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An Evaluation of the Roadside Technique for Censusing Breeding Waterfowl

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AN EVALUATION OF THE ROADSIDE TECHNIQUE FOR CENSUSING BREEDING WATERFOWL

BY

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

Thesis Adviser Date

Head Date
Wildlife Management Department

AN EVALUATION OF THE ROADSIDE TECHNIQUE FOR CENSUSING BREEDING WATERFOWL

Abstract

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An evaluation of the roadside technique for censusing breeding waterfowl was conducted in east-central South Dakota. On the 54-mile transect used in 1968, number of counts necessary to be within 20 percent of population mean with specified confidence of 0.90 for blue-winged teal (Anas discors) and gadwall (Anas strepera) was five and three using miles or wetlands. Within same limits counts needed for mallard (Anas platyrhynchos) were at least four for miles and three for wetlands. Shorter transects, used in 1967 required more counts. Transects 21 miles long required up to 10 counts based on miles and 11 based on wetlands. The seven-mile transect required 25 counts based on miles and 10 based on wetlands. When wetland numbers exceeded mile numbers more counts were necessary for miles and the reverse was true when mile numbers exceeded wetland numbers.

Optimum period for censusing blue-winged teal was May 20 to June 6 in 1967, while optimum periods for mallard and gadwall were May 5 to 25 and May 25 to June 12. Optimum periods in 1968 were May 5 through 30 for mallard and May 23 through June 14 for blue-winged teal and gadwall.

New vegetation growth did not generally affect observability of ducks until the third week in May during both years. Vegetation on each wetland was placed into one of three categories: (1) 0 to 30

percent covered, (2) 35 to 60 percent covered, and (3) 65 to 100 percent covered. In 1967 fewer breeding pairs of blue-winged teal were observed on wetlands as vegetation increased. However, in 1968 no pattern of breeding pair means in vegetative classes within Type 3 wetlands was found and not all differences were significant. Significantly more pairs of blue-winged teal, gadwall and mallard were attracted to Type 4 wetlands containing 35 to 60 percent cover than other cover classes. Significantly more ducks were observed on Type 4 wetlands than Type 3 since Type 4 wetlands were larger and more permanent. However, more breeding pairs per acre were counted on smaller wetlands.

Wind and light conditions exerted no significant influence on counts of breeding pairs of blue-winged teal, gadwall, and mallard on the Sinai study area.

Flushing counts among vegetative classes for blue-winged teal and gadwall were significantly different for vegetative Class 3 but not Classes 1 or 2. Roadside and flushing counts were significantly different only in Class 2 for mallards.

Observers varied consistently in their ability to see waterfowl. Observer bias should be recognized and when possible, compensated for in conducting waterfowl counts.

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INTRODUCTION

Each spring, waterfowl biologists carry out extensive breeding pair surveys in the United States and Canada. Aerial transects, with ground-comparison counts to correct for pairs missed from the air, are currently used by United States Bureau of Sport Fisheries and Wildlife personnel (Martinson and Kaczynski 1967). Roadside counts from vehicles are also used.

Enumerations of waterfowl populations without regard for factors affecting variability are of relatively little value in waterfowl management (Diem and Lu 1960). Weather, vegetative cover, water acreage and other ecological factors are constantly changing and numbers of breeding pairs that can be observed on a given area fluctuate from day to day and at different time periods of the same day (Diem and Lu 1960). Several counts should be taken and averaged to be within specified accuracy limits. Breeding counts also vary depending on wetland size and amount of vegetative cover.

Even though several observers use the same basic set of instructions or techniques, variation within breeding pair counts is likely to occur. However, where variation occurs has not been investigated.

The present study was initiated to (1) determine number of replicate counts needed on a given roadside transect to be within specified accuracy limits, (2) determine influence of wind, light intensity, vegetative phenology, and wetland size on census counts of breeding waterfowl, and (3) determine variation among different observers.

DESCRIPTION OF STUDY AREA

The 80-square-mile study area, located in southwestern Brookings, northeastern Lake, and extreme eastern Kingsbury Counties, South Dakota (Figure 1), is situated in the southwestern part of the Prairie Hills physiographic region, a glaciated upland area lying between the Minnesota and James River Valleys (Flint 1955). Topography of the area consists of undulating grass-covered hills. Although drainage and farming have reduced their numbers, numerous wetland basins are still found among hilly portions of this area.

Soils originated from the Cary substage of the Wisconsin age glacial drift sheet (Flint 1955). They are mainly calcareous, fine-textured, silty clay and silty-clay loams intermixed with areas of poorly-drained soils of closed depressions and glacial till (Westin et al. 1967).

East Central South Dakota has a continental climate with average monthly temperatures of 73.2 F during July and 19.6 F in January. Annual mean precipitation is 21.63 inches of which 16.35 falls during the growing season. Snow cover averages about 23 inches per year (Anonymous 1962).

Native vegetation on the area was a mid-grass association which included needlegrass (*Stipa* sp.), western wheatgrass (*Agropyron smithii*), prairie dropseed (*Sporobolus heterolepis*), Junegrass (*Koeleria cristata*), sideoats grama (*Bouteloua curtipendula*), little

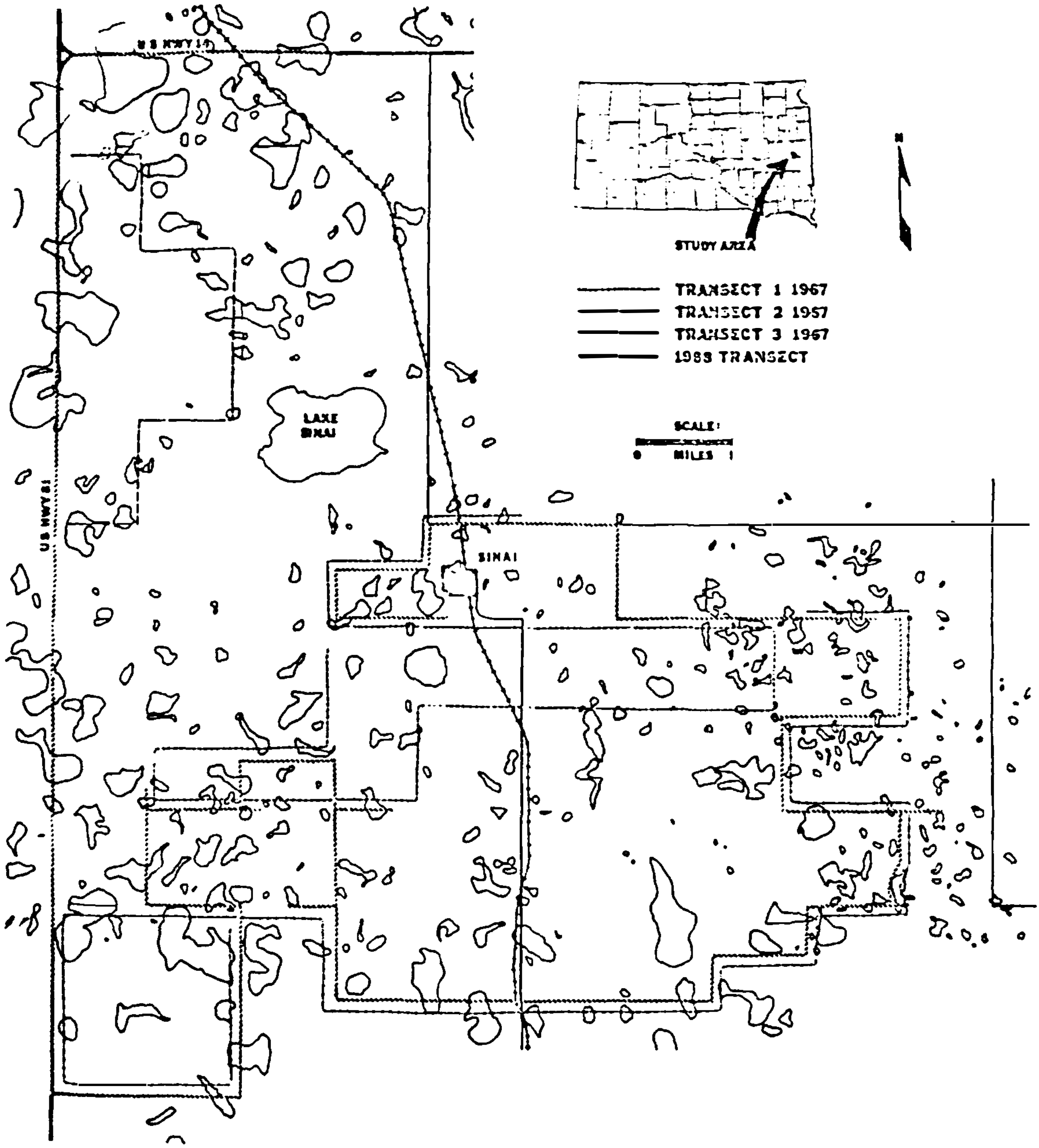


Figure 1. Types 3, 4, and 5 wetland basins and waterfowl breeding pair transects, Sinai study area 1967-68.

bluestem (*Andropogon scoparius*), and big bluestem (*Andropogon gerardi*) (Weaver 1954). Almost all of the grassland occurring on the study area was heavily grazed.

Evans and Black (1956) grouped wetland plants of the prairie pothole region into four main categories. These categories, with plants common to the Sinai study area are:

Submerged and floating plants found in deepest water:

Pondweeds (*Potamogeton* spp.)
Duckweeds (*Lemna* spp.)
Coontail (*Ceratophyllum demersum*)
Buttercups (*Ranunculus* spp.)
Water milfoils (*Myriophyllum* spp.)
Bladderworts (*Utricularia* spp.)

Deep-water emergents:

Cattail (*Typha latifolia*)
Hardstem bulrush (*Scirpus acutus*)
Sedges (*Carex* spp.)

Shallow-water emergents:

Burreeds (*Sparganium* spp.)
Arrowheads (*Sagittaria* spp.)
Water plantain (*Alisma plantago-aquatica*)
Mannagrass (*Glyceria grandis*)
Slough grass (*Beckmannia syzigachne*)
Spikerush (*Eleocharis palustris*)
River bulrush (*Scirpus fluviatilis*)
Alkali bulrush (*S. paludosus*)
Smartweeds (*Polygonum* spp.)

Plants of intermittently flooded shorelines:

Wild barley (*Hordeum jubatum*)
Bluejoints (*Calamagrostis* spp.)

River bulrush, cattail, and hardstem bulrush are predominant plant species on most Types 3 and 4 wetlands.

