Characteristics of scattered wetlands in relation to duck production in southeastern Wisconsin. No. 116 1979

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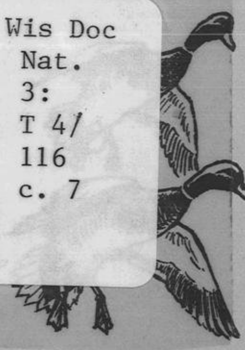

CHARACTERISTICS OF SCATTERED WETLANDS IN RELATION TO DUCK PRODUCTION IN SOUTHEASTERN WISCONSIN

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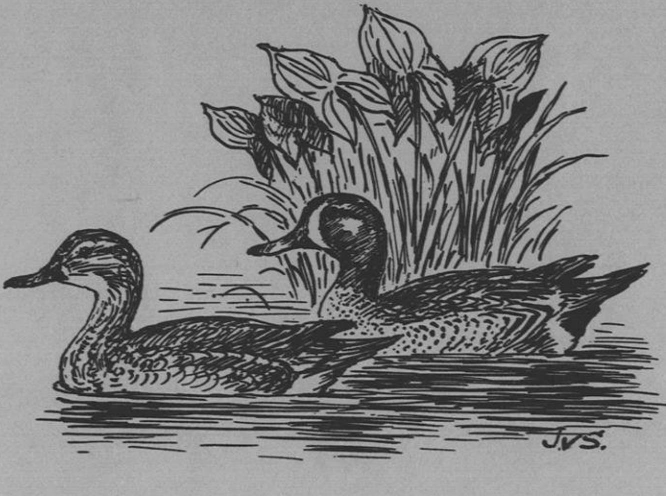

ABSTRACT

Breeding waterfowl were studied from 1973 to 1975 in southeastern Wisconsin on the 504 sq mile Scattered Wetlands Study Area (SWSA). This area contains some of the best waterfowl production lands in Wisconsin and encompasses parts of Dodge, Fond du Lac, Green Lake, and Columbia counties. Waterfowl pair densities, production, habitat utilization, and food habits were examined.

Helicopter surveys and random plot censuses were used simultaneously to estimate pair densities and wetland occupancy rates and the results are compared.

Helicopter and random plot methods indicated mallard breeding pair populations were relatively stable during 1973-75 and averaged 1.8/sq mile and 2.0/sq mile, respectively. These mallard densities based on overall surface area are much lower than those of the prairies of the United States and Canada but higher than densities from production areas in Minnesota and Ontario. Estimates for blue-winged teal from both methods averaged 5.7/sq mile with each method indicating a decline in pairs of greater than 25% during the period. Since occupancy rates are high, these population densities reflect the low number of wetlands per square mile on the SWSA when the densities are compared to those from the prairies of the Dakotas or Canada. Helicopter surveys to estimate breeding pairs could be run at approximately 1/3 the cost of the concurrent ground censuses of random plots.

Random plot censuses proved to be the best method for estimating occupancy rates of wetland types. The major drawbacks to occupancy estimated by helicopter surveys were the detection of less than 50% of the blue-winged teal pairs and a 3-fold over-estimation of wetland numbers when compared to actual mapped densities on the study area.

Occupancy of all wetland types averaged 56% for the random plot censuses, which was at least 3 times that of previous estimates in southeastern Wisconsin and was similar to rates in the parklands of Canada. Previous aerial surveys probably underestimated occupancy rates just as the helicopter surveys in this study did. All deep marshes and lakes were utilized by breeding pairs of ducks. Occupancy of shallow marshes averaged 61% and dropped from 75% to 50% over the period studied, as a result of drying and closure by vegetation. Occupancy rates of all wetlands combined were directly correlated with pair densities of all species combined. Occupancy rates of seasonally flooded basins, fresh meadows, shallow marshes, dug ponds, streams, and ditches were each directly correlated with pair densities of all species combined.

Mallard pairs on semi-permanent and permanent wetlands equalled one pair for every two ponds present which was similar to prairie and parkland areas of the United States and Canada.

Although ducklings were seen on all wetland types, only 19% of the total study area wetlands were utilized by broods. All deep marshes and lakes in the study area were used by broods. Poor production of ducklings and the drying out of poorer grade wetlands by the time broods are hatched both contribute to the lack of ducklings on study area wetlands.

A loss of 9% in wetland acreage occurred during the 3-yr study. Corresponding increases of 5.5% in total acreages under cultivation and 6.3% in corn acreage also occurred.

Net sample estimates of total biomass of those available invertebrates most heavily utilized, indicated that the lakes had the highest available biomass. Deep marshes, also considered excellent pair and brood waters, were first in biomass for bottom-associated invertebrates but ranked only seventh in biomass of the most heavily utilized invertebrates sampled from the surface. A total of 21 orders and 55 families of invertebrates were found in study area wetlands. Net samples of invertebrates revealed biomass estimates ranging from 5.5 ml/cu m to 39.9 ml/cu m and numbers of organisms ranging from 1,028/cu m to 26,771/cu m. Samples of bottom substrates indicated the presence of 22-156 ml of invertebrates/sq m and numbers of organisms ranging from 3,960/sq m to 50,260/sq m. Adequate invertebrate populations indicate low production is not the result of low food resources for breeding hens.

Fertility and food resources appeared adequate on all areas studied. The yearly fluctuations in precipitation and the resulting presence or absence of water was apparently the major factor in determining which areas would be utilized by pairs and broods.

The diets of breeding blue-winged teal hens on the SWSA consisted of 59% and 93% animal materials for prelaying and laying hens, respectively. The diets of post-laying hens and all males consisted of 100% and 95% animal materials, respectively. This indicates that although the high need for protein by a laying hen may be met by selecting invertebrates, both post-laying hens and males may utilize just as high a percentage of invertebrates when they are easily available.

Earlier nesting mallard hens consumed 25% and 48% animal materials for prelaying and laying periods, respectively. Lower availability of invertebrates to earlier nesting birds would explain the lower proportion of these high protein foods in the diet of hen mallards.

Molluscs provided the largest proportion of any food consumed by all age classes of blue-winged teal ducklings.

Duck production on the SWSA ranged from 29 to 86 ducklings/100 acres of wetlands (shallow and deep marshes, lakes, and ponds) during 1973-75 with the highest production occurring in the extremely wet 1973 breeding season. The production of 0.3 broods/pair of ducks on the SWSA was similar to areas of the Canadian parklands.

Pioneering of both mallards and blue-winged teal hens very likely had to occur each year (1973-75) to reach the succeeding year's population, unless a highly unlikely homing rate of 100% for all surviving adults, 40-70% for immature female mallards, and 50-100+% for immature female blue-winged teal occurred.

Management considerations for scattered wetlands should concentrate on increasing permanent brood water on marginal wetlands and adding secure nesting cover to increase the production of present breeding pair populations of this highly significant segment of Wisconsin waterfowl habitat. This would reduce the dependence on pioneering, help maintain the present populations, and provide additional space for the available pioneers.

Recommendations are offered on the use of helicopter surveys and random plot censuses for estimating breeding populations, and for monitoring habitat utilization and land use changes.

CHARACTERISTICS OF SCATTERED WETLANDS IN RELATION TO DUCK PRODUCTION IN SOUTHEASTERN WISCONSIN

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INTRODUCTION

Small privately owned wetlands are the heart of Wisconsin's wetland heritage. These scattered, often temporary, water areas not only produce waterfowl but are some of the only remaining havens for wildlife resisting man's efforts to satisfy his increasing needs for food, space, and materials. The future of these small wetlands surely depends on the recognition of their value to future generations.

Nearly 10 million acres of wetland once existed in Wisconsin (Johnson 1976). Wisconsin now has only 2.5 million acres of wetlands remaining, with approximately 1.6 million acres (64%) in private ownership and approximately 911,000 acres in public ownership (Nat. Resour. Council of State Agencies 1973). It is the portion of our wetlands in private ownership that is in greatest jeopardy of being lost. These small, scattered wetlands currently produce the highest percentage of Wisconsin's ducks.

Wisconsin wetlands considered to be of highest value to waterfowl are found in the southeastern and northwestern regions of the state. Wetlands in southeastern Wisconsin are being affected the most by drainage and development (Mann 1955; Jahn and Hunt 1964). Statewide surveys of breeding ducks during 1965-70 indicated that the SE/Central region had the highest breeding duck densities in 3 of 5 yr with the Northwest region having equal or higher densities in the other 2 yr (March et al. 1973).

Wetland losses in southeastern Wisconsin have been documented by several authors. Kabat (1972) estimated losses in the southeast to be over 50% of the wetlands present in the 1870's. In the southeast's Fox River watershed, 60% of that area's wetlands were lost by 1968 (O'Donnell et al. 1973).

The importance of scattered wetlands in southeastern Wisconsin and their steadily decreasing numbers has long been a concern. Along with recognizing the demise of wetlands, biologists felt wetlands were not being fully utilized by breeding ducks. Cross-country road transects in southeastern Wisconsin indicated the averaged occupancy of wetlands by breeding ducks was 18% during 1948-50 (Jahn and Hunt 1964). Aerial surveys in the SE/Central region during 1965-70 also indicated a very low average occupancy rate of 5.7% for all wetlands (March et al. 1973). Both previous studies led their authors to conclude that many of the wetlands surveyed were unattractive to breeding ducks or that the number of breeding ducks was too low to fill available habitat.

