminant analyses. Surface water area was the most important variable associated with variation in gadwall (*Anas strepera*) and mallard (*A. platyrhynchos*) numbers with more pairs found on larger ponds. Turbidity (negative) and distance to nearest pond (positive) were second in importance in the equations for gadwall and mallard respectively. Ponds with a higher emergent vegetation height and a greater percent of hemi-marsh tended to have more blue-winged teal (*A. discors*) while American wigeon (*A. americana*) appeared to be most associated with ponds with a greater percent hemi-marsh and dense marsh. The single most discriminating variable in predicting the presence of blue-winged teal was percent of pond hemi-marsh. Ponds with a higher proportion of shallow area were associated with absence of gadwall. Larger ponds and those with more dense marsh were most likely to have mallard pairs present. Percent of pond hemi-marsh and emergent vegetation height diversity were associated with ponds having American wigeon present.

INTRODUCTION

An important proportion of waterfowl breeding pairs in South Dakota, particularly mallards, occurs on man-made stock ponds in the non-glaciated prairies west of the Missouri River (Brewster

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et al. 1976). During a drought year in 1974, 30% of the breeding pairs in South Dakota were found in the area west of the Missouri River (Brewster et al. 1976). The primary objective of this study was to determine the importance of several habitat variables in explaining the use of stock ponds by breeding pairs of waterfowl. A secondary objective was to determine some of the variables and analysis methods that should be considered in additional studies we are planning on breeding waterfowl use of stock ponds.

STUDY AREA

The study was in Harding County in northwestern South Dakota and lies within the mixed grass prairie (Johnson and Nichols 1970). The area is primarily rangeland although some small grain is grown. Common grasses of the mixed grass prairie include western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), needle-and-thread (*Stipa comata*), and green needlegrass (*Stipa viridula*).

Average annual precipitation from 1941-70 was 34.7 cm at Camp Crook in Harding County (U.S. Department of Commerce 1973). Most of the precipitation comes in spring and early summer (Westin et al. 1967). The climate of the area is characterized as continental with warm to hot summers and cold winters (Spuhler et al. 1971).

METHODS

Twenty stock ponds were selected within a 32 km radius of Buffalo in central Harding County. Stock ponds were defined as ponds developed through damming of natural drainages and did not include dugouts. Surface water area of ponds varied from .45 to 9.47 ha. Ponds were well dispersed to reduce the probability of recounting ducks flushed from a nearby pond. The two closest ponds were 2.4 km apart. All ponds were located in rangeland habitat.

Habitat variables analyzed in relation to numbers of breeding pairs are listed in Table 1. Pond size and shoreline distance were determined from aerial photographs (U.S. Agricultural Stabilization and Consevation Service, Buffalo Office) with the use of a planimeter and map measurer, respectively. Shoreline distance was used to compute shoreline development (Wetzel 1975). Shoreline development is the ratio obtained by dividing the actual perimeter of a pond by the circumference of a circle of an area equal that of the pond.

Most of the independent variables were recorded at the study ponds during the waterfowl censuses. Dense marsh, hemi-marsh, and open marsh classifications were adapted from Weller and Spatcher (1965). In their work the classifications referred to stages of glacial marsh succession. We have used the terms to define the

TABLE 1

Independent Habitat Variables[a] Examined in Relation to Waterfowl Use of Stock Ponds Through Multiple Regression and Descriminant Analysis

(1)	Surface water (ha)	(12)	Emergent vegetation height diversity (no. of distinct emergent vegetation height levels) (0-5)
(2)	% Surface water (% of normal wetland basin area with water)	(13)	Turbidity (1 = clear, 2 = moderate, 3 = highly turbid)
(3)	% Pond<31 cm deep	(14)	% Shoreline trampled by cattle
(4)	% Pond 31-61 cm deep	(15)	Grazing intensity on surrounding 100 m of upland (1 = light, 2 = moderate, 3 = heavy)
(5)	% Shoreline with bare soil (≥.5 m width)	(16)	Shoreline development (actual shoreline distance divided by circumference of that pond if it were perfectly circular)
(6)	% Shoreline vegetation 1-30 cm tall	(17)	No. of ponds within 1.6 km
(7)	% Shoreline vegetation 31-61 cm tall	(18)	Distance to nearest pond (km)
(8)	% Pond dense marsh (more emergent vegetation than open water)	(19)	Wind speed (km/hr) (Beaufort scale)
(9)	% Pond hemi-marsh (emergent vegetation and open water equally interspersed)	(20)	% Cloud cover
(10)	% Pond open marsh (more open water than emergent vegetation)	(21)	Temperature
(11)	$\overline{X}$ Emergent vegetation height		