Mammals common to the area are whitetail deer (Odocoileus virginianus), red fox (Vulpes fulva), striped skunk (Mephitis mephitis), raccoon (Procyon lotor), whitetail jackrabbit (Lepus townsendi), eastern cottontail (Sylvilagus floridanus), badger (Taxidea taxus) eastern fox squirrel (Sciurus niger), muskrat (Ondatra zibethica) and numerous small rodents (names of mammals are taken from Burt and Grossenheider 1964).

Cover mapping of transects during 1967 indicated about 50 percent of the area was in cultivated crops (corn, oats, wheat, and soybeans), approximately 28 percent was used for pasture and hayland (includes alfalfa and sweet clover), and 10 percent was shelterbelts, farmsteads, fencerows, cemeteries, and idle acres. Intensive agricultural practices on the area have resulted in drainage and "silting in" of many wetland basins.

METHODS

Study area selection was made from aerial flights, U. S. Soil Conservation Service aerial photos, and ground observations.

In early spring of 1967, all wetland basins within 1/8-mile of all-weather roads on the area were mapped and wetlands containing sufficient water to attract breeding ducks were noted. Other wetlands were added when they became attractive to breeding ducks. From this map, two 21-mile transects (Transects 1 and 2) and one 7-miles long (Transect 3) covering 12.25 square miles were selected. Transects passed through heaviest concentrations of water areas (Figure 1). Land use and cover types were recorded along 1967 transect roads. Effects of early morning sun on visibility made it desirable to locate transects in an east-west direction, although it was necessary to locate portions of transects on north-south roads.

Drought conditions during early spring made it necessary to set up a different transect for 1968 field work. This 54-mile (11.4 square miles) transect included parts of 1967 Transects 1 and 2 and portions of U. S. Highways 14 and 81 (Figure 1). No wetlands east of U. S. Highway 81 were included because of visibility factors pointed out above.

Miles on each transect and all wetlands within 1/8-mile were numbered consecutively. If more than half of a water area was outside 1/8 mile, only that portion lying inside was censused.

If less than half was outside, all of the water area was censused. Aerial photos were used to locate 1/8-mile boundaries.

Censusing on all transects was begun as soon as light conditions premitted in early morning and ended about 9:30-10:30 A. M. Less censusing time was required as the breeding season advanced. Enough stops were made at each wetland area to assure a complete count of all ducks. Trial counts on each transect were made in late April to help identify migration patterns. Weather permitting, transects were censused daily from the first week in May through the second week in June. All 1967 transects were censused in a different order and/or direction each day of censusing. The 1968 transect was censused similarly each time.

Date of census was noted and weather data were gathered from two nearby weather stations (precipitation from Arlington-2 miles away; temperature, wind and light intensity from Brookings-14 miles away). Average light and wind conditions for the 3½ - 4½ hour census period were recorded. Daily wind and light intensities were divided into three categories for computer analysis.

Binoculars (7 X 50) and a spotting scope (20-60 power) were aids in identifying ducks. Counts were tape recorded (Figure 2) and transferred to field forms at end of each day's field work.

Bennett (1938), Smith (1957), Glover (1956) and others have used a variety of waterfowl population components to estimate breeding pair abundance. Dzubin (1967) discussed at length use of breeding

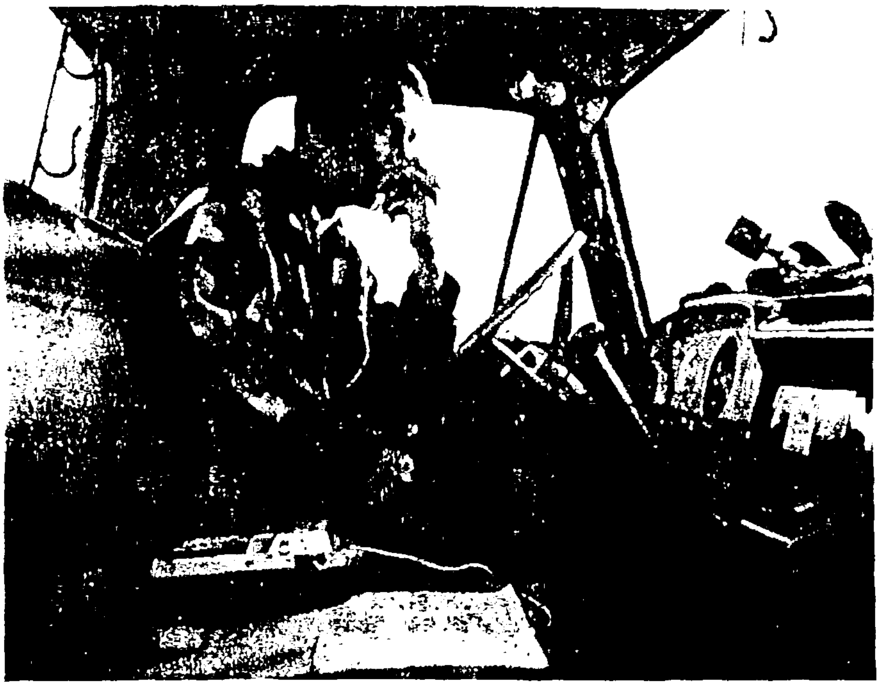


Figure 2. Recording breeding waterfowl on a wetland, Sinai study area, 1968.

Figure 3. Making flushing count of breeding waterfowl on a wetland, Sinai study area, 1968.

pair components as indicated breeding pairs and made recommendations for different species. In the present study all population components were recorded but only lone drakes and pairs were used as indicated breeding pairs. Ducks noted as lone drakes were separated from other ducks and did not enter into courtship activities. A drake and hen were considered paired when they (1) were separate from other ducks on a wetland and in proximity to one another (15-20 feet) and (2) were near groups of ducks but remained together and were intolerant of intruders. Birds that could not be separated into pairs, drakes, or hens at time of observation were classed as groups. These included flocked birds as well as two or more drakes with a single hen. Ducks flying or alighting on water areas within a transect were not tabulated. However, ducks observed flushing from water areas within a transect were counted (Hammond 1966). Ducks that flushed were "marked down" to avoid recounting.

Wetlands were classified as road-ditch basins, dugouts, and pothole Types 1, 3, 4, and 5 (Martin et al. 1953). Classification was based on potential, not necessarily appearance of the wetland when typed. Wetlands were placed into one of three vegetative classes (0-30, 35-60, 65-100 percent covered) according to percent of water surface hidden from view. As the season progressed and more vegetative growth appeared, it became necessary to reclassify many wetlands.

All wetland-basin acreages were obtained from 8-inch aerial photos. Type 1 and road-ditch-basin acreages were figured from random samples of 50 basins. Water area in each basin was estimated weekly to the nearest 10 percent. Basin acres were multiplied by this percentage figure to obtain acres of water in each basin.

Flushing counts (Figure 3) were made on all wetlands in 1968. At each wetland, ducks were censused in the same manner as during breeding pair count. Following this count, one or two assistants and the investigator made a flushing count on the same wetland. "Roll up" on the same wetland was eliminated by watching each bird after it had flushed. Ducks were not tabulated until they had completely left the wetland or landed behind the flushing crew. Roll up between wetlands was eliminated by watching birds down. If flushed ducks landed on an adjacent wetland, that wetland was not censused until the next day. Four flushing counts were made during the same period of time breeding pairs were censused.

Water depth, amount and pattern of vegetative cover, and other ecological data were collected on each wetland as flushing counts were made.

Broods were recorded whenever seen and several early morning and evening brood counts were made during early August. Brood counting techniques were similar to those used in breeding pair census. Number, species, and age class of each brood were noted. No flushing counts for broods were made.

Five simultaneous breeding pair counts were made by two experienced observers and the investigator in May, 1968. Four similar counts were made in June by one observer and the investigator. Censusing technique was identical to breeding pair census except observers were in the same vehicle. Each observer and the investigator wore ear plugs to avoid audio-interference from each other.

Ecological, census, and flushing count data were transferred to Hollerith cards for analysis.

RESULTS AND DISCUSSION

Results of this study should be viewed in light of such factors as distribution of wetland basins, homogeneity of the study area, spring migration, influence of vegetation, and other ecological factors. An understanding of these provide a base for examination of census results.

Distribution and Numbers of Wetland Basins

Type 1, road ditch, and Type 3 wetland basins were more numerous during both years of study than Type 4 (Tables 1 and 2). However, Type 4 wetland basins were greatest in acreage.

Many wetland basins did not contain water during the study period. Drought conditions in spring of 1967 caused more than a 50-percent decrease in wet water areas, due chiefly to a loss of Type 3 areas. On June 13, 14, and 15, 1967, heavy rains filled all water basins to capacity, which accounted for a three-fold increase on June 16 (Table 3).

Insufficient rainfall in spring of 1968 caused about a 30-percent decrease in total wetland numbers during the censusing period. Since over half were more permanent types, there was a lower percentage loss than in 1967 (Table 3).

Wetland Vegetation

Dry, Type 1 basins contained mainly dryland species of plants whereas emergents grew in shallow water and along shorelines. Open

Table 1. Wetland basins by size and type (Transects 1, 2 and 3), Sinai study area, 1967.

Size (acres)	Road Ditch Basins	1	3	4	5	Total
	Type					
0.1 - 2.9	65	69	55	4	--	193
3.0 - 5.9	--	--	26	5	--	31
6.0 - 6.9	--	--	11	10	--	21
9.0 - 11.9	--	--	3	3	--	6
12.0 - 14.9	--	--	2	5	1	8
15.0 - 17.9	--	--	1	--	--	1
18.0 - 20.9	--	--	1	2	--	3
21.0 - 23.9	--	--	1	3	--	4
24.0 -	--	--	--	3	1	4
Total	65.0	69.0	100.0	35.0	2.0	271.0
Total Acres	7.3	49.7	370.4	391.9	57.4	876.6
Avg. Size	.1*	.7*	3.7	11.1	28.7	3.2
Avg. No. (Sq. Mi.)	5.3	5.6	8.2	2.9	0.2	22.1
Avg. Acreage (Sq. Mi.)	.6	4.4	30.2	32.0	4.7	71.6
% Total Number	24.0*	25.5*	36.9	12.9	0.7	100.0
% Total Acreage	.8	5.7	42.2	44.7	6.6	100.0

* Based on average size of 50 basins on study area.

Table 2. Wetland basins by size and type (1968 Transect), Sinai study area, 1968.