Studies in Minnesota indicate wetland use by breeding pairs is directly related to soil and water fertility (Jessen et al. 1964). Moyle (1961) pointed out relationships between good bottom fauna production and associated good waterfowl production. Drewien and Springer (1969) found habitat use was influenced by pond size, and type and availability of temporary ponds. Other factors thought to affect usage of wetlands in Wisconsin included territorial requirements, wetland densities, and breeding pair densities.

Prior hypotheses regarding low wetland occupancy rates and a lack of basic knowledge about wetland characteristics and related use of wetlands by breeding ducks in Wisconsin precipitated our study which took place from April, 1973 to September, 1975.

The objectives of this study were: (1) to determine breeding duck densities, brood densities, and occupancy rates on scattered wetlands in SE/Central Wisconsin; (2) to determine physical, chemical, and biological characteristics of study area wetlands and to relate these parameters to observed duck use; and (3) to determine relationships between food availability and its utilization by breeding ducks and broods.

STUDY AREA

The study was conducted on the "Scattered Wetlands Study Area" (SWSA), a 504-sq mile block (1260 sq km) of land in the SE/Central region (March et al. 1973) (Fig. 1). This block included all or part of 9 townships in Dodge County, 3 townships in Columbia County, and 2 townships each in Fond du Lac and Green Lake counties. Previous studies indicated this area had some of the highest densities of breeding ducks to be found anywhere in Wisconsin (Jahn and Hunt 1964; March et al. 1973).

The topography of the region is level to rolling with elevations varying from approximately 850 to 1050 ft (259 to 320 m) above sea level. The soils are primarily rich silt loams, well suited for farming (U.S. Dep. Agric. 1969, 1971, 1973). The deeper depressions contain organic soils or peat which are often utilized for muck farming.

Lands cultivated for row crops comprise about 56% of the area. If pasture lands, hay, and woodlots are included with row crops, approximately 80% of the study area was being intensively utilized for agriculture and farmsteads. Wetlands comprise approximately 11% of the study area, or 33,000-36,000 acres (13,355-14,569 ha). Lakes comprise approximately one third of this acreage with the balance divided among all other types of wetlands.

The climate of the study area is continental in nature. Temperatures ranged from approximately -40°F to 110°F (-40°C to 43°C). Annual precipitation averaged 30 in (76 cm). During the 3-yr study, annual precipitation was approximately 37, 35, and 25 in (94, 89, and 64 cm) (U.S. Dep. Commer.-Environ. Data Serv. 1973, 1974, 1975).

Wetland fertility in southeastern Wisconsin has previously been found to be quite high. Average alkalinities for April-August 1968 on Horicon Marsh, located just east of the study area, averaged 266 ppm (Beule unpubl.).

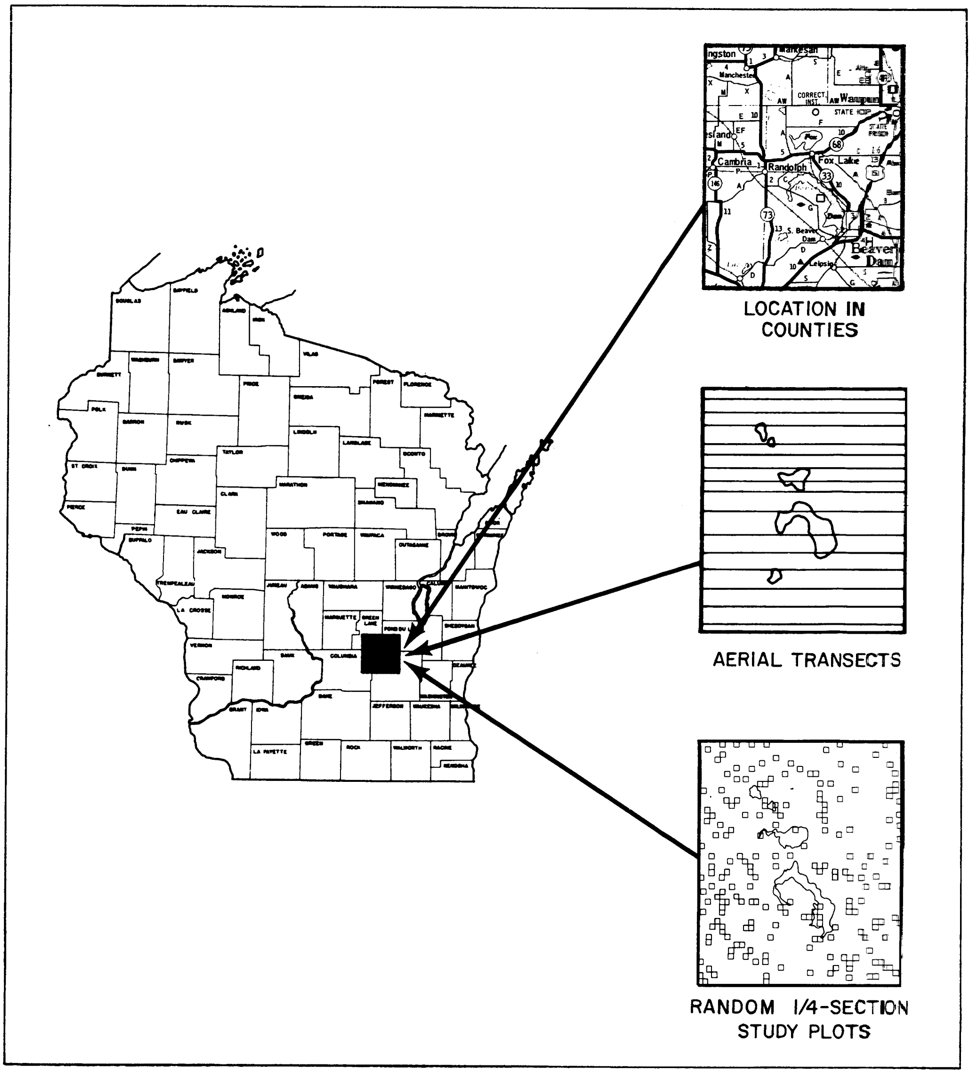


FIGURE 1. *Location of the Scattered Wetlands Study Area, aerial transect routes, and random 1/4-section study plots.*

METHODS

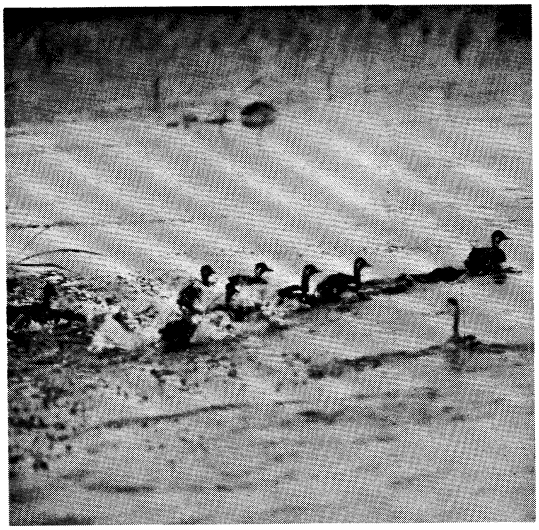
BREEDING POPULATION SURVEYS

The major objectives of breeding pair surveys were to estimate breeding pair densities on the unmanaged and privately owned (in most cases) scattered wetlands and to document changes in these densities over a 3-yr period.

Since 1948, breeding populations of ducks in Wisconsin have been surveyed by various methods. Road counts were made during 1948-49, fixed-wing aerial surveys were flown in 1949-50, and ground observations were made on specific sites during 1951-56 (Jahn and Hunt 1964). Fixed-wing surveys were also used in 1965-66, 1968-70 (March et al. 1973), and 1973-78 (Evenson et al. 1978). The results of prior fixed-wing surveys and their estimated precision (Diem and Lu 1960; Martinson and Kaczynski 1967; Henney et al. 1972; March et al. 1973) and the use of helicopter surveys in Labrador-Ungava (Gillespie and Wetmore 1974) led to the use of helicopters on the SWSA.

The need for more detailed information on wetland cover and brood use of wetlands prompted the use of a simultaneous ground survey. The successful use of random plot surveys to census waterfowl and other birds in South Dakota (Wheeler 1972), Canada (Dennis 1974), and North Dakota (Stewart and Kantrud 1972, 1973, 1974) led to their use in this study. Simultaneous use of helicopter and random plot methods then provided a basis for comparing effectiveness while meeting the primary objective of determining waterfowl densities.

A small helicopter was used to survey 15 aerial transects each 21 miles long and 1/4 mile wide.



Intensive ground searches flushed out ducks present but not seen from the air.