[a]Habitat variables dropped from the analysis due to correlations exceeding .80 with one or more other independent variables were as follows: basin size (correlated with 1), open water area (with 1), % open water (9), % pond 61-91 cm deep (4), % pond > 91 cm deep (3,4), % shoreline vegetation greater than 61 cm tall (6,8), % shoreline with dense marsh or hemi-marsh within 152 cm of shore (8), and % bottom silted in (13).

interspersion of stands of emergent vegetation in stock ponds. Stands of emergents with more vegetation than open water were defined herein as dense marsh, those with open water and vegetation about equal as hemi-marsh, and those with more open water than emergents as open marsh.

Emergent vegetation height diversity was recorded as the number of the following height categories that occurred on the pond: no emergents (0 cm), 1-12 cm, 13-31 cm, 32-91 cm, and 91 cm. The possible diversity value for each pond ranged from 1 to 5. Open water ponds (0 cm) with no emergents received the minimum rating of 1. If a pond had an open water area (0 cm) and distinct stands of emergents in the 1-12 cm, 13-31 cm, 32-91 cm, and > 91 cm categories, it would receive a maximum height diversity rating of five.

The average emergent vegetation height was estimated by measuring the height of distinct stands of emergents and by estimating the fraction of the total area of all emergents occupied by each height category of emergents. The average height of emergents was obtained by multiplying the various height categories (in cm) by the decimal fraction of the total area of emergents occupied by each height category and summing.

Pond turbidity was assigned a value of clear, moderate, or highly turbid by observer estimate. Grazing intensity estimates of light, moderate, or heavy were made by observer estimate for rangeland within 91 m of the ponds. Areas classed as lightly grazed showed little or no evidence of grazing by livestock and had an average vegetation height of grasses and forbes estimated as ≥15 cm. Heavily grazed areas had an average vegetation height <6 cm while moderately grazed rangeland included areas with 6 to 14 cm average vegetation height. No historical data were available on grazing intensity around the study ponds and, therefore, grazing estimates represented immediate and relative comparisons for the 20 ponds. Bare shoreline was defined as shoreline with bare soil at least 1.5 m in width.

Each pond was censused for breeding waterfowl from June 1-11 and again from June 11-18. Pairs, lone males, grouped males, females in excess of lone males, and mixed flocks were recorded. Interpretation of indicated pairs from lone males and grouped males followed the criteria established by Hammond (1969). Females in excess of lone males were also interpreted as indicated pairs throughout, as suggested by Stewart and Kantrud (1972). Breeding pairs refers to indicated pairs throughout the paper. All ponds were censused by walking the shoreline and wading through areas of thick emergents.

The four major duck species in our study included one early nester (mallard) and three mid- and late nesting species (blue-winged teal, American wigeon, and gadwall) (Hammond 1969). Censuses of breeding pairs over the entire state from 1972-1975 indicate only a small change in total indicated mallard pairs between the May (early pair count) and June (mid- and late pair count) census. Social categories such as numbers of pairs, lone males, group males of less than five, group females, and mixed groups also indicate little or no change between the May and June count (Lester D. Flake, unpublished data, Dept. of Wildlife and Fisheries Sciences, South Dakota State University, Brookings). Pintails (*Anas acuta*) (28 indicated pairs), green-winged teal (*A. crecca*) (4 pairs), and northern shoveler (*A. clypeata*) (2 pairs) were included in the total indicated pairs category but were not analyzed separately.

Stepwise multiple regression (Snedecor and Cochrane 1967) was run utilizing the 21 habitat variables (Table 1) as independent variables and indicated pairs of a particular duck species, total pairs, or number of species as the dependent variable. All ponds and both census counts were utilized in developing the multiple regression equations.