Size (acres)	Type: Road Ditch Basins	1	3	4	5	Total
0.1 - 2.9	47	81	40	4	--	172
3.0 - 5.9	--	--	23	7	--	30
6.0 - 6.9	--	--	8	12	--	20
9.0 - 11.9	--	--	3	4	--	7
12.0 - 14.9	--	--	2	6	--	8
15.0 - 17.9	--	--	1	4	--	5
18.0 - 20.9	--	--	1	2	--	3
21.0 - 23.9	--	--	--	2	--	2
24.0 -	--	--	--	5	--	5
Total	47.0	81.0	78.0	46.0	--	252.2
Total Acres	5.2	58.3	299.7	550.0	--	913.2
Avg. Size	.1*	.7*	3.8	12.0	--	3.6
Avg. No. (Sq. Mi.)	4.1	7.1	6.8	4.0	--	22.1
Avg. Acreage (Sq. Mi.)	.5*	5.1*	26.3	48.3	--	80.1
% Total Number	18.6	32.1	31.0	18.3	0.0	100.0
% Total Acreage	.6	6.4	32.8	60.2	0.0	100.0

* Based on average size of 50 basins on study area.

Table 3. Numbers of wetland basins on transects which contained water, Sinai study area, 1967-1968.

	Type						
Date	Road Ditch Basins	1	3	4	5	Total	Number/ Sq. Mi.
1967 Transects							
May 5	--	--	61	34	2	97	7.9
May 12	--	--	60	34	2	96	7.8
May 19	--	--	51	34	2	87	7.1
May 26	--	--	32	30	2	64	5.2
June 2	--	--	17	28	2	47	3.8
June 9	--	--	14	26	2	42	3.4
June 16	65	69	100	35	2	271	22.1
1968 Transect							
May 5	--	--	30	41	--	71	6.2
May 12	--	--	30	41	--	71	6.2
May 19	--	--	30	41	--	71	6.2
May 26	--	--	29	41	--	70	6.1
June 2	--	--	21	35	--	56	4.9
June 9	--	--	16	37	--	53	4.6
June 16	--	--	13	36	--	49	4.3

areas in deeper portions of Types 3 and 4 wetlands contained submerged plants. Rise and fall of water levels and changes in land use practices resulted in a mixture of deep and shallow water plants in many wetlands. River bulrush, cattail, and hardstem bulrush were predominant plant species on most Types 3 and 4 wetlands.

Evans and Black (1956) found an inverse relationship between plant density and water levels. Stewart and Kantrud (1967) stated cover interspersion within a wetland correlated fairly well with water depth. They said closed stands of emergents occurred in comparatively shallow water, open stands in deep water, and semi-open stands were characteristic of intermediate depths. They also stated that expanses of open water, when present, were usually found in deepest water but could be found anywhere with land use practices such as heavy grazing. This was also the case on the Sinai study area. As water levels dropped (Table 4), many wetlands became nearly choked with almost pure stands of river bulrush.

Grazing practices on some wetlands, caused a marked decrease in vegetation height and growth. Plants were trampled as well as eaten. Sayler (1962) in his studies on Lostwood Refuge, found no direct evidence to show that size of breeding populations was related to grazing rates.

Table 4. Average water depths in inches of Type 3 and Type 4 wetlands that held water throughout breeding season, Sinai study area, 1968.

Wetland Type	May 14-21	May 22-31	June 1-6	June 10-14	Total Water Depth Loss
3	7.7	5.2	5.6	6.4	1.3
4	13.6	10.7	8.7	8.9	4.7

Homogeneity of Study Area

Since 1967 transects covered most of the study area, a comparison of blue-winged teal (Anas discors) breeding pair counts on each transect should show if the study area was homogeneous with respect to distribution of breeding pairs for this species.

Using orthogonal T tests, comparison of 1967 transects were made based on breeding pair means per wetland and per mile of transect (Table 5). Breeding pair data were transformed using $\sqrt{x + \frac{1}{2}}$ to provide a more normal distribution of breeding pair numbers.

Table 5. Mile and wetland means and standard errors of blue-winged teal breeding pairs based on transects, Sinai study area, 1967. Data transformed using $\sqrt{x + \frac{1}{2}}$.

By Mile				By Wetland			
Transect	Miles	Mean	Std. Error	Transect	Wetlands	Mean	Std. Error
1	231	1.056	0.0510	1	257	1.053	0.0427
2	231	1.175	0.0620	2	215	1.234	0.0657
3	231	1.264	0.1070	3	133	1.101	0.3780
1 and 2	462	1.116	0.0399	1 and 2	472	1.135	0.5440

Mile and wetland means of Transect 1 were compared with Transect 2 since both were 21 miles in length. An orthogonal set from these two transects was compared with Transect 3. No significant differences were detected between any comparisons using breeding pairs per mile.

Transects 1 and 2 were significantly different based on breeding pairs per wetland. Transect 2 contained larger, more permanent type wetlands and had a larger number of blue-winged teal breeding pairs. No difference was detected when Transects 1 and 2 were compared with Transect 3.

Transects did not differ significantly based on blue-winged teal breeding pairs per mile but differed significantly based on pairs per wetland.

Breeding Populations

Spring Migration

Fourteen species of ducks were recorded each year of study. These included, in order of abundance at peak migration, blue-winged teal, gadwall (Anas strepera), shoveler (Spatula clypeata), scaup (Aythya spp.), mallard (Anas platyrhynchos), American widgeon (Mareca americana), redhead (Aythya americana), ring-necked (Aythya collaris), green-winged teal (Anas carolinensis), pintail (Anas acuta), ruddy (Oxyura jamaicensis), bufflehead (Bucephala albeola), canvasback (Aythya valisineria), and wood duck (Aix sponsa) (names of ducks were taken from The American Ornithologists' Union checklist 1957).

These species were present when the study was initiated in 1967 and mallard and pintail were first ducks observed on March 7, 1968. Remainder of ducks arrived the second week in March except ruddy duck which arrived a week later. A drake cinnamon teal (*Anas cyanoptera*), rarely seen in east-central South Dakota, was sighted on two occasions in May 1967.

Murdy (1953) divided waterfowl migration into activity periods for each species with each period categorized by dominant activity in that particular period of time as, (1) start of migration which is marked by arrival of first migrants, (2) arrival phase during which more birds are arriving than departing, (3) peak of migration when bird density is greatest, (4) departure phase when more birds are departing than arriving, (5) early breeding residence beginning with departure of last migrants and encompassing birds residing in area to breed, and (6) late breeding residence which includes remainder of study period.

Following Murdy's categories, census counts for both years of study were begun during arrival phase of migration and continued through period of early breeding residence and first part of late breeding residence for all species. Mallard and pintail were early nesters and were ending departure phase and starting early breeding residence when census counts were started first week in May.

Blue-winged teal, gadwall, and mallard were most numerous breeding and brood producing ducks both years. Shoveler, redhead, and ruddy also produced broods. Only blue-winged teal counts were analyzed during 1967 and blue-winged teal, gadwall, and mallard counts during 1968.

Selection of Period of Breeding Pair Residence

Since not all species migrate into a region or initiate nesting at the same time, different census periods are necessary for many species. Diem and Lu (1960), Smith (1957), and others made note of differing times of breeding pair residence for several species. Dzubin (1967) stated that censusing should be conducted when greatest proportion of any species is in prenesting, laying, or early incubation stages. He stated all censusing should terminate before first broods appear or when first nesting hens are in last states of incubation. Hammond (1966) noted optimum census periods vary annually by 7 to 10 days in North Dakota.

A valid census of waterfowl breeding pairs may be obtained from start of prenesting activity until males have abandoned their mates and begun to flock (Sayler 1962). Hammond (1966) and Drewien (1968) suggested that this time be set during period of initiation of nesting and continue long enough to include both late nesters and renesting by early breeders. Murdy (1953) stated that observed waterfowl densities are expected to be more constant during period of early breeding residence than other periods and would provide best estimates of breeding population.

Day-to-day chronology and variance of duck breeding populations were analyzed to select optimum breeding pair census periods. Periods were selected by: (1) noting when migrants departed, (2) examination of sex ratio data, and (3) back-dating from brood sightings.

Migrant Departure - Mallard migration peak had passed and breeding population had stabilized when censusing was begun during both years (Figure 4). A slight increase in mallard pairs during last of May through first of June was probably due to drake abandonment of hens. Main migration of blue-winged teal occurred second through third week in May during both years (Figure 5).

Migrant gadwalls departed third to fourth week in May 1967 and second to third week in May 1968 (Figure 6).

Loss of wetland areas (Table 3) and influence of vegetative growth on censusing were believed responsible for gradual decrease in indicated breeding pairs of the above three species during last week in May and first half of June.

Sex Ratios - Hochbaum (1944), Dzubin (1967) and others agree increase in percentage of lone drakes is an indicator of beginning of laying. Dzubin (1967) stated that by enumeration of sex ratio data from censusing and a comparison with prebreeding sex ratios, time of laying can be deduced.

A high sex ratio in favor of drake mallards increasing as the month progressed indicated laying and incubation were underway