Helicopter Surveys

Sampling Scheme and Survey Mechanics. Fifteen aerial transects were used to sample the number of breeding ducks on the 504-sq mile SWSA (Fig. 1). The transects, each 21 miles (33.8 km) long and 1/4 mile (0.4 km) wide, were selected randomly. To do this, the north-south study area boundary was divided into 1/2-mile (0.8 km) intervals and each interval was numbered. Fifteen starting points were then chosen from a randomized table of digits and each transect ran from these points completely across the study area. Starting point selection was done without replacement. Also, starting points that would place a transect closer than 1 mile from a previously selected transect were discarded and a new point was randomly selected until the desired number of transects was established. The 78.75-sq mile (204 sq km) sample representing 16% of the study area totaled 315 linear miles (507 km). Approximately 8 h were required to fly all 15 transects. In order to apply statistical procedures one must assume: (1) that the habitat is homogeneous; and (2) that the ducks are distributed at random within the habitat (Benson 1962). Selection of random transects should then allow calculation of crude estimates of sampling variability.

The general procedures were modified from those used by March et al. (1973) during statewide surveys in Wisconsin. A small helicopter was used in place of a fixed-wing aircraft. This considerably improved the ease of spotting ducks as transects were flown at 45-50 mph (72-80 km/h) and from 75 to 100 ft (23 to 30 m) above ground level. Previous fixed-wing surveys were flown at average ground speeds of 85-100 mph (137-161 km/h) and 100-200 ft (30-61 m) above ground. The added noise made by the helicopter also aided in flushing ducks thereby increasing their visibility. Two observers plus the pilot were utilized. Each observer recorded all waterfowl seen on a 1/8-mile strip (0.2 km) on his side of the aircraft. Tape recorders were used by each observer to record all observed ducks by species and to classify the birds as pairs, lone drakes, lone hens, groups of drakes, or mixed flocks. Pairs, lone drakes, and groups of 5 or less drakes were later tallied as indicated breeding pairs (Dzubin 1969). All wetlands within the 1/4-mile transect were classified by "type" (Appendix A) (Shaw and Fredine 1956). Wetlands occupied by waterfowl were specifically identified. The slow speed and low altitude of the helicopter allowed easy identification of the dominant vegetation in the wetlands, greatly aiding classification by "types".

Helicopter surveys were flown in mid-April and mid-May of 1973-75. April flights were timed to survey early breeding species such as wood ducks and mallards. In May, surveys were delayed until mid-month to allow blue-winged teal to become well established on their territories. Although all species of ducks seen were tallied during the surveys, densities were only calculated for the major species of dabbling ducks, namely the mallard *(Anas platyrhynchos)*, blue-winged teal *(Anas discors)*, green-winged teal *(Anas crecca)* shoveler *(Anas clypeata)*, pintail *(Anas acuta)*, wood duck *(Aix sponsa)*, American wigeon *(Anas americana)*, and gadwall *(Anas strepera)*. Diving ducks were encountered, but May surveys indicated few remained as breeders. Redheads *(Aythya americana)* were seen on transects only once in the 3 yr (2 pairs). Only 3 pairs of ruddy ducks *(Oxyura jamaicensis)* and 7 pairs of lesser scaup *(Aythya affinis)* were seen on the study area during the May surveys of 1973-75. No ring-necked ducks *(Aythya collaris)* were encountered.

Air: Ground Comparisons. Since not all breeding pairs of ducks were seen from the helicopter, an adjustment was made to correct all indexes obtained from helicopter surveys for ducks present but missed from the air. Air: ground correction ratios were determined from intensive ground searches (as described by Martinson and Kaczynski 1967) of predetermined segments of the aerial transects. During 1973-75, 21-27% of all aerial transects were also censused on the ground the day after the helicopter flights. An air: ground ratio (or correction factor) was then established for each species and each flight, wherever sufficient numbers of ducks permitted. Raw breeding pair indexes for each species were divided by the air: ground correction ratio to obtain breeding population estimates.

Random Plot Censuses

Sample Selection. A "simple random sample" (Cochran 1965; Snedecor and Cochran 1974) representing 10% of the total area was selected. This was done by first numbering each of the 2,016 possible 1/4 sections (160 acres; 65 ha) and then selecting the plots as their numbers appeared in a table of random digits (Steel and Torrie 1960). Plot number selections were also accomplished without replacement. Originally 202 plots were selected (Fig. 1). During the first year, 1 plot was abandoned due to poor landowner cooperation and another was randomly chosen to replace it. During the second year, 3 additional plots were abandoned for similar reasons. Since no new plots were selected, the total sample was reduced to 199 plots for 3 yr, which still equaled 10% (9.87%) of the total area. The same plots were visited each year to facilitate documentation of year-to-year waterfowl and land use changes in the same wetland basins and/or plots.

Censuses. On 1/4-section plots so selected, breeding pair counts and/or brood surveys were made 5 times during the breeding season (April-August). Breeding pairs were counted during April and May visits. Brood production was determined during visits in June, July, and August. All wetlands on the 1/4-section plots were waded ("beat out") to determine the number of pairs and broods on each plot. During the censuses, occupancy by ducks was established for each wetland. The censuses took from 2 to 3 weeks each month for completion, depending on the number of wet areas present.

Breeding chronology for mallards and blue-winged teal was calculated by back-dating annual brood observations. The small numbers of wood duck, pintail, and shoveler broods observed each year made it impractical to measure breeding chronology on an annual basis. Instead, brood data for all 3 yr were combined to obtain a generalized outline of breeding chronology for each species. Broods were assigned to the age classes of Gollop and Marshall (1954) and incubation periods were taken from Bellrose (1976).

All wetlands on the 1/4-section plots were waded or "beat out" to determine the number of pairs and broods on each plot.

WETLAND AND LAND USE SURVEYS

Each of the random 1/4 sections was cover mapped to provide an index to existing land use and to document any subsequent changes. All wetlands were classified using the system of Shaw and Fredine (1956). The approximate dates wetlands dried up were noted during these surveys.

WETLAND CHARACTERISTICS MONITORING

Water Chemistry

Wetlands of Types I(1), II(2), III(3), IV(2), and V(2) were monitored monthly (April-August) for changes in water chemistry. Each water sample was analyzed for the following parameters: pH, total alkalinity, conductance, total hardness, NO_2, NO_3, NH_3, organic N, total N, PO_4, total P, SO_4, Cl, Ca, Mg, Na, K, Fe, and Mn. Chemical analyses were performed in the Wisconsin Department of Natural Resources Water Laboratory at Delafield and in the field. Field tests were done for pH, total alkalinity, and dissolved oxygen utilizing a "Hach" chemical kit.

Soil Analysis

Bottom soil samples were taken using a core sampler designed by Beule and Janisch (unpubl.) with which we removed the top 2 in (5 cm) of bottom strata for analysis. The soils were analyzed (at the University of Wisconsin-Extension Soils Laboratory) for percentages of sand, silt and clay, percent organic material, and the content of Ca, Mg, SO_4-S, salts, and NO_3-N.

Vegetation Surveys

Vegetation transects were established on the same 10 selected wetlands from which water chemistry data were collected. Each transect contained 10 stations at which visual estimates were made of the percent of volume each plant species contributed to the emergent, floating, and submergent plant communities. Visual estimates of submergents were based on rake samples taken with a modified garden rake sampler described by Modlin (1970). Final vegetation inventories were prepared on the basis of the presence or absence of each species in the various wetland types.

Duck Food Utilization and Availability

Feeding blue-winged teal and mallards were collected on 28 wetlands throughout the study area. Breeding females and ducklings were collected on all of the available wetland types with the exception of streams (Types I-VI and ditches). Females were categorized as prelaying, laying or post laying, as determined by the condition of the ovaries. All ducklings collected were categorized by the age classes of Gollop and Marshall (1954). Although sub-class designations were given to ducklings, the small sample sizes limited presentation of the data only to the major classes (I, II, III).

Feeding hens were collected throughout the day, but ducklings were collected almost exclusively at dusk. Actively feeding ducks were collected only after they were observed feeding for at least 10 min. The contents of the esophagus, proventriculus, and gizzard were removed immediately and preserved separately in vials of 95% ethyl alcohol to avoid postmortem digestion. Only esophagus data are presented as they were felt to best represent the most recent feeding activities.

Potentially available foods were collected by taking net samples and dredge samples in the immediate area where the bird was collected. Six net sweeps, 39.25 in (1 m) long were made using a net of 6 in (15.2 cm) in diameter. This method sampled 3.67 cu ft (0.11 cu m) of water in the area from the surface to 6 in (15.2 cm) in depth. A single Ekman dredge sample removed material from approximately 81 sq in (0.05 sq m) of the wetland bottom. These samples were stored in a 10% Formalin solution.

The esophagus, net, and bottom samples were washed gently over a sieve of 30 meshes per inch (0.8 mm apertures) so that all samples retained materials of the same size range. All samples were sorted and foods were blotted to remove excess moisture, left damp, and measured volumetrically by liquid displacement.

Invertebrates, seeds, and vegetation were identified using the publications of Pennak (1953), Muenscher (1967), Ward and Whipple (1959), Fassett (1966), Martin and Barkley (1973), Hotchkiss (1972), Usinger (1971), Hilsenhoff (1975) and Eddy and Hodson (1961). The foods contained in the esophagus, net, and bottom samples are presented as both the aggregate percent by volume and as the percent occurrence to enable comparisons between proportions of foods in the diet and the proportions of foods present in the wetlands. The aggregate percent by volume method was chosen because it gives equal weight in the analysis to each item and greatly reduces the importance of foods infrequently consumed in large quantities (Swanson et al. 1974). Frequency of occurrence is presented to enable comparisons with previous studies (Swanson et al. 1974; Krapu 1974; Sugden 1973).