Multiple regression equations in habitat evaluation research can be valuable but require careful interpretation. The first independent variable in the equation explains more of the variation in the dependent variable than any of the other independent variables. Also, the sign (+ or −) on the variable is the same for the standardized partial regression coefficient and the simple correlation coefficients (r) on the first variable entered. However, the sign on the simple correlation coefficient and the partial are sometimes opposite particularly after the third or fourth step in the equation. This is due to interaction of the variables in the multiple regression equation. Therefore, strict interpretation of the sign on the partial regression coefficient is often misleading. The positive or negative sign on the partial regression coefficient should be looked at in the context of the total equation and in regard to the simple correlation coefficient.

Stepwise discriminant analysis (Morrison 1976) was conducted utilizing the 21 habitat variables to discriminate between ponds with a particular waterfowl species present versus those lacking that species. In our discriminant analyses the sign on the two group centroids (most common location of a case from a particular group in the discriminant function space) and the sign on the standardized discriminant function can generally be used to determine how the two groups are discriminated for by a particular variable. If the discriminating habitat variable and group centroid have the same sign then that particular group is more likely to be present where that variable is most abundant. However, if there are high correlations between discriminating variables, the signs on the discriminant function are sometimes the reverse of what the group means would indicate. Therefore, group means were checked in our interpretation of the discriminant functions. Our discriminant analyses were based on two groups so only one discriminant function was involved.

The variables presented in this paper are those that entered in the top steps of the discriminant analysis. Addition of further steps achieved only a small improvement in correct classification of groups. Variables correlated with previously entered variables may not be entered as major discriminating variables because of this correlation. The top discriminating variable is the best discriminator. Those entered in the following steps achieve maximum discrimination in the context of the equation.

We have assumed that pond selection by breeding pairs, even for hens homing to their natal area, is based largely on attractiveness of pond and/or upland habitat characteristics as was found by Mundinger (1976).

RESULTS

Blue-Winged Teal

Five habitat variables explained 49% (R^2) of the variation in numbers of indicated pairs of teal in the multiple regression equation significant at $P \leq .10$ (Table 2). Average emergent vegetation height was the most important variable in the equation and was positively associated with pairs of blue-winged teal. Likewise, the percent of a pond composed of hemi-marsh was important in the equation and was positively associated with blue-winged teal according to the simple correlation coefficient and the partial regression coefficient. The above mentioned variables comprise the highly significant equation ($P \leq .01$) and together explain 30% of the variance in blue-winged teal numbers per pond.

Four other potentially important variables are percent pond dense marsh ($r = .37$), emergent vegetation height diversity ($r = .36$), surface water area ($r = .30$), and numbers of ponds within 1.6 km ($r = .29$). These variables do not enter the equations due to correlations with previously entered variables.

As in multiple regression, discriminant analysis indicated that emergent vegetation characteristics were highly important in determining the presence of blue-winged teal. Ponds with more hemi-marsh and greater emergent vegetation height diversity were more likely to have blue-winged teal present (Table 3).

TABLE 2

Results of Multiple Regression Analysis of Breeding Pairs of Waterfowl in Relation to 21 Habitat Variables on Stock Ponds in Harding County, South Dakota

Species and habitat variables (in order of entry)	Coefficient of determination (R^2)	R^2 Change and significance level[a]	Simple correlation coefficient (r)	Standardized partial regression coefficient for equations at different significance levels[b]		
				$P \leq .10$	$P \leq .05$	$P \leq .01$
Blue-winged Teal (n = 73 indicated pairs)						
$\overline{X}$ Emergent vegetation height	.180	.180	.424	.582	.334	.394
% Pond hemi-marsh	.302	.122***	.383	.539	.516	.350
% Pond 30 cm deep	.403	.101**	−.176	−.498	−.361	
% Shoreline vegetation 2-30 cm tall	.446	.043	−.074	.351		
% Surface water	.491	.045*	.096	.258		
Mallard (n = 67)						
Surface water area	.342	.342	.585		.399	.569
Distance to nearest pond	.469	.127***	.383		.431	.357
% Pond dense marsh	.539	.070	.273		.226	
% Shoreline vegetation 31-61 cm tall	.588	.048	−.193		−.394	
Emergent vegetation height diversity	.652	.064**	.338		.342	