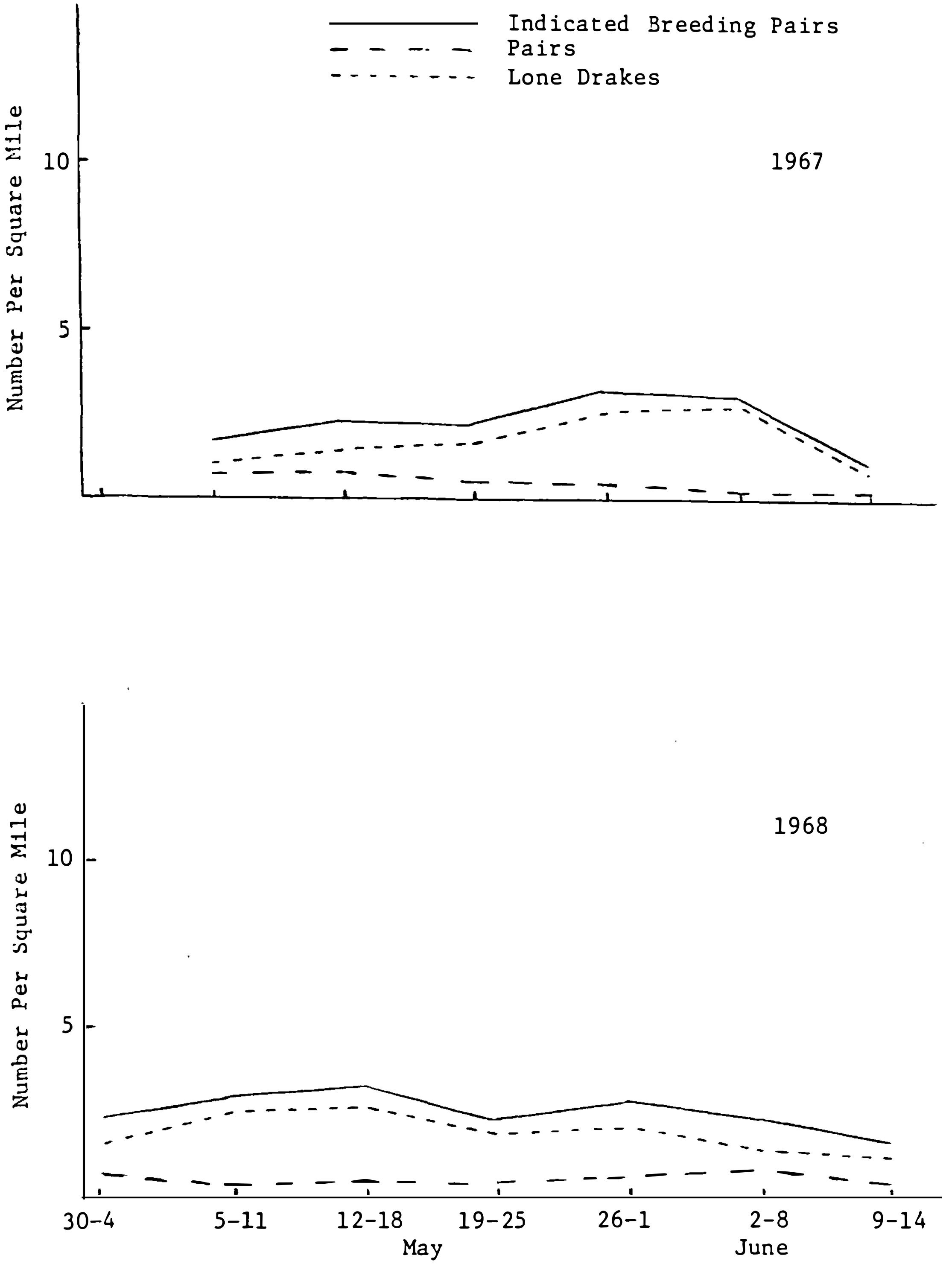


Figure 4. Weekly average of mallard breeding populations, Sinai study area, 1967-68. Data transformed using $\sqrt{x + \frac{1}{2}}$.

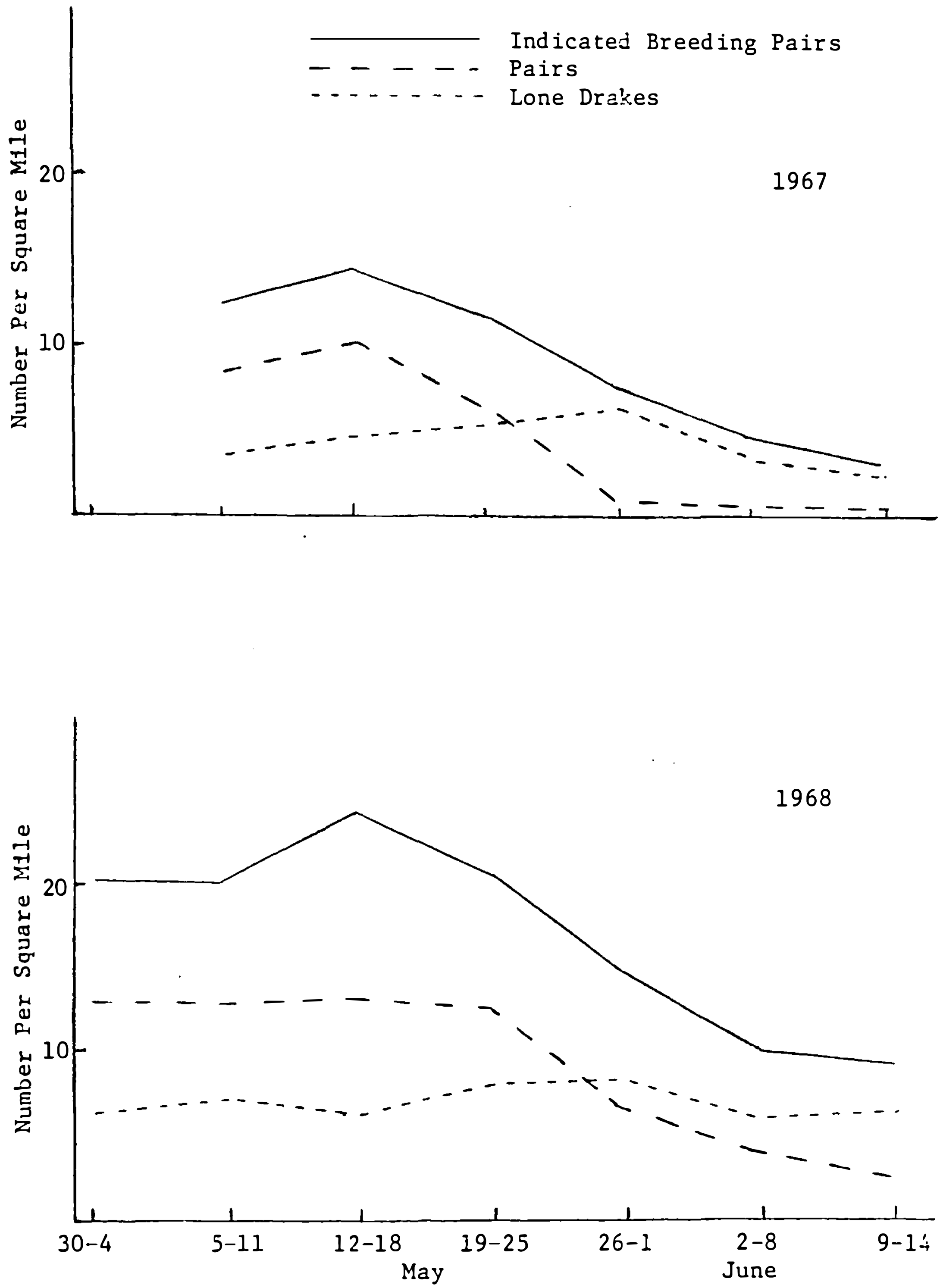


Figure 5. Weekly average of blue-winged teal breeding populations, Sinai study area, 1967-68. Data transformed using $\sqrt{x + \frac{1}{2}}$.

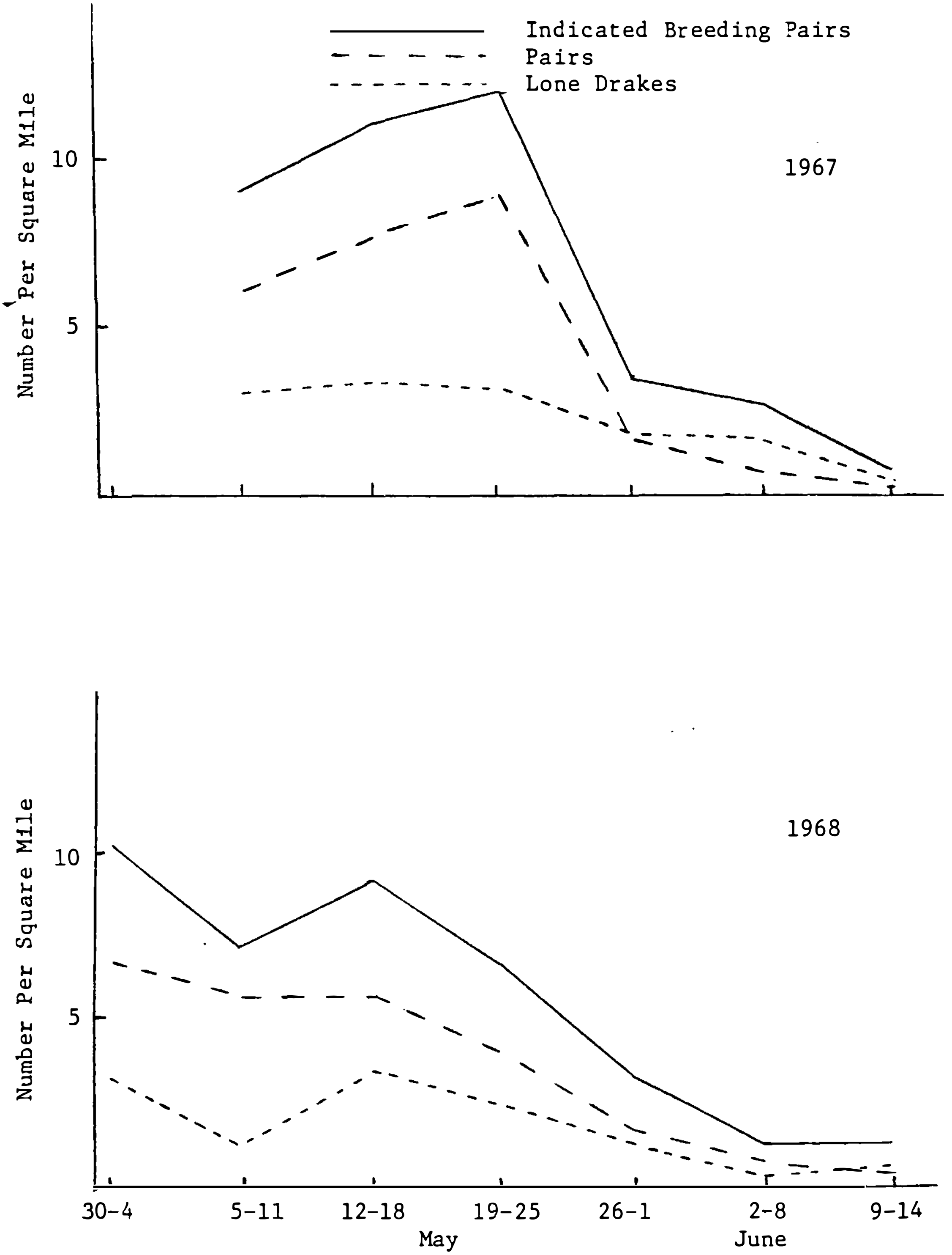


Figure 6. Weekly average of gadwall breeding populations, Sinai study area, 1967-68. Data transformed using $\sqrt{x + \frac{1}{2}}$.

when censusing began (Table 6). An increase in blue-winged teal and gadwall drakes during last week in May indicated start of laying then (Table 6).

Broods - Backdating from broods as described by Blankenship et al. (1953) gave an approximate date for hatching, start of incubation, and beginning of egg laying. Hatching dates for most mallard broods in 1967 and 1968 were first two weeks in June. Egg laying for mallards began near the first week in May. Newly hatched blue-winged teal broods sighted from late June through July both years indicated laying began last week in May through last week in June. Gadwall hens began laying first week in June 1967 and last week of May 1968.

Census Period - Using time of migrant departure, sex ratios, and backdating from brood sightings, optimum census periods for blue-winged teal, gadwall, and mallard were determined.

Optimum time for censusing blue-winged teal was May 20 to June 6 in 1967. Optimum periods for mallard and gadwall were May 5 to 25 and May 25 to June 12.

Optimum censusing periods in 1968 were May 5 through May 30 for mallard and May 23 through June 14 for blue-winged teal and gadwall.