RESULTS and DISCUSSION

BREEDING DUCK POPULATIONS

Estimations From Helicopter Surveys

Breeding duck population estimates based on data from helicopter surveys are presented in Table 1. April estimates of mallard numbers apparently still included some migrant birds, as a 46% or greater decrease in estimated mallard breeding populations appears to have occurred between 15 April and 15 May in all years. Brood data indicate that less than 6%, 2%, and 4% of the mallards in 1973, 1974, and 1975, respectively, had initiated nesting by the mid-April survey dates. May surveys have much higher air:ground ratios indicating a better count once pairs have dispersed over the available habitat.

May surveys were felt to provide the best overall estimates of all species surveyed. It must be pointed out that wood duck, green-winged teal, American wigeon, and gadwall were present in such small numbers that air:ground ratios could only be determined for April. Therefore, population estimates for May for these species represent helicopter surveys made in May corrected by April air:ground ratios.

The 3-yr average May breeding pair density (for all species) was 8.86 pairs/sq mile (18 ducks). The SWSA lies within the SE/Central region surveyed yearly during statewide surveys. The average density for 1973-75 in the entire SE/Central region (based on fixed-wing surveys) was 7.25 pairs/sq mile (15 ducks) (Wheeler et al. 1975). The average breeding population for the same region during 1965-70 was estimated at 5 pairs/sq mile (10 ducks) (March et al. 1973), or approximately two-thirds the average 1973-75 densities. Earlier estimates of the area in general (Eastern Ridge and Lowlands) indicated 3.9 ducks/sq mile (Jahn and Hunt 1964). The latter estimate was not corrected for birds present but missed from the air. Populations of breeding ducks appear either to be considerably higher in this part of the state in recent years or variations in survey techniques accounted for these differences.

Yearly population densities for all species combined were significantly different between 1973 and 1974 and also between 1973 and 1975, as indicated by the results of Duncan's New Multiple Range Test (Steel and Torrie 1960) (Table 2) on the actual number of pairs seen. Densities of all species, as found by helicopter surveys, dropped from approximately 11 pairs/sq mile in 1973 to 7-8 pairs/sq mile in 1974 and 1975, with the major decrease occurring in 1974. This decrease is also supported by a reduction in the uncorrected index (only birds seen from the air) which does not include the unknown variation and biases associated with the air:ground correction ratios that are used to obtain the total population estimates (Table 1).

Mallard populations on the study area remained at approximately 2 pairs/sq mile over the 3-yr period (Table 1). Duncan's New Multiple Range Test on actual numbers of pairs seen indicates no significant differences between yearly mallard densities during 1973-75 (Table 2).

Blue-winged teal densities decreased during the 3-yr period (Table 1). Significant yearly differences ($P \leq 0.05$) in breeding blue-winged teal densities were found between 1973 and 1974, and between 1973 and 1975 when the actual numbers of pairs seen were tested using Duncan's New Multiple Range Test (Table 2).

The population change in total breeding pairs was due primarily to fluctuations in blue-winged teal densi-

TABLE 1. *April and May breeding population estimates as determined from helicopter surveys and corrected for pairs missed from the air, Scattered Wetlands Study Area, 1973-75.*

	Population Index (pairs/sq. mile)			Air:Ground Ratio			Population Estimate (pairs/sq. mile)			
Species	1973	1974	1975	1973	1974	1975	1973	1974	1975	Avg.
April										
Mallard	1.37	1.69	2.06	0.35	0.49	0.47	3.91	3.45	4.38	3.91
Blue-winged Teal	3.11	2.31	2.83	0.42	0.33	0.76	7.40	7.00	3.72	6.04
Shoveler	0.84	0.50	0.20	0.58	0.55	0.20	1.45	0.91	1.00	1.12
Pintail	1.15	0.14	0.15	0.50	0.09	0.25	2.30	1.56	0.60	1.49
Wood Duck	0.03	0.04	0.06	0.33	0.63	0.80	0.09	0.06	0.08	0.08
Green-winged Teal	0.37	0.48	0.24	0.13	0.18	0.11	2.85	2.67	2.18	2.57
Wigeon	1.21	0.18	0.30	0.33	0.07	0.39	3.67	2.57	0.77	2.33
Gadwall	0.01	0.04	0.01	0.33*	0.33*	0.33*	0.03	0.12	0.03	0.06
Total	8.09	5.38	5.85				21.70	18.34	12.76	17.60***
May										
Mallard	1.69	1.24	1.35	1.00	0.67	0.80	1.69	1.85	1.69	1.74
Blue-winged Teal	2.92	2.32	1.97	0.40	0.54	0.36	7.30	4.30	5.47	5.69
Shoveler	0.27	0.09	0.09	0.33	0.60	0.25	0.82	0.15	0.36	0.44
Pintail	0.14	0.16	0.05	0.38	0.33	0.75	0.37	0.48	0.07	0.31
Wood Duck	0.05	0.00	0.01	0.33**	—	0.80**	0.15	—	0.01	0.08
Green-winged Teal	0.07	0.04	0.02	0.13**	0.18**	0.11**	0.54	0.22	0.18	0.31
Wigeon	0.04	0.00	0.01	0.33**	—	0.39**	0.12	—	0.03	0.08
Gadwall	0.04	0.03	0.19	0.33**	0.33**	0.33**	0.12	0.09	0.58	0.26
Total	5.22	3.88	3.69				11.11	7.09	8.39	8.86***

* Insufficient pairs seen per year so ratio was calculated from data collected during the same month for the 3-yr period.

** April ratios used because of insufficient pairs in May.

*** Averages presented vary slightly from totals due to rounding.

TABLE 2. *Significant differences in year-to-year breeding duck densities from helicopter surveys as determined by Duncan's New Multiple Range Test, SWSA, 1973-75.*

	Analysis of Variance				
Species	Source	d.f.	Mean Square	F-ratio	Significance
Mallard	Among Years (Treatments)	2	22.50	1.52	n.s.
	Within Transects (Error)	42	14.81		
	Total	44	15.20		
Blue-winged Teal	Among Years	2	107.50	4.91	P ≤ 0.01
	Within Transects	42	21.88		
	Total	44	25.77		
All Species	Among Years	2	373.50	7.88	P ≤ 0.01
	Within Transects	42	47.38		
	Total	44	67.59		

	Differences in Breeding Pair Densities		
Yearly Comparisons	Mallard	Blue-winged Teal	All Species
1973 vs. 1974	n.s.	P ≤ 0.05	P ≤ 0.05
1973 vs. 1975	n.s.	P ≤ 0.01	P ≤ 0.01
1974 vs. 1975	n.s.	n.s.	n.s.

ties as mallard populations seem to have remained stable.

Mean densities estimated for breeding pairs contain many sources of error, some predictable and others completely unknown. Sampling error associated with the air:ground ratios is generally unknown. Variances cannot be calculated for these ratios which are used to adjust population indexes without any corresponding estimate of precision.

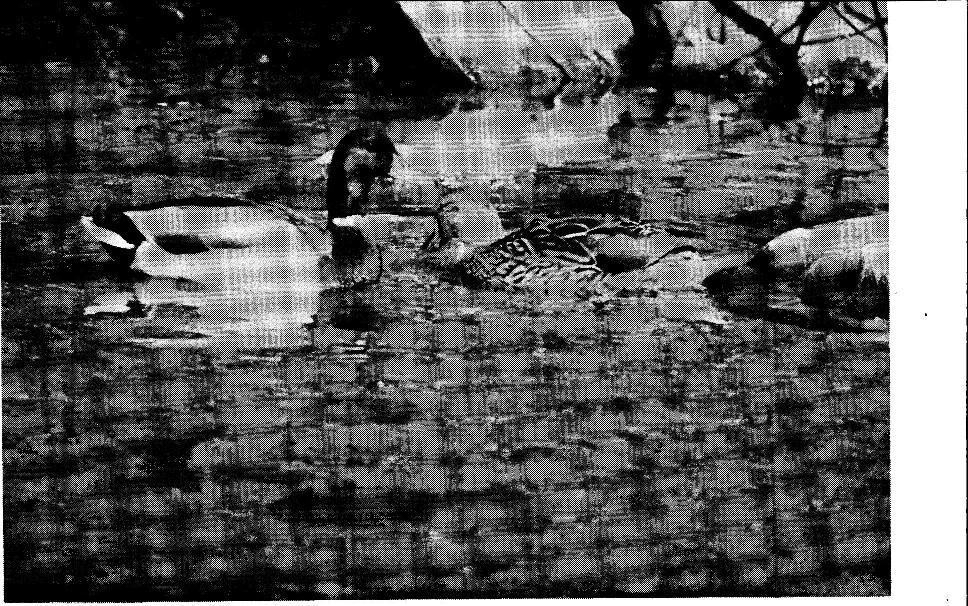
Confidence limits about the mean densities of the pairs actually seen from the air (Table 3) are quite broad. Confidence intervals were found to be smaller in May. May confidence intervals also decrease when dealing with higher pair densities, when considering all species together, or when considering blue-winged teal (the most abundant species) separately. Based on confidence limits, the most valid density estimates seem to be those based on May surveys during years of high populations or for individual species with higher breeding densities.