TABLE 2 (Continued)

Species and habitat variables (in order of entry)	Coefficient of determination (R^2)	R^2 Change and significance level[a]	Simple correlation coefficient (r)	Standardized partial regression coefficient for equations at different significance levels[b]		
				P≤.10	P≤.05	P≤.01
American Wigeon (n = 66)						
% Pond hemi-marsh	.206	.206	.453	.686	.471	.398
% Pond dense marsh	.319	.114***	.406	.227	.407	.342
No. of other ponds within 1.6 km	.399	.079**	−.064	−.586	−.300	
Surface water area	.439	.040	.090	.407		
Turbidity	.495	.056	−.287	−.317		
Distance to nearest pond	.548	.054*	.062	−.324		
Gadwall (n = 39)						
Surface water area	.183	.183	.428	.544		
Turbidity	.252	.069	−.116	−.437		
% Shoreline trampled by cattle	.344	.092*	.178	.341		
Total Indicated Pairs of Dabblers[c]						
Surface water area	.272	.272	.522	.810		.619
% Pond hemi-marsh	.419	.147***	.243	.330		.395
% Pond 31-61 cm deep	.475	.056*	−.085	.320		

TABLE 2 (Continued)

Species and habitat variables (in order of entry)	Coefficient of determination (R^2)	R^2 Change and significance level[a]	Simple correlation coefficient (r)	Standardized partial regression coefficient for equations at different significance levels[b]		
				P≤.10	P≤.05	P≤.01
No. of Species						
Surface water area	.259	.260	.510	.158	.604	
Emergent vegetation height diversity	.365	.105**	.486	.411	.365	
% Pond 31-61 cm	.421	.056	−.164	.105	.349	
Cloud cover	.480	.059*	−.196	−.016		

[a]All steps above the single asterisk are included in the regression equation significant at P≤.10, those above the double asterisk at P≤.05, and those above the triple astrisk at P≤.01.

[b]Where an equation is given at a higher significance level but not at a lower significance level the step significant at the lower level was also significant at the higher level (they are the same).

[c]Includes pintails, green-winged teal, and northern shoveler.

TABLE 3

Major Discriminating Variables Influencing the Presence or Absence of Breeding Pairs (by Species) On Stock Ponds in Harding County, South Dakota, as indicated by Stepwise Discriminant Analysis

Group	No. of cases	% of total cases	% of cases correctly classified	Centroids in reduced space	Major discriminating variables (A) and value (B) on standardized discriminant function: A	B	Group Means: Absent	Group Means: Present
Blue-winged Teal								
Absent	13	32.5	84.6	1.06	% pond hemi-marsh	−.294	2.69	9.81
					emergent vegetation height diversity	−.645	3.00	4.11
Present	27	67.5	92.6	−0.51	% pond 31-61 cm deep	−.767	14.62	19.63
TOTAL			90.0		% shoreline vegetation 1-30 cm tall	−.423	45.62	60.41
					surface water area	−.366	6.48	6.54
Mallard								
Absent	14	35.0	92.9	−1.09	surface water area	.515	2.27	8.81
					% pond dense marsh	.436	2.14	8.46
Present	26	65.0	88.5	0.59	cloud cover	−.178	36.36	23.42
					shoreline development	−.378	1.91	2.01
TOTAL	40		90.0		% surface water	−.235	79.64	79.42
					emergent vegetation height diversity	.726	3.00	4.15
					% shoreline vegetation 31-61 cm tall	−.528	18.57	9.42
					no. of ponds within 1.6 km	−.320	2.93	2.58

TABLE 3 (Continued)