Effects of Vegetation on Counts

Effects of Height and Density

Dead vegetation affected roadside counts during early breeding season. Some wetlands contained only remnants of old vegetation, whereas others had dense stands of cattails and river bulrush.

Table 6. Average weekly sex ratios of blue-winged teal, gadwall and mallard, Sinai study area, 1967-1968.

	Blue-winged Teal	Gadwall	Mallard
	Male:Female	Male:Female	Male:Female
1967			
4/30 - 5/4	- : -	- : -	- : -
5/5 - 5/11	153:100	165:100	250:100
5/12 - 5/18	146:100	136:100	272:100
5/19 - 5/25	170:100	137:100	400:100
5/26 - 6/1	318:100	216:100	656:100
6/2 - 6/8	491:100	282:100	946:100
6/9 - 6/15	600:100	250:100	433:100
6/16 - 6/22	325:100	266:100	325:100
1968			
4/30 - 5/4	160:100	185:100	377:100
5/5 - 5/11	193:100	152:100	1421:100
5/12 - 5/18	154:100	156:100	581:100
5/19 - 5/25	168:100	157:100	470:100
5/26 - 6/1	222:100	164:100	392:100
6/2 - 6/8	241:100	143:100	304:100
6/9 - 6/15	311:100	250:100	790:100
6/16 - 6/22	- : -	- : -	- : -

Later in the breeding season, new emergent vegetation began affecting visibility of waterfowl. Grasses and sedges were first to emerge. Due to warmer temperatures in spring of 1968 aquatic plants appeared a week to ten days earlier than in 1967. New vegetation did not affect visibility of waterfowl until it had reached a height of almost six inches above waterline and had grown dense enough to screen ducks from observation. Cattail, sedge, and grasses had reached 6 inches in some wetlands by second week of May 1967 and by first week of May 1968. However, average new vegetation height and density did not generally affect observability of ducks until third week in May during both years.

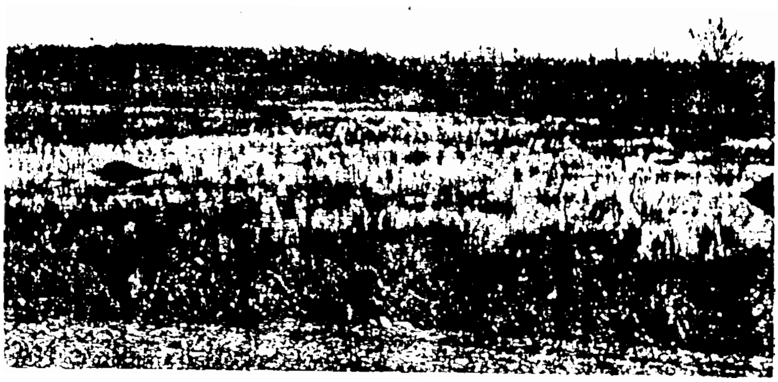
Water depths decreased and plant heights increased later in the breeding season. Average growth rates of four dominant species of emergents indicated cattail grew fastest (1.4 inches per day) and river bulrush slowest (0.7 inches per day) (Table 7).

Amount of vegetation cover on wetlands is difficult to visually measure or estimate. However, if amounts of vegetative cover are categorized into large enough percentage classes, an observer can accurately place his percentage estimate into a class. Percentage estimates were placed into Class 1 (0 to 30 percent covered), Class 2 (35 to 60 percent covered), and Class 3 (65 to 100 percent covered). Percent covered refers to water hidden from view at point of observation along transect. Some wetlands passed through all three vegetative cover classes during breeding season (Figure 7).

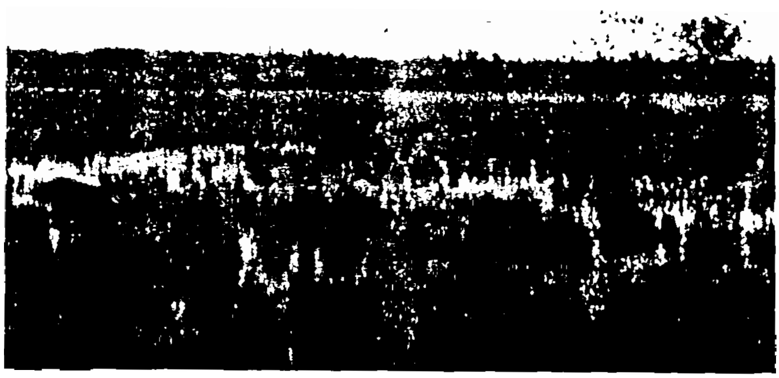
Table 7. Heights and average growth rates in inches of four dominant wetland plants found in Types 3 and 4 wetlands that held water throughout breeding season, Sinai study area, 1968.

Date	Average Water Depth	Cattail Total Height	Cattail Above Surface	River Bulrush Total Height	River Bulrush Above Surface	Hardstem Bulrush Total Height	Hardstem Bulrush Above Surface	Grass* Total Height	Grass* Above Surface	Four Plant Avg. Total Height	Four Plant Avg. Above Surface
May 14-21	11.7	13.3	1.6	11.4	.3	19.0	7.3	7.6	-4.1	12.8	1.1
May 22-31	8.9	20.0	11.1	15.6	6.7	32.6	23.7	12.9	4.0	20.3	11.4
June 1-6	7.7	46.4	38.7	23.7	16.0	46.6	38.9	17.2	9.5	33.5	25.8
June 10-14	8.1	58.2	50.1	34.0	25.9	57.8	49.7	43.0	34.9	48.3	40.2
Average Growth/day		1.4		.7		1.3		1.1		1.1	

* Mainly mannagrass and slough grass.



Class 1 May 9, 1968



Class 2 May 31, 1968

Class 3 June 10, 1968

Figure 7. Vegetative changes on a wetland, Sinai study area, 1968.

A geometric relationship existed between height of vegetation and amount of water hidden from view. For example, from the same observation point, a 12-inch high plant hid from view more than twice as much water as did a 6-inch plant in the same location.

Effects of Amounts of Vegetative Cover

Hammond (1966), Smith (1957) and others noted effects vegetation had on visibility of waterfowl both from air and ground. They found more dense vegetation resulted in fewer ducks observed. As following results will indicate, this was not always so on Sinai study area.

Using orthogonal T tests, differences between breeding pair means of blue-winged teal, gadwall, and mallard were tested among vegetative classes within wetland types, within vegetative classes, and within wetland types. Means of vegetative Classes 2 and 3 were more similar than means of Classes 1 and 2. Therefore, Class 2 was compared to Class 3 and Classes 2 and 3 were pooled and compared to Class 1 to provide an orthogonal set.

The inverse relationship pointed out above held true for blue-winged teal in 1967, that is, fewer pairs were observed with increasing vegetation (Table 8). However, all differences were not significant (Table 9).

Within Type 3 wetlands in 1968, greatest numbers of blue-winged teal and gadwall were observed in vegetative Class 1 and fewer were

Table 8. Indicated breeding pairs of blue-winged teal within vegetative classes and wetland types, Sinai study area, 1967. Data transformed using $\sqrt{x + \frac{1}{2}}$.

Vegetative Classes Within Type 3

Class	Sample	Mean	Std. Error
1	58	.832	.0306
2	36	.793	.0326
3	157	.791	.0172
2 and 3	193	.791	.0153

Vegetative Classes Within Type 4

Class	Sample	Mean	Std. Error
1	187	1.549	.0652
2	36	1.045	.0962
3	109	.853	.0394
2 and 3	145	.901	.0381

Vegetative Classes Within Types 3 and 4

Class	Sample	Mean	Std. Error
1	245	1.379	.0172
2	72	.908	.0508
3	266	.816	.0191
2 and 3	338	1.062	.0233

Types 3 and 4 Within Classes

Type	Sample	Mean	Std. Error
3	251	.798	.0136
4	332	1.266	.0202

Table 9. Tests of indicated breeding pair means of blue-winged teal, gadwall, and mallard within vegetative classes and wetland types, Sinai study area, 1967-68.

	Blue-winged Teal 1967	Blue-winged Teal 1968	Gadwall 1968	Mallard 1968
Type 3				
Class 2 vs Class 3				**
Classes 2&3 vs Class 1		**		
Type 4				
Class 2 vs Class 3		**	**	**
Classes 2&3 vs Class 1	*	**	**	**
Class (disregarding type)				
Class 2 vs Class 3	**	**	**	**
Classes 2&3 vs Class 1	**	**	**	
Type (disregarding class)				
Type 3 vs Type 4	**	**	**	**

* Significant
** Highly significant

observed in Class 2 than Class 3 (Tables 10 and 11). More mallard breeding pairs were observed in Class 2 than either Class 1 or 3. Contrary to expected values, fewer pairs were observed in Class 1 than 3.

Using vegetative classes within Type 4 wetlands and vegetative classes disregarding wetland type, more breeding pairs of blue-winged teal, gadwall, and mallard were observed in Class 2 than Classes 1 or 3 (Tables 10, 11 and 12). As expected, fewer pairs were observed within Class 3 than Class 1.

Within all classes, higher standard error seemed to be correlated with higher breeding pair means for all three species of ducks analyzed (Tables 10, 11 and 12).

Within Type 3 wetlands, greater blue-winged teal and gadwall breeding pair means were found in vegetative Class 1. However, differences were significant from Classes 2 and 3 only for blue-winged teal in 1968. Significantly more mallard pairs were observed within Class 2 than Class 3 (Table 8). No pattern of mean values in vegetative classes within Type 3 wetlands was found and not all differences were significant (Table 9).

Data for classes within Type 4 wetlands and for classes disregarding wetland type were more consistent. More pairs of blue-winged teal, gadwall, and mallard were attracted to Type 4 wetlands containing 35 to 60 percent vegetative cover than other cover classes.

Table 10. Indicated breeding pairs of blue-winged teal within vegetative classes and wetland types, Sinai study area, 1968. Data transformed using $\sqrt{x + \frac{1}{2}}$.

Vegetative Classes Within Type 3				Vegetative Classes Within Type 4			
Class	Sample	Mean	Std. Error	Class	Sample	Mean	Std. Error
1	173	.973	.0288	1	307	1.967	.0576
2	41	.808	.0326	2	130	2.236	.0970
3	190	.813	.0179	3	307	1.349	.0470
2 and 3	231	.812	.0375	2 and 3	437	1.613	.0439

Vegetative Classes Within Types 3 and 4				Types 3 and 4 Within Classes			
Class	Sample	Mean	Std. Error	Type	Sample	Mean	Std. Error
1	480	1.610	.0383	3	404	.882	.0484
2	171	1.894	.0746	4	744	1.758	.0351
3	497	1.144	.0298				
2 and 3	668	1.336	.0293				

Table 11. Indicated breeding pairs of gadwall within vegetative classes and wetland types, Sinai study area, 1968. Data transformed using $\sqrt{x + \frac{1}{2}}$.