Confidence intervals of 15-22% about mean densities of all species for raw unadjusted data from May surveys would tend to indicate that changes of approximately 21-31% in the population index would be detectable with the methods used. Both the teal and mallard data indicate that the reliability of the method to detect changes in population decreases when populations decline and when used to detect changes in density of individual species.

Estimations from Random Plot Censuses

May random plot censuses were thought to be the best estimate of breeding pair densities. Flocks of mallards were still present through mid-April and blue-winged teal were just beginning to arrive on the study area. April surveys for mallards averaged 2.41 pairs/sq mile while May surveys averaged 2.01 pairs/sq mile (Table 4). Shoveler, pintail, American wigeon, green-winged teal, and gadwall numbers all also decreased each year between April and May, indicating that the early counts in April included migrants present on the study area.

During the 3-yr period, May duck densities, as indicated by random plot censuses, decreased from 10.25 pairs/sq mile in 1973 to 6.85 pairs/sq mile in 1975, or a loss of 33%. Helicopter surveys also indicated a drop in breeding populations, but only 25%.



Densities of breeding mallards were relatively stable during 1973-75, averaging 1.8 pairs/sq mile and 2.0 pairs/sq mile as determined by helicopter surveys and random plot censuses, respectively.

Random plot censuses also indicate mallard numbers remained relatively constant while blue-winged teal, shovelers, pintail, wood duck, and green-winged teal all decreased in abundance during 1973-75. Other exceptions to the 3-yr downward trend were peaks in pintail and gadwall pairs in 1974. These species, however, then dropped to the lowest levels in 3 yr in 1975.

Coot *(Fulica americana)* were also recorded during the May pair censuses (Table 5). Total coot numbers declined by 83% between 1973 and 1975. At the same time, the number of 1/4 sections utilized by coots declined by 72%. Since sex could not be identified, the coot breeding pair density estimate assumes a 50:50 sex ratio.

Confidence limits at the 95% level were calculated for the mean observed breeding pair densities from the 199 1/4 sections (Table 6). Confidence limits on mallard mean densities averaged ±33% for April surveys and ± 32% for May surveys. Confidence limits on blue-winged teal for May surveys averaged ± 29%. For all species combined, confidence limits averaged ± 28% in May. Confidence limits calculated from random plot censuses are larger than the confidence limits calculated from May helicopter transects (15) of 5.25 sq miles each (Table 3).

No significant difference ($P \leq 0.05$) in densities of mallards, blue-winged teal, or all species were found between years even though indicated mean densities changed by as much as 37%.

No significant difference ($P \leq 0.05$) in blue-winged teal densities between 1974 and 1975 was detected by Duncan's New Multiple Range Test, yet mean density was 32% lower in 1975 (Table 7).

Comparison of Methods

Helicopter surveys and random plot censuses both indicated that over the 3 yr, total breeding pairs declined (Fig. 2). The majority of decrease in pairs was due to declines in blue-winged teal, again evident from both methods. This downward trend was statistically significant for data obtained from helicopter surveys (Table 2), but not for data from random plot censuses (Table 7), although the mean plot densities did decline numerically.

Breeding population estimates (Table 8) varied considerably between methods with no detectable pattern. Neither method produced consistently higher or lower estimates but varied with the species and year. Figure 2 suggests that much of this variability is due to air:ground corrections of population indexes obtained from the air. Some of the year-to-year variability in air:ground correction ratios is evident from Table 1. Sources of variation associated with the helicopter surveys have been dealt with at considerable length by Diem and Lu (1960), Martinson and Kaczynski (1967), and March et al. (1973), and will not be considered in detail in this report. By using a helicopter, flying 40-50 mph (75-83 kmh) at 75 to 100 ft (23-31 m), and using 2 observers, it was felt that at least some of these biases would be reduced. One of the observers who flew in 1973 was replaced in 1974 introducing an unavoidable bias into the first year's data. The 1974 and 1975 counts were made by the same two observers.

In conclusion, it appears that either method would identify population trends. A reduction in variability

Random plot censuses proved the best method of estimating wetland occupancy because helicopter surveys detected less than 50% of the blue-winged teal pairs actually present.

TABLE 3. *Confidence limits about breeding population indexes* as determined from helicopter surveys, SWSA, 1973-75.*

	Population Index (mean no. of pairs/sq. mile ± 95% confidence limits)		
Month and Species	1973	1974	1975
April			
Mallard	1.42 ± 0.57 (40%)**	1.69 ± 0.52 (31%)	2.15 ± 0.54 (25%)
Blue-winged Teal	3.00 ± 2.17 (72%)	2.44 ± 1.24 (51%)	2.85 ± 1.71 (60%)
All Species	7.24 ± 2.86 (40%)	5.31 ± 1.89 (36%)	5.94 ± 2.17 (37%)
May			
Mallard	1.69 ± 0.40 (24%)	1.24 ± 0.39 (31%)	1.35 ± 0.44 (30%)
Blue-winged Teal	2.92 ± 0.42 (14%)	2.31 ± 0.44 (19%)	1.96 ± 0.60 (31%)
All Species	5.36 ± 0.82 (15%)	3.89 ± 0.71 (18%)	3.58 ± 0.78 (22%)

*Raw pair data uncorrected for birds not seen from the air.

**95% confidence limits expressed as percent of the mean.

TABLE 4. *April and May breeding population estimates as determined from random plot censuses, SWSA, 1973-75.**

	Population Estimate (pairs/sq. mile)							
	April				May			
Species	1973	1974	1975	Avg.	1973	1974	1975	Avg.
Mallard	2.31	3.14	1.79	2.41	2.14	1.87	2.01	2.01
Blue-winged Teal	2.77	5.47	6.35	4.86	6.45	6.11	4.14	5.57
Shoveler	0.92	0.56	0.38	0.62	0.84	0.32	0.20	0.45
Pintail	0.28	0.56	0.28	0.37	0.34	0.46	0.22	0.34
Wood Duck	0.10	0.22	0.06	0.13	0.22	0.06	0.14	0.14
Green-winged Teal	0.80	1.00	0.34	0.71	0.22	0.18	0.08	0.16
Wigeon	0.82	0.80	0.24	0.62	0.00	0.00	0.00	0.00
Gadwall	0.08	0.12	0.00	0.07	0.04	0.12	0.06	0.07
Total	8.08	11.87	9.44	9.80	10.25	9.12	6.85	8.74

*Area sampled equals 10% of the total study area.

TABLE 5. *May indexes to coot use of the study area wetlands, 1973-75, as estimated during random plot censuses.*

Year	No. Wet Plots	No. Plots Utilized	No. Adults Counted	Est. No. Pairs/ Sq. Mile	No. Broods Seen
1973	113	32	228	2.3	27
1974	96	10	61	0.6	6
1975	90	9	37	0.4	9

TABLE 6. *Confidence limits about breeding population estimates as determined from random plot censuses.*

Month and Species	Population Estimate (mean no. of pairs/sq. mile ± 95% confidence limits) 1973	1974	1975
April			
Mallard	2.31 ± 0.78 (34%)*	3.14 ± 1.14 (36%)	1.79 ± 0.53 (30%)
Blue-winged Teal	2.77 ± 1.45 (52%)	5.47 ± 1.84 (34%)	6.35 ± 2.55 (40%)
All Species	8.08 ± 3.31 (41%)	11.87 ± 3.16 (27%)	9.44 ± 3.33 (35%)
May			
Mallard	2.14 ± 0.73 (34%)	1.87 ± 0.63 (34%)	2.01 ± 0.59 (29%)
Blue-winged Teal	6.45 ± 1.84 (29%)	6.11 ± 1.70 (28%)	4.14 ± 1.23 (30%)
All Species	10.25 ± 2.72 (27%)	9.12 ± 2.49 (27%)	6.85 ± 1.92 (28%)

*95% confidence limits expressed as percent of the mean.

TABLE 7. *Significant differences in year-to-year breeding duck densities from random plot censuses as determined by Duncan's New Multiple Range Test, SWSA, 1973-75.*

	Analysis of Variance				
Species	Source	d.f.	Mean Square	F-ratio	Significance
Mallard	Among Years (Treatments)	2	3.02	0.139	n.s.
	Within Plots (Error)	594	21.76		
	Total	596	21.69		
Blue-winged Teal	Among Years	2	310.68	2.30	P ⩽ 0.10
	Within Plots	594	135.08		
	Total	596	135.67		
All Species	Among Years	2	458.33	1.61	n.s.
	Within Plots	594	301.40		
	Total	596	302.01		

	Differences in Breeding Pair Densities		
Yearly Comparisons	Mallard	Blue-winged Teal	All Species
1973 vs. 1974	n.s.	n.s.	n.s.
1974 vs. 1975	n.s.	n.s.	n.s.
1973 vs. 1975	n.s.	n.s.	n.s.

One of the study area wetlands as seen from the air. Helicopter surveys could be run at 1/3 the cost of concurrent ground censuses of random plots.

within sampling units would be desirable for both methods in order to reduce the confidence limits about mean pair densities. Further stratifying the area might be one method to accomplish this, but the relatively low numbers of pairs, the clumping of pairs about certain wetlands, and the overall topographical uniformity of the area suggest few criteria for establishing strata.