Group	No. of cases	% of total cases	% of cases correctly classified	Centroids in reduced space	Major discriminating variables (A) and value (B) on standardized discriminant fraction: A	B	Group Means: Absent	Group Means: Present
American Wigeon								
Absent	13	32.5	76.9	−1.04	% pond hemi-marsh	.678	3.46	9.44
					temperature	.449	71.92	73.89
Present	27	67.5	92.6	0.50	emergent vegetation height diversity	.815	3.08	4.07
TOTAL	40		87.5		turbidity	−.509	2.00	1.62
					% pond dense marsh	−.490	6.54	6.11
					% shoreline vegetation 31-61 cm tall	−.516	10.00	13.89
					no. of ponds within 1.6 km	−.481	2.69	2.70
					% shoreline trampled by cattle	−.360	51.38	34.44
Gadwall								
Absent	24	60.0	91.7	0.615	% pond < 31 cm deep	1.203	31.04	20.31
					turbidity	.852	1.92	1.50
Present	16	40.0	81.3	−0.922	% shoreline trampled by cattle	−.323	36.63	44.94
TOTAL	40		87.5		% pond open marsh	−.516	10.21	5.63
					no. of ponds within 1.6 km	.491	3.08	2.13
					% of shoreline bare soil	.372	11.63	14.31

Mallard

Habitat variables in the equation significant at $P \leq .10$ explained 65% of the variation in mallard pairs (Table 2). Five variables entered in the equation at $P \leq .10$, with surface water area the most important. The second variable in the equation indicated that more mallard pairs were present on study ponds most distant from other ponds. The above two variables comprised the equation at $P < .01$. Percent pond dense marsh, as in the case of American Wigeon, was positively associated with numbers of mallards present. Emergent vegetation height diversity, although entered fifth, had a simple correlation coefficient exceeded only by the first two variables and was positively associated with numbers of indicated mallard pairs per pond.

Surface water area was the most discriminating variable for presence of mallards with larger ponds more likely to have mallards present (Table 3). Mallards were also more likely to be present on ponds with a higher percentage of dense marsh.

American Wigeon

Fifty-five percent of the variation in American wigeon numbers was accounted for by the six variables comprising the multiple regression equation significant at $P \leq .10$ (Table 2). The first two variables, percent pond hemi-marsh and percent pond dense marsh, were positively associated with numbers of wigeon per pond and indicate the importance of emergents to this species. These two emergent variables comprised the highly significant equation. Numbers of ponds in the surrounding area (1.6 km) were negatively associated with pairs of wigeon. The simple correlation coefficient also indicates that the more isolated the pond from other ponds (distance to nearest pond) the more American wigeon were present. However, the sign on the partial regression coefficient is opposite of the simple correlation coefficient for distance to nearest pond due to interaction with previously entered variables. Turbidity was negatively related to wigeon numbers. Average emergent vegetation height had a simple correlation coefficient preceeded only by the top two variables in the equation but did not enter in the equation due to correlations with previously entered variables.

Percentage of a pond classed as hemi-marsh was the most important discriminating variable for indicating presence of American wigeon (Table 3). The third variable entered in the discriminant equation, emergent vegetation height diversity, was also positively associated with ponds having American wigeon. We are unable to give an explanation for the occurrence of air temperature as the second most discriminating variable.

Gadwall

Three habitat variables entered the equation at $P \leq .10$ and explained 34% of the variation in gadwall numbers (Table 2). Surface water area was the most important variable and was positively associated with gadwall pairs while turbidity entered second and was negatively associated. Shoreline trampling by cattle was positively associated with gadwall numbers. Percent of the pond <31 cm deep ($r = .42$) and percent surface water ($r = .31$) did not enter the multiple regression equation due to correlation with previously entered variables but appeared to be important.

Shallowness of the pond was the best discriminator and was associated with ponds lacking gadwalls. A higher turbidity rating likewise was an indicator of lack of gadwall pairs on ponds. Gadwalls were more likely to be present on ponds with a higher percentage of open marsh and with a higher percentage of shoreline in bare soil.

Total Indicated Pairs and Number of Species

Three variables explained 48% of the variance in total pairs with pond size most important (Table 2). Four variables with comparatively high simple correlation coefficients did not enter the multiple regression equation for total pairs due to correlations with previously entered variables. These were emergent vegetation height diversity ($r = .40$), percent of pond<31 cm deep ($r = -.31$), average emergent vegetation height ($r = .30$) and percent of the pond dense marsh ($r = .29$).

Four variables also explained 49% of the variation in numbers of species. Pond size followed by emergent vegetation height diversity were highly important in the multiple regression equation and had the two highest simple correlation coefficients. Both were positively associated with number of species present. Percent of pond 31 cm deep had the third highest simple correlation coefficient ($-.33$) but did not enter the significant multiple regression equation.