Vegetative Classes Within Type 3

Class	Sample	Mean	Std. Error
1	173	.740	.0097
2	41	.707	.0022
3	190	.725	.0097
2 and 3	231	.722	.0052

Vegetative Classes Within Type 4

Class	Sample	Mean	Std. Error
1	307	1.067	.0275
2	130	1.074	.0457
3	307	.823	.0046
2 and 3	437	.898	.0170

Vegetative Classes Within Types 3 and 4

Class	Sample	Mean	Std. Error
1	480	.949	.0179
2	171	.986	.0352
3	497	.786	.0094
2 and 3	668	.837	.0113

Types 3 and 4 Within Classes

Type	Sample	Mean	Std. Error
3	404	.730	.0070
4	744	.968	.0151

Table 12. Indicated breeding pairs of mallard within vegetative classes and wetland types, Sinai study area, 1968. Data transformed using $\sqrt{x + \frac{1}{2}}$.

Vegetative Classes Within Type 3

Class	Sample	Mean	Std. Error
1	306	.733	.0070
2	80	.813	.0255
3	196	.753	.0134
2 and 3	276	.770	.0120

Vegetative Classes Within Type 4

Class	Sample	Mean	Std. Error
1	365	1.011	.0205
2	188	1.220	.0455
3	260	.851	.0198
2 and 3	448	1.001	.0223

Vegetative Classes Within Types 3 and 4

Class	Sample	Mean	Std. Error
1	671	.884	.0102
2	268	1.099	.0329
3	456	.809	.0129
2 and 3	724	.921	.0152

Types 3 and 4 Within Classes

Type	Sample	Mean	Std. Error
3	502	.870	.0079
4	813	1.008	.0154

Highly significant differences were detected between Classes 2 and 3 and when these two classes were compared to Class 1 (Table 8).

Significantly more ducks were observed on Type 4 wetlands than Type 3 possibly since Type 4 wetlands were larger and more permanent than Type 3.

Even though Class 2 had more vegetation than Class 1, more ducks were observed per unit area of open water. It is believed more ducks were seen within Class 2 because of more "edge" or dispersion of cover than in Class 1. It is also believed that fewer ducks were seen in Class 3 since open water was limited and less "edge" was available for breeding pairs.

Effects of Wind and Light on Counts

Roadside census data from 1968 were subjected to an analysis of variance to determine if variations of wind velocity and light intensity influenced counts of blue-winged teal, gadwall, and mallard.

Three wind and three light categories used in the analysis were as follows:

Wind

1 - Observations with wind velocities of 0 to 6 miles per hour.
2 - Observations with wind velocities of 7 to 10 miles per hour.
3 - Observations with wind velocities of 11 or more miles per hour.

Light
- 1 - Observations at light intensities of 1 to 2.9 Langleys.[1]
- 2 - Observations at light intensities of 3 to 4.9 Langleys.
- 3 - Observations at light intensities of 5 or more Langleys.

Results revealed that wind and light conditions exerted no significant influence on counts of breeding pairs of blue-winged teal, gadwall, and mallard on the Sinai study area (Table 13).

Diem and Lu (1960) found that wind and light exerted no significant influence on counts of puddler and diving ducks.

Number of Counts Needed for Specified Accuracy

Transects used during both years were run as many times as possible during May and June but only counts falling within optimum breeding pair census periods were used. Because some wetlands contained no breeding pairs data were transformed using $\sqrt{x + \frac{1}{2}}$.

Only blue-winged teal data were analyzed during 1967. All three transects were run on same day eleven times within optimum breeding pair census period of May 20 to June 6.

Number of counts needed to be within 20 percent of population mean with specified confidence of 0.90 when using breeding pairs per mile was 9 and 10 on the two longer transects and 25 on the shorter transect (Table 14). Number of counts needed when using breeding pairs per wetland at the same designated limits was 6 and 11 for the longer transects and 10 for Transect 3 (Table 14).

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[1]Langley - a unit of energy per unit area commonly employed in radiation theory and is equal to one gram-calorie per square centimeter (Huschke 1959).

Table 13. An analysis of variance of wind and light influences on counts of blue-winged teal, gadwall and mallard, Sinai study area, 1968. Data transformed using $\sqrt{x + \frac{1}{2}}$.

Source of Variation	D. F.	Sum of Squares	Mean Square	F
BLUE-WINGED TEAL				
Wind	2	.0439	.0219	.024
Light	2	.2933	.1466	.165
Error	1144	1014.2898	.8866	
GADWALL				
Wind	2	.0082	.0041	.030
Light	2	.2094	.1047	.768
Error	1144	155.7607	.1362	
MALLARD				
Wind	2	.0420	.0210	.140
Light	2	.0132	.0066	.044
Error	1391	207.9873	.1495	

Table 14. Number of breeding season counts on transects 1, 2 and 3 necessary to obtain a given accuracy based on breeding pairs per mile of transect or per wetland for blue-winged teal, Sinai study area, 1967. Data transformed using $\sqrt{x + \frac{1}{2}}$.

	Transect 1				Transect 2				Transect 3			
	Miles		Wetlands		Miles		Wetlands		Miles		Wetlands	
Mean	1.056		1.050		1.175		1.234		1.264		1.101	
Std. Error	0.1583		0.1299		0.1910		0.2096		0.3444		0.1825	
Conf. Limits	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95
Number of Counts												
within 10% of mean	30	36	21	27	35	45	38	49	95	114	36	45
within 20% of mean	9	11	6	8	10	13	11	13	25	34	10	13

When pothole numbers exceeded mile numbers as in Transects 1 and 3, more counts were necessary for miles than for wetlands. However, the reverse was true on Transect 2 where mile numbers exceeded wetland numbers. Data indicated that the greater the number of miles or wetlands, the less the standard error, consequently requiring fewer counts. Small number of miles on Transect 3 may have caused a high standard error which increased number of runs required.

In 1968 twenty counts made during optimum census periods for blue-winged teal, gadwall, and mallard were broken down into three census-day periods (first 10, middle 10, and last 10 days). Average number of wetlands containing water for each of these time periods was 64.9, 55.7 and 50.0.

Number of counts necessary to be within 20 percent of population mean with specified confidence of 0.90 for blue-winged teal were five using miles and ranged from five to six using wetlands for all three time periods (Table 15).

Using same limits, counts ranged from two to three for both miles and wetlands for gadwall, and three for miles and two to three for wetlands for mallards.

Number of counts during any of three time periods selected for each species varied only one or two counts for both miles and wetlands for these limits. Mean number of ducks and standard error decreased with time but number of counts for each species within

Table 15. Number of breeding season counts necessary to obtain a given accuracy based on breeding pairs per mile of transect or per wetland for blue-winged teal, gadwall and mallard, Sinai study area, 1968. Data transformed using $\sqrt{x + \frac{1}{2}}$.

	May 23 - June 2				May 29 - June 8				June 3 - June 14			
	Miles		Wetlands		Miles		Wetlands		Miles		Wetlands	
Blue-winged teal												
Mean	1.530		1.496		1.365		1.439		1.253		1.387	
Std. Error	0.1613		0.1214		0.1392		0.1197		0.1343		0.1284	
Conf. Limits	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95
Number of Counts												
within 10% of mean	16	20	10	13	15	19	11	13	16	20	13	16
within 20% of mean	5	7	4	5	5	6	4	5	5	7	5	6
Gadwall												
Mean	0.941		0.917		0.858		0.867		0.823		0.841	
Std. Error	0.0640		0.0509		0.0434		0.0403		0.0362		0.0373	
Conf. Limits	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95
Number of Counts												
within 10% of mean	8	10	6	7	5	6	5	6	4	5	4	5
within 20% of mean	3	4	3	3	2	3	2	2	2	3	2	3
Mallard	May 5 - May 19				May 15 - May 28				May 20 - May 30			
Mean	0.969		0.911		0.947		0.897		0.925		0.888	
Std. Error	0.0650		0.0489		0.0593		0.0441		0.0571		0.0433	
Conf. Limits	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95	0.90	0.95
Number of Counts												
within 10% of mean	7	9	5	7	7	8	5	6	7	9	5	6
within 20% of mean	3	4	3	3	3	4	3	2	3	4	2	3

same designated limits were similar. Number of counts for other specified accuracy limits were also calculated (Tables 14 and 15).

Mean number of blue-winged teal was greater in 1968 but standard error was smaller, probably since more miles and wetlands were involved and fewer wetlands dried up (Tables 14 and 15).

Fewer counts were necessary for blue-winged teal (1967-68), gadwall and mallard (1968) when using wetlands rather than miles for calculating number of runs. This difference, however, was rather small when desired accuracy was within 20 percent of mean with specified confidence of 0.90 or 0.95.

Analysis of data for blue-winged teal, gadwall, and mallard indicate several replicate counts along the same route are necessary to obtain desired accuracy.

Roadside and Flushing Counts

Four flushing counts were made during optimum census period for blue-winged teal, gadwall and mallard in 1968. Flushing counts were made May 14 to 21, May 22 to 31, June 3 to 8, and June 10 to 14. All flushing counts were made on the same wetland immediately after roadside counts were made (Table 16).

Roadside and flushing count breeding pair means for each vegetation class and total for all classes combined were checked for significant differences using Student's T test. Breeding pair data was transformed using $\sqrt{x + \frac{1}{2}}$.

Table 16. Roadside and flushing counts of indicated breeding pairs of blue-winged teal, gadwall and mallard within vegetation classes, Sinai study area, 1968.

Veg. Class	No. of Obser- vations	Mean Pairs From Road	Std. Error	Mean Pairs Flushed	Std. Error
BLUE-WINGED TEAL					
1	66	3.136	.5273	3.682	.6789
2	25	3.640	.7994	6.800	1.6881
3	67	1.358	.2775	3.642	.6181
Total	158	2.462	.2892	4.158	.4743
GADWALL					
1	66	.530	.1300	.773	.1711
2	25	.520	.2323	.960	.4884
3	67	.209	.0583	.522	.1172
Total	158	.392	.0706	.696	.1123
MALLARD					
1	63	.397	.0863	.540	.1157
2	25	1.040	.3813	1.880	.0662
3	48	.270	.0927	.521	.1464
Total	136	.471	.0892	.779	.1481

A highly significant difference for blue-winged teal and a significant difference for gadwall breeding pairs was detected between roadside and flushing counts within Class 3. Counts within Class 1 did not differ significantly for either species. Roadside and flushing counts within Class 2 were not significantly different but sample size was small. Only roadside and flushing counts within Class 2 were significantly different for mallards (Table 16).