The economics of breeding pair counts greatly favors using the helicopter surveys to establish population trends. This method's costs were approximately $640 to sample 50 sq mile (12,800 ha). Censusing 50 sq mile (12,800 ha) using 1/4-section plots (200) would cost a minimum of $1720 in labor and transportation.

Ground surveys appear to remain the best method of providing additional data on cover types, wetland characteristics, and brood densities.

IMPORTANCE OF SCATTERED WETLANDS AS BREEDING PAIR HABITAT

The density of breeding pairs ranged from 7 to 11 pairs/sq mile on the SWSA. This is considerably higher than the statewide (southwest Wisconsin not included) densities of 3.7 to 4.8 pairs/sq mile during 1973-75 (Wheeler et al. 1975).

The Scattered Wetlands Study Area contains considerably fewer pairs/sq mile (total surface area) than the Prairie Pothole Region of the United States. Drewien and Springer (1969) reported pair densities on the Waubay Study Area of South Dakota of 4 to 8 times (45.4-86.4 pairs/sq mile) those found on the SWSA. The SWSA pair densities did approach the 12 pairs/sq mile found in the James River Lowland of South Dakota (Brewster et al. 1976). A population of that magnitude was described by the authors as a "median" density for South Dakota. SWSA pair densities were also much higher than the 3.94 pairs/sq mile present in southern Ontario during 1971 (Dennis 1974).

Mallard densities on the SWSA (1.7 pairs/sq mile) are slightly higher than those (0.8-1.5 pairs/sq mile) reported for the 10 best production counties on Minnesota during 1966-68 (Jessen 1970).

DUCK PRODUCTION ON SCATTERED WETLANDS

Breeding Chronology

Mallards initiated successful nests as early as 20-26 March in 1973 but not until 3-9 April during 1974-75 (Fig. 3). Nests hatched as early as 24-30 April and young fledged as late as 25 September-1 October.

Blue-winged teal initiated successful nests as early as 17-23 April in 1973 and 1974, but not until 1-7 May in 1975 (Fig. 4). Nests hatched as early as 22-28 May and young fledged as late as 25 September to 1 October.

First egg dates of 20-26 March and 17-23 April for mallards and blue-winged teal, respectively, were up to 1 week earlier than the earliest clutches reported by Jahn and Hunt (1964).

Pintails began nesting as early as 27 March-2 April and as late as 19-25 June (Fig. 5). Seventy-two percent of the wood ducks observed with broods initiated nesting in the period 17 April-

TABLE 8. *Comparison of May breeding pair estimates as determined from helicopter surveys and random plot censuses, SWSA, 1973-75.*

	No. of Pairs/sq. mile								
	1973			1974			1975		
Species	Helicopter	Plots	Diff.	Helicopter	Plots	Diff.	Helicopter	Plots	Diff.
Mallards	1.69	2.14	0.45	1.85	1.87	0.02	1.69	2.01	0.32
Blue-winged Teal	7.30	6.45	0.85	4.30	6.11	1.81	5.47	4.14	1.33
All Species	11.11	10.25	0.86	7.09	9.12	2.03	8.39	6.85	1.54

7 May. Two-thirds of the successful shovelers began egg laying from 1-21 June. Ages of the only two gadwall broods observed indicated hens had begun nesting around 25 June. Green-winged teal initiated nests during 13-31 May. The only American wigeon brood observed indicated that nesting was begun around 27 May.

The peak of the SWSA coot hatch took place from 27 June to 10 July. This corresponds with the peak of coot hatching reported by Jahn and Hunt (1964) on Horicon Marsh. The small number of coot nests and broods from 1974 and 1975 made it impractical to draw yearly hatching curves and compare hatching peaks.

Reproductive Success

Reproductive success was calculated from pair and brood data collected during random plot censuses. Success is defined as a brood that hatched and was able to reach a wetland. Egress of broods from the plots

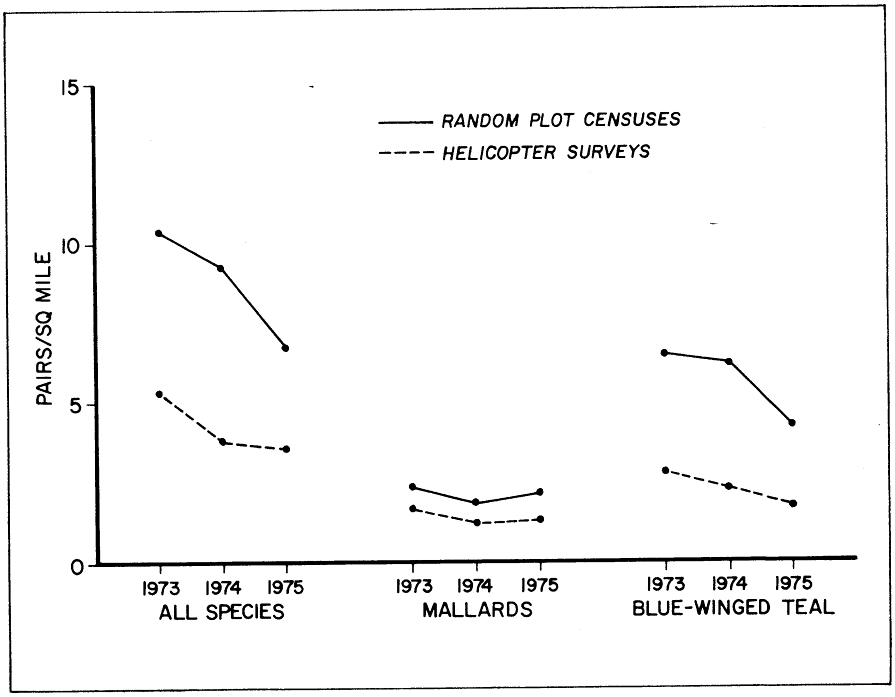


FIGURE 2. *Comparison of May population trends on the SWSA, 1973-75, as indicated by random plot censuses and helicopter surveys (uncorrected for birds missed).*

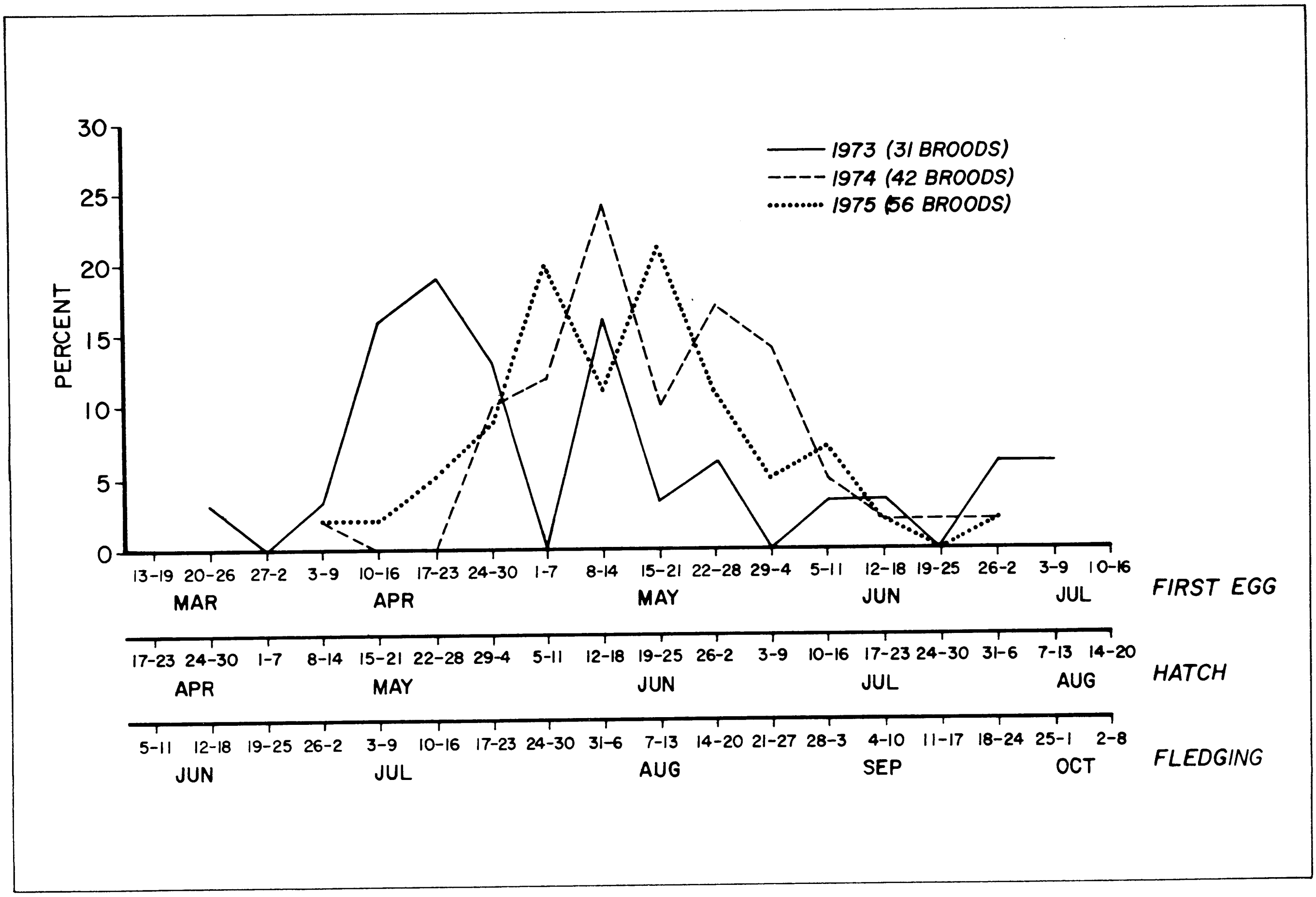


FIGURE 3. *Breeding chronology by 7-d periods for successful mallard hens, SWSA, 1973-75.*