DISCUSSION

Lokemoen (1973) found pond size to be the most highly correlated habitat variable with numbers of dabbling duck pairs on stock ponds in western North Dakota. Likewise, pond size (surface water area) was the primary variable associated with total indicated pairs on our study ponds. Of the major species, surface water area was the primary variable associated with numbers of mallard and gadwall pairs but was of lesser importance to blue-winged teal and American wigeon. Several variables, particularly emergent vegetation characteristics, were more associated with numbers of pairs of blue-winged teal and American wigeon than was pond size.

Literature dealing with the relationship of emergent vegetation interspersion to breeding Anatini use of ponds is limited. Smith (1969) and Evans and Black (1956) noted that glacial ponds choked with emergents were of little value to breeding pairs of waterfowl. These dense growths of emergent vegetation were not found on our study ponds, as water depth limited emergents from spreading over entire ponds. Several studies have dealt with shoreline emergents and terrestrial vegetation in relation to pond use. Sowls (1955) observed that ungrazed glacial marshes with dense edges were not attractive to breeding waterfowl and that grazing of marsh shorelines by cattle could improve duck use by providing loafing sites. Similarly, removal of shoreline cattails greatly increased breeding pair use of some glacial wetlands in southeastern Alberta (Keith 1961).

In contrast, Smith (1971) concluded that mallards in Alberta parklands avoided ponds where stock had trampled the edges and eaten the emergents. Similar observations on the negative relationship of grazing were made for mallard, blue-winged teal, and pintail in the Saskatchewan parklands (Stoudt 1971). Bue et al. (1952) observed dabbling duck pairs to be much less abundant on stock ponds with mud shorelines (versus grass) and recommended control of overgrazing as a remedy. Studies on man-made wetlands by Shearer (1960), Uhlig (1963), and Mundinger (1976) further indicate that heavy grazing of shoreline and surrounding upland vegetation is deleterious to pond use by breeding pairs of waterfowl.

Our results indicate that emergent vegetation on stock ponds is highly important to total breeding pairs of dabbling ducks and that species-specific preferences in relation to emergents occur. On a species basis, emergent vegetation variables were particularly important for blue-winged teal and American wigeon. In contrast, gadwall showed little association with emergents and were the only species positively associated with trampling of the shoreline by cattle and bare soil shoreline. It was interesting that the diversity index for emergent vegetation height was second only to pond size in explaining variation in number of breeding duck species present.

Distance to the nearest pond was positively associated with numbers of mallards present in our study, as was also found by Lokemoen (1973). Lokemoen's results indicated that blue-winged teal and pintail were both negatively associated to distance to other water. As noted by Lokemoen, the large home range in mallards (Dzubin 1955, Gilmer et al. 1975) would explain their use of more isolated ponds. In our study, American wigeon were also positively associated with distance to the nearest pond and, further, were negatively associated with numbers of ponds within 1.6 km. Number of other ponds within 1.6 km was not in the significant multiple regression equation but had the sixth highest simple correlation coefficient (.29) of the 21 variables and was positively associated. The small home range of blue-winged teal and their normal use of other nearby wetlands in their daily activities (Dzubin 1955) would make blue-winged teal best adapted for areas with nearby wetlands. Gadwall have home ranges intermediate between mallard and blue-winged teal (Gates 1962). In this study gadwall showed little or no relationship to either numbers of nearby ponds or distance from the nearest pond.

Lokemoen (1973) recorded that bottom siltation was negatively related to mallard, American wigeon, and pintail pair numbers on stock ponds. He concluded that clay and sediments increase turbidity and reduce food and cover plants and, therefore, reduce duck use. Bottom siltation was dropped from our analyses because of an .83 correlation with turbidity. Turbidity was negatively associated with numbers and presence of American wigeon and gadwall in our study. Turbidity level did not appear to influence blue-winged teal or mallard numbers or presence. Blue-winged teal in Lokemoen's study were positively associated with siltation, but apparently the associaton was due to a single pond that developed a new fertile substratum. In our study turbidity was not included in the significant ($P \leq .10$) multiple regression equation for total numbers of species or for total breeding pairs, and the simple correlation coefficient in both cases indicated little association.

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