A correction factor (pairs flushed divided by pairs seen from road) for breeding pairs of blue-winged teal and gadwall would only have to be made on Class 3 and only on Class 2 for mallard. Correction factors for blue-winged teal and gadwall are 2.682 and 2.497 on Class 3. A correction factor of 1.808 could be used for mallard on Class 2. Overall correction factors for all wetlands were 1.659 for blue-winged teal, 1.776 for gadwall and 1.654 for mallard.

Indicated Pairs Compared With Total Ducks Observed

It is important to know if roadside and flushing counts of pairs appear in same proportions as roadside and flushing counts of total ducks observed. Roadside and flushing count data from 1968 were compared in this manner for blue-winged teal, gadwall, and mallard (Figure 8).

During flushing counts on the Sinai study area, indicated pairs were distinguished from other ducks. Proportion of roadside

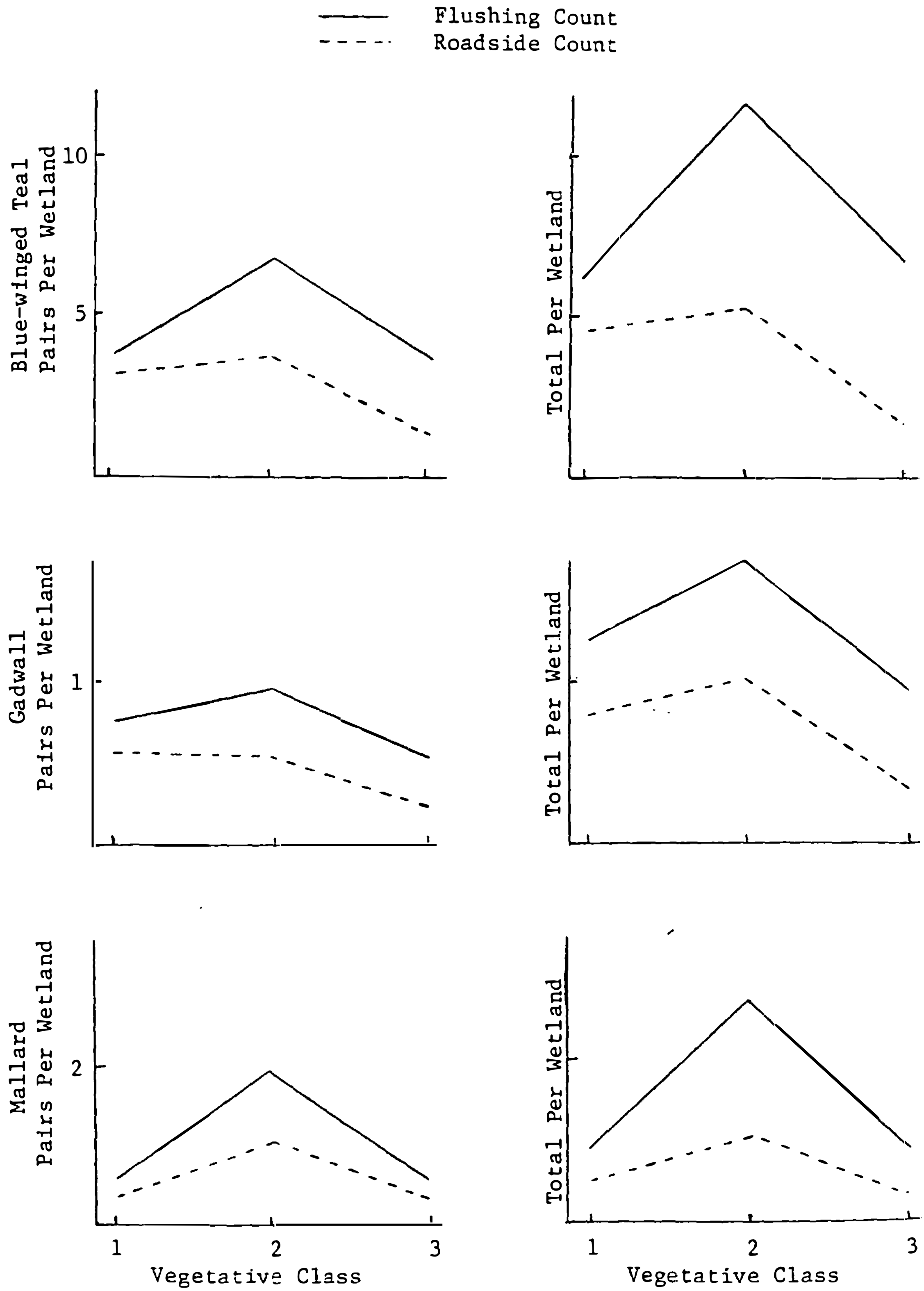

Figure 8. Relationship between flushing and roadside counts for indicated breeding pairs and total ducks flushed, Sinai study area, 1968.

indicated pairs to flushed indicated pairs was nearly the same as proportion of total roadside count to total birds flushed for all three species.

Relationship of Acres of Water in Wetland Basins to Number of Breeding Pairs

Acres of water that each wetland basin contained were placed into one of five acreage categories for analysis. Acre categories were: (1) 0.01 to 2.9 acres, (2) 3.0 to 5.9 acres, (3) 6.0 to 8.9 acres, (4) 9.0 to 11.9 acres, and (5) above 11.9 acres. As wetlands lost water and wet acres became less, they were placed in a new acreage category. All breeding pair data were transformed using $\sqrt{x + \frac{1}{2}}$.

Greater numbers of breeding pairs were observed on wetlands containing more acres of water. As water acreage increase, blue-winged teal pairs also increased (Figure 9).

Orthogonal T tests were used to test differences between mean number of pairs seen on different water-acreage categories (Table 17). Comparisons were made between: 2 and 3; 4 and 5; 2 and 3 vs 4 and 5; and 1 vs 2, 3, 4, and 5. No significant differences were detected between 2 and 3 for blue-winged teal and gadwall or between 4 and 5 for gadwall. Remainder of comparisons made for all species showed highly significant differences. Therefore, except for acreage categories 2 and 3, and 4 and 5 for gadwall, a

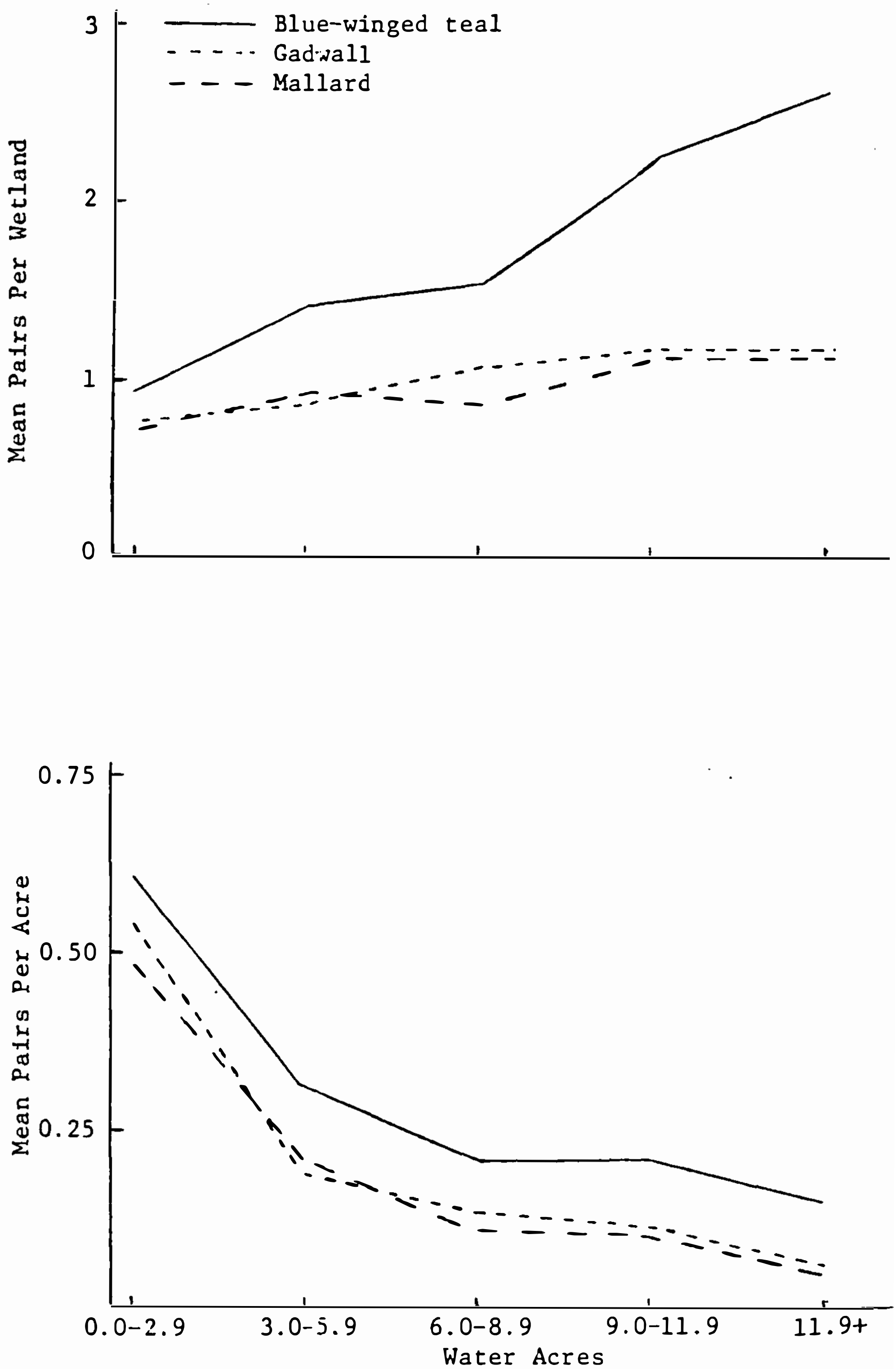

Figure 9. Relationship of water area to mean number of indicated pairs per acre and wetland, Sinai study area, 1968. Data transformed using $\sqrt{x + \frac{1}{2}}$.

Table 17. Indicated breeding pairs of blue-winged teal, mallard, and gadwall within different size categories of wetlands, Sinai study area, 1968. Data transformed using $\sqrt{x + \frac{1}{2}}$.

Acreage Category	Number of Observations	Mean	Std. Error
BLUE-WINGED TEAL			
1	553	.915	.0164
2	209	1.406	.0451
3	124	1.566	.0834
4	74	2.271	.0807
5	188	2.672	.0775
2 and 3	333	1.466	.0420
4 and 5	262	2.559	.0608
2,3,4 and 5	595	1.947	.0355
GADWALL			
1	553	.746	.0318
2	209	.938	.0748
3	124	.889	.0843
4	74	1.134	.0605
5	188	1.128	.0404
2 and 3	333	.920	.0179
4 and 5	262	1.130	.0336
2,3,4 and 5	595	1.947	.0356
MALLARD			
1	666	.756	.0021
2	282	.869	.0176
3	124	1.010	.0113
4	79	1.193	.0495
5	244	1.184	.0120
2 and 3	406	.912	.0165
4 and 5	323	1.137	.0212
2, 3, 4 and 5	729	1.011	.0216

three acre change in water area resulted in a significant difference in number of breeding pairs for the three species tested.