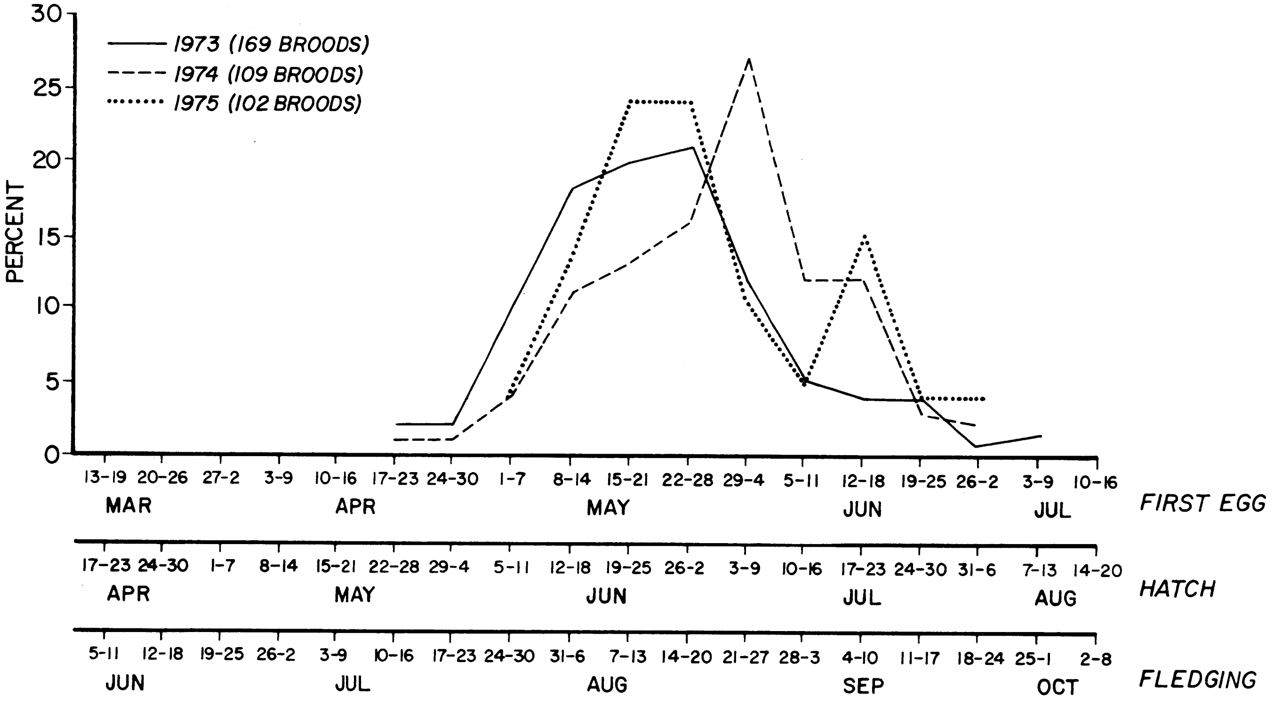


FIGURE 4. *Breeding chronology by 7-d periods for successful blue-winged teal, SWSA, 1973-75.*

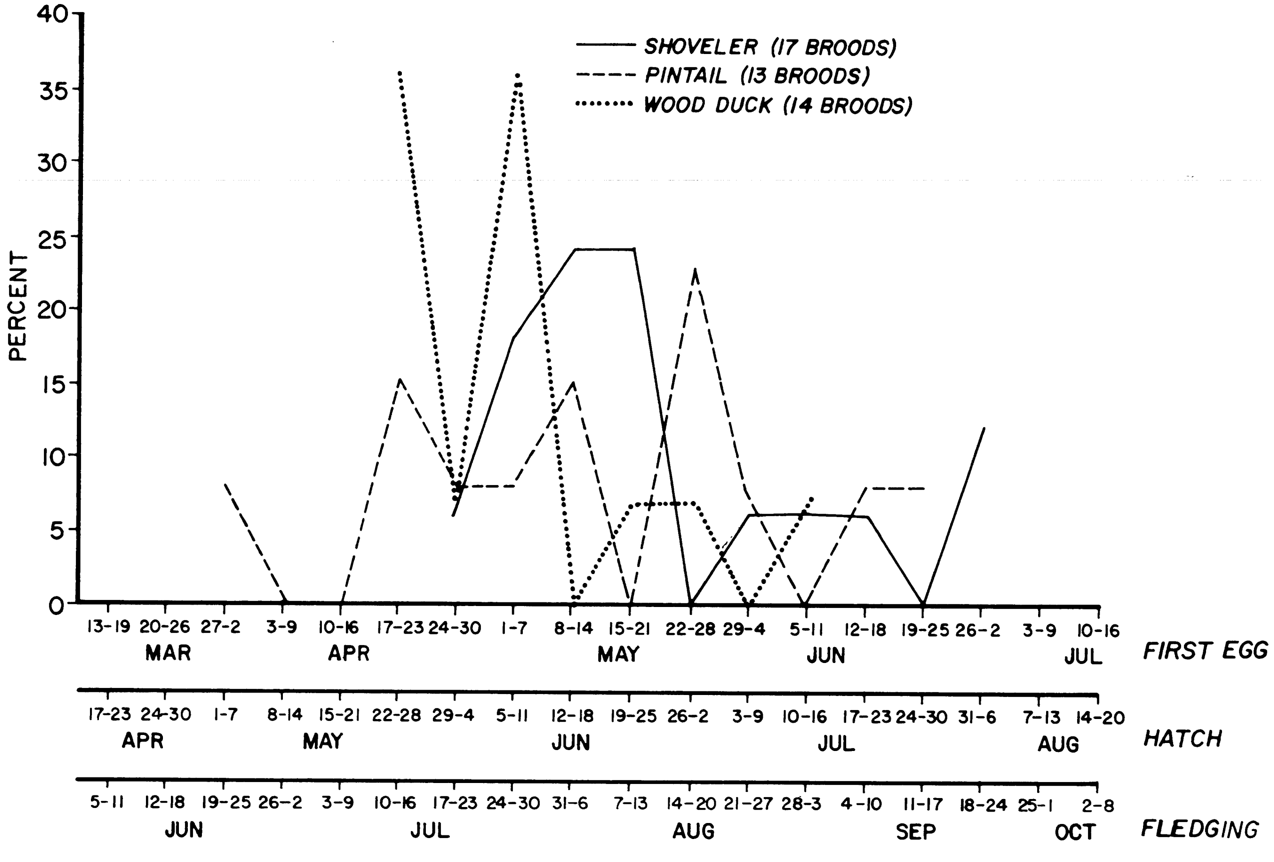


FIGURE 5. *Breeding chronology by 7-d periods for successful shoveler, wood duck, and pintail hens, SWSA, 1973-75.*

before they could be tallied was assumed to equal ingress of broods into the plots from adjacent areas.

Overall pair success was highest in 1973 (44%) compared to the following 2 years (22%; Table 9). Mallard pair success averaged 30% for the 3 years, with the lowest success occurring in 1975 (27%). Much of the overall better pair success in 1973 resulted from the greater number of blue-winged teal pairs (53%) producing a brood. High levels of precipitation during the fall of 1972 and spring of 1973 provided excellent breeding habitat conditions which attracted a larger population of breeding blue-winged teal and shovelers. These same wet conditions improved June and July water conditions greatly and significantly affected the number of blue-winged teal broods reaching sufficient brood water.

No similar increase in mallard pair success was observed in 1973. Although mallards nested earlier in 1973 than in 1974 and 1975, the total nesting effort extended further into the summer, indicating that a greater amount of renesting may have occurred. Poor success of early nests, as indicated by some very late broods, may not have been compensated for by the ideal brood water conditions. Mallards appeared unable to take advantage of the ideal conditions, as neither the number of breeding pairs nor breeding success was above average in 1973.

Average Brood Sizes and Class I to III Attrition

Average sizes of Class I, II, and III broods are presented in Table 10. Average sizes of Class I broods observed of mallards and blue-winged teal were 24% larger in 1973 than in 1974, and 10% and 7% larger, respectively, than in 1975. This again reflects wet conditions in 1973 that favored brood movement to easily accessible water and increased survival from nest to water as compared to the greatly drier years of 1974 and 1975.

Differences in observed brood size between Class I and Class III have been used to indicate attrition in brood size from hatch to fledging. In several instances, the mean Class III brood sizes appear to be larger than Class II and Class I mean brood sizes. Small sample sizes in all categories of mallard broods and Class III blue-winged teal broods would make any yearly attrition estimates questionable.

The 3-yr average attrition between Class I and Class III broods was 13% for both mallards and blue-winged teal (Table 10). Similar attrition was noted by Stoudt (1971) in the parklands of Alberta with losses of 13% and 15% for mallards and blue-winged teal, respectively.