The more permanent water areas received heavier use possibly due to a total absence of Type 1 water areas and many of the smaller Type 3 water areas did not last through the breeding season. Jenni (1956) also found more permanent wetlands received heaviest use by breeding pairs on a per wetland basis.

Based on breeding pairs per unit area of wetland however, Jenni (1956), Evans and Black (1956) and others have found that smaller wetlands receive heaviest use. This was also true on the Sinai study area (Figure 9). The smaller the wet acres per wetland, the greater the breeding pair use per acre by all three species of ducks.

The standard error for blue-winged teal and gadwall mean pairs was less for 0.01 to 2.9 acre category than for all other categories. Same was true for 3.0 to 5.0 and 6 to 8.9 acre categories for mallard (Table 17). This could indicate two things, (1) a more consistent number of blue-winged teal and gadwall can be censused on smaller (0.01 to 2.9 acre) wetlands, or (2) pair numbers on smaller wetlands fluctuate less as there may be less movement of pairs into or out of smaller wetlands.

Variability Among Observers

Two experienced observers and the investigator made five simultaneous roadside breeding pair counts in May 1968. The investigator and a less experienced observer made four simultaneous counts during first two weeks of June 1968. Counts were analyzed for significant differences among observers within: (1) vegetative classes, (2) wetland types, and (3) total count (Tables 18, 19, and 20). Species analyzed were blue-winged teal, gadwall, and mallard and orthogonal sets were used for comparisons (Table 21).

Relationship of number of blue-winged teal and gadwall pairs seen by each observer remained the same in all categories. Most pairs were seen by observer number 2, followed by observers 3, 1, and 4. However, not all comparisons were significantly different (Table 18).

Although different orthogonal sets were used in some categories for gadwall, with the exception of vegetative Class 3, a significant difference was detected within all categories.

Except for vegetative Class 2, no significant differences were detected between any comparisons made for mallard.

A probable reason for lack of significant differences within Class 3 for blue-winged teal and gadwall is that fewer ducks were observed within this Class than in other classes and all observers tended to see a high percentage of those ducks present.

The investigator, (observer number 1) with qualifications similar to observers 2 and 3, saw fewer ducks in almost every case. Observer number 1 was also driver of the vehicle and therefore had less opportunity for observing. Observer number 4 may have seen fewer ducks due to lack of experience.

Table 18. Simultaneous counts of blue-winged teal by different observers, Sinai study area, 1968.

Within Vegetative Classes

	Class 1				Class 2				Class 3		
Obs.	Wetlands Sampled	Mean	Std. Error	Obs.	Wetlands Sampled	Mean	Std. Error	Obs.	Wetlands Sampled	Mean	Std. Error
1	244	3.074	.2902	1	99	3.939	.4916	1	221	1.357	.1813
2	168	4.429	.5209	2	67	5.925	1.0403	2	110	1.836	.3766
3	167	3.659	.4332	3	68	5.235	.7872	3	110	1.845	.3847
4	63	3.063	.4654	4	28	3.535	.7997	4	84	1.536	.3474
2&3	335	4.045	.3831	2&3	135	5.577	.6349	2&3	220	1.841	.2693
1&4	307	3.072	.2493	1&4	127	3.845	.4224	1&4	305	1.406	.1624

Within Pothole Types

	Type 3				Type 4		
1	216	.519	.0768	1	348	3.816	.2543
2	143	.734	.1357	2	202	6.129	.5467
3	143	.699	.1164	3	202	5.298	.4512
4	53	.358	.1012	4	122	3.295	.3636
2&3	286	.715	.0890	2&3	404	5.714	.3548
1&4	269	.487	.0649	1&4	470	3.681	.1892

Total

1	564	2.553	.1403
2	345	3.892	.1029
3	345	3.391	.0269
4	175	2.406	.2557
2&3	690	3.642	.2103
3&4	739	2.518	.1229

Table 19. Simultaneous counts of gadwall by different observers, Sinai study area, 1968.

Within Vegetative Classes

Class 1				Class 2				Class 3			
Obs.	Wetlands Sampled	Mean	Std. Error	Obs.	Wetlands Sampled	Mean	Std. Error	Obs.	Wetlands Sampled	Mean	Std. Error
1	244	1.267	.1984	1	99	1.212	.2423	1	221	.186	.0361
2	168	1.571	.2612	2	67	2.000	.4174	2	110	.273	.0763
3	167	1.635	.2792	3	68	2.074	.4723	3	110	.200	.0560
4	63	.444	.0817	4	28	.500	.0481	4	84	.131	.0407
1,2,3	579	1.461	.1373	2&3	135	2.037	.3156	2&3	220	.237	.0473
				1,2,3	234	1.688	.2093	3&4	305	.171	.0285

Within Pothole Types

Type 3				Type 4			
Obs.	Wetlands Sampled	Mean	Std. Error	Obs.	Wetlands Sampled	Mean	Std. Error
1	216	.0370	.0128	1	348	1.328	2.8842
2	143	.0629	.0374	2	202	2.074	3.5604
3	143	.0350	.0154	3	202	2.134	3.7936
4	53	.0377	.0264	4	122	.418	.6413
2&3	286	.0489	.0597	1,2,3	752	1.744	.1212
1&4	269	.0372	.0115				

Total

Obs.	Wetlands Sampled	Mean	Std. Error
1	564	.834	.0302
2	345	1.240	.1552
3	345	1.251	.1563
4	175	.457	.0414
2&3	686	1.246	.1104
1&4	690	.774	.0733

Table 20. Simultaneous counts of mallard by different observers, Sinai study area, 1968.

Within Vegetative Classes

	Class 1				Class 2				Class 3		
Obs.	Wetlands Sampled	Mean	Std. Error	Obs.	Wetlands Sampled	Mean	Std. Error	Obs.	Wetlands Sampled	Mean	Std. Error
1	244	.504	.0576	1	99	.707	.1201	1	221	.244	.8604
2	168	.393	.0597	2	67	.970	.2201	2	110	.227	.8313
3	167	.509	.0690	3	68	1.074	.2283	3	110	.127	.5097
4	63	.651	.1203	4	28	.321	.1465	4	84	.357	1.0834
2&3	335	.451	.0448	2&3	135	1.022	.1584	1,2,3	44	.221	.0372
3&4	307	.534	.0520	1&4	127	.622	.0994				

Within Pothole Types

	Type 3				Type 4		
Obs.	Wetlands Sampled	Mean	Std. Error	Obs.	Wetlands Sampled	Mean	Std. Error
1	216	.0926	.0255	1	348	.652	.0606
2	143	.119	.0365	2	202	.688	.0941
3	143	.098	.0286	3	202	.782	.0965
4	53	.132	.0604	4	122	.598	.1032

Total

Obs.	Wetlands Sampled	Mean	Std. Error
1	564	.438	.0386
2	345	.440	.0571
3	345	.498	.0578
4	175	.457	.0862

Table 21. Tests of simultaneous counts by four different observers of blue-winged teal, gadwall and mallard, Sinai study area, 1968.

	Blue-winged Teal	Gadwall	Mallard
Veg. Class 1	1 vs 4 2 vs 3 1&4 vs 2&3*	1,2,3 vs 4*	1 vs 4 2 vs 3 1&4 vs 2&3
Veg. Class 2	1 vs 4 2 vs 3 1&4 vs 2&3*	2 vs 3 1 vs 2&3* 1,2,3 vs 4**	1 vs 4* 2 vs 3 1&4 vs 2&3*
Veg. Class 3	1 vs 4 2 vs 3 1&4 vs 2&3	1 vs 4 2 vs 3 2&3 vs 1&4	1,2,3 vs 4
Type 3	1 vs 4 2 vs 3 1&4 vs 2&3*	1 vs 4 2 vs 3 1&4 vs 2&3*	1 vs 3 2 vs 4
Type 4	1 vs 4 2 vs 3 1&4 vs 2&3**	1 vs 2,3,4**	1 vs 4 2 vs 3
Total	1 vs 4 2 vs 3 1&4 vs 2&3**	1 vs 4** 2 vs 3 1&4 vs 2&3*	1 vs 4 2 vs 3 1&4 vs 2&3

* Significant difference detected
** Highly significant difference detected

CONCLUSIONS

The period for most accurately censusing breeding pairs of blue-winged teal, gadwall, and mallard was after migrants had left and before drakes abandoned hens. Optimum period for censusing mallards was throughout May. The last week in May through second week in June was optimum for blue-winged teal and gadwall.

Several replicate counts were necessary within a reasonably short period of time before desired accuracy limits could be obtained. To be within 20 percent of population mean at 0.90 confidence on the 54-mile transect, at least four counts were required for blue-winged teal and three for gadwall and mallard. These counts could be taken any time during censusing period although mean number of pairs would be less if censused after new vegetation affected observability. If wetland numbers exceeded mile numbers, fewer counts were required if calculations were based on breeding pairs per wetland. However, if mile numbers exceeded wetland numbers, fewer counts were required if calculations were based on breeding pairs per mile of transect.

Number of breeding pairs observed did not necessarily decrease as vegetative cover increased. More blue-winged teal and gadwall were observed on wetlands with 35 to 60 percent cover than other vegetative classes. Differences between roadside and flushing counts were not significant for Class 1 or Class 2 wetlands but were significant for Class 3 wetlands.

Since highest breeding pair counts were recorded on more permanent wetlands with 35 to 60 percent vegetative cover and no difference between roadside and flushing counts was detected, perhaps population trends could be established by censusing only these types of wetlands.

Several factors, such as vegetation height and density and size of wetland influenced census counts. If dense and high enough, old vegetation affected breeding pair counts throughout censusing period. New vegetation did not affect breeding pair counts until the third week in May. Smaller wetlands could be more thoroughly censused and contained a higher concentration of pairs per acre than larger wetlands. Wind velocity and cloud cover exerted no significant influence on breeding pair counts of blue-winged teal, gadwall, or mallard.

Since wetland classification under the present system of Types 1, 3, 4, etc. is difficult, perhaps a better system for censusing purposes would be to place each wetland into vegetative classes and disregard other factors.

To obtain accurate waterfowl counts, each observer should receive training and be given concise, explicit, standardized instructions on how to make counts. Since bias exists between observers, either the same observer could be maintained throughout censusing, or several observers could be alternated on census routes to overcome bias.

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