Average duck brood sizes for southeastern Wisconsin for several periods are presented in Table 11. It appears an 11% duckling loss for mallards could be expected as the average when considering recent Wisconsin studies (Table 11). Blue-winged teal duckling losses from Class I to Class III averaged 15% for all studies. A yearly brood size index would be the best way to calculate duckling production in conjunction with pair success rates; however, the problem of acquiring adequate numbers of Class III brood observations limits the practical application of this technique on a yearly basis.

Production and Homing

Observed brood production, based on total square miles of surface area, is presented in Table 9. Production in 1973 totalled 4.5 broods/sq mile, but dropped to 2.0 and 1.5 broods/sq mile in the succeedingly drier years of 1974 and 1975. Brood production in the parklands near Redvers, Saskatchewan averaged 22 broods/sq mile (Stoudt 1971); however, production/breeding pair on the SWSA equaled that of the Redvers Study Area for mallards and blue-winged teal (0.3 broods/pair).

Mallard production/breeding pair near Lousana in the Alberta Parklands also equaled 0.3 broods/pair, but blue-winged teal were slightly more productive, producing 0.4 broods/pair (Smith 1971).

Pairs on the SWSA appear to be producing at a rate similar to these Canadian parkland areas but with much greater numbers of wetlands and their associated breeding pairs, total production in the parklands averages 8 to 17 times greater per unit of surface area.

Young produced/100 acres of SWSA wetland Types III, IV, and V are presented in Table 12. These are the wetland types which provide the bulk of breeding habitat during most years and most nearly approximate the kinds of wetlands described by Jahn and Hunt (1964) when determining densities of young/100 acres of wetland occupied by individual species. A direct comparison of Table 12 and data by Jahn and Hunt (1964) should not be made. The SWSA estimates are a direct ratio of ducklings to wetland acreage present while estimates in the earlier study were calculated by assigning a subjective acreage per pair which then was compared with calculated duckling numbers.

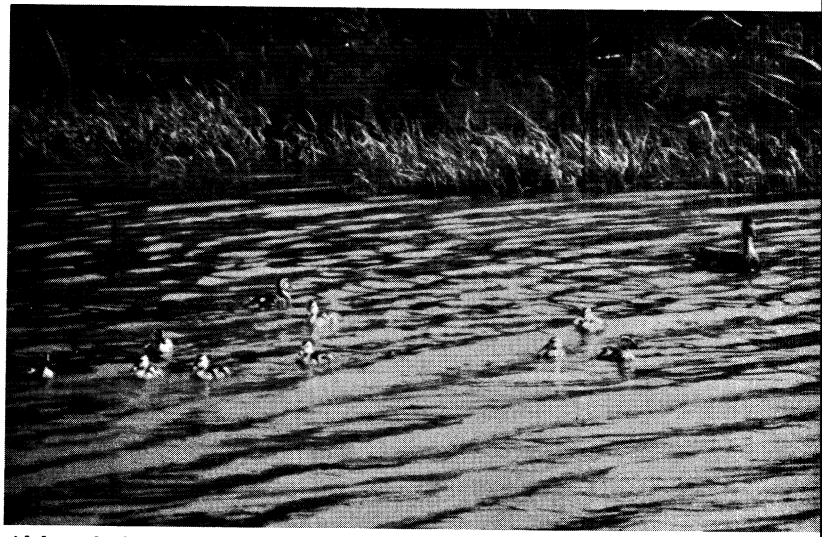
The 1973 estimates may provide the best index to the expected maximum SWSA production/100 acres of high value wetlands as this was a year of extremely good water conditions. In more normal years (1974-75), poorer water conditions and much poorer blue-winged teal pair success indicate a lower yield/100 acres. Conditions in 1974 and 1975 may not represent the lower ranges of production. Much drier conditions followed in 1976 and 1977 and surely resulted in poorer production than was documented in 1974-75.

Although not directly comparable, a considerably higher yield of young was indicated for the Eastern Ridges and Lowlands (southeastern Wisconsin) by Jahn and Hunt (1964). They estimated total duckling yields to be 68-130 young/100 acres of occupied wetlands. Part of this is due to a higher pair success (43%) estimated for mallards. Also black ducks *(Anas rubripes)* contributed 14-46 young/100 occupied acres during 1951-56, but were not found to breed on the SWSA in 1973-75.

Estimates of total breeding pairs (21-31/100 acres) from this study agree well with the 1950's estimates of 21-40 pairs/100 acres (Jahn and Hunt 1964), yet all indications seem to point to lower productivity in the 1973-75 period. Jahn and Hunt (1964) stated: "We conclude that productivity of duck populations breeding on Wisconsin's *better quality, more permanent wetlands* exceeded total mortality during the approximate period of 1950-56" (emphasis added). They concluded further that populations would decline if brood sizes and mortality remained stable and if the proportion of hens producing a brood dropped below 35% for mallards and 33% for blue-winged teal. Mallard success on the SWSA did not reach 35% during the 3-yr period and blue-winged success was above 33% only in 1973. Jahn and Hunt's (1964) estimates of the percent of hens producing a brood in a stable population may have been somewhat high. Mortality rates used to derive these figures (Adult mallards = 47%, Immature mallards = 69%) were high in comparison to more recent mortality estimates of 42% for Wisconsin adult females and 50% for its immature females (Anderson 1975). If these more recent and presumably more precise mortality figures were used, it would in effect drop the calculated minimum success required from hens to achieve a stable population.

The effects of the estimated production, under specified mortality conditions, on future spring populations of

Duck production on the SWSA ranged from 29 to 86 ducklings/100 acres of permanent wetlands during 1973-75.



Although ducklings were seen on all wetland types, only 19% of the total study area wetlands were utilized by broods.

Pioneering of both mallards and blue-winged teal hens very likely had to occur each year (1973-75) to reach the succeeding year's population.

mallards and blue-winged teal on the SWSA are predicted in Tables 13 and 14. Production estimates were calculated from field data. Survival estimates are from Anderson (1975) for mallards and Bellrose (1976) for blue-winged teal.

Mallard populations were potentially capable of reaching the numbers of females estimated present in 2 subsequent springs *only* if all adult females surviving homed to the study area and 40-70% of the immature females surviving also homed to the area. Although adult females are persistent in homing (Sowls 1955; Coulter and Miller 1968), 100% homing by adult females would be very unlikely. Sowls (1955) also indicated that the proportion of immature females homing is much lower than that of adults. Applying average survival rates of mallards found by Anderson (1975) to Sowls' (1955) data on homing would give homing rates of 22% for adult females and 10% for immature females.

Pioneering would have had to occur each year during 1973-75 to reach the indicated spring breeding populations, unless: (1) the highly unlikely homing rates for both adult and immature hens were achieved; or (2) summer hen survival was underestimated.

The immatures/adult ratio for mallard production on the SWSA was 1.1 in 1973 and 1974, and 1.0 in 1975. This reflects the drop in pair success recorded for 1975. Wing collection data, adjusted for differential vulnerability to hunting, summarized by March (1976), yielded a 1961-72 mean preseason mallard population age ratio of 0.9 ± 0.2 young/adult. Young/adult on the SWSA exceeded these average statewide figures as well as surpassed the yearly estimates for 9 of 12 yr during 1961-72.

Anderson (1975) indicates that age ratio estimates of mallards derived from harvest and wing surveys and continentwide banding have averaged 1.0 young/adult in the fall population since 1961. This would indicate that the production rate on the SWSA equaled the continental average.

Dzubin and Gollop (1972) indicated that 35% of the mallard hens must produce broods to flight stage to attain a production of 1.1 immatures/adult, assuming balanced sex ratios and average brood size of 6.3. Using the same average brood size and a percent of hens producing broods that ranged from 27% to 31%, the young/adult ratio on the SWSA did appear to drop below 1.1. Crissey (1957) felt that a population of mallards must produce 1.25 young/adult to maintain itself under the mortality rates occurring in the 1950's.

TABLE 9. *Duck reproductive success based on pair and brood estimates obtained during random plot censuses, SWSA, 1973-75.**

Species	1973			1974			1975		
	Pairs/ Sq. Mile	Broods/ Sq. Mile	Percent of Pairs Producing Broods	Pairs/ Sq. Mile	Broods/ Sq. Mile	Percent of Pairs Producing Broods	Pairs/ Sq. Mile	Broods/ Sq. Mile	Percent of Pairs Producing Broods
Mallard	2.14	0.66	31 ± 9**	1.87	0.58	31 ± 10	2.01	0.54	27 ± 9
Blue-winged Teal	6.45	3.44	53 ± 5	6.11	1.31	21 ± 4	4.14	0.82	20 ± 5
Shoveler	0.84	0.24	29 ± 14	0.32	0.02	6 ± 12	0.20	0.02	10 ± 19
Pintail	0.34	0.12	35 ± 23	0.46	0.06	13 ± 14	0.22	0.08	36 ± 28
Wood Duck	0.22	0.06	27 ± 26	0.06	0.04	67 ± 53	0.14	0.00	0
Green-winged Teal	0.22	0.02	9 ± 9	0.18	0.00	0	0.08	0.04	50 ± 49
Gadwall	0.04	0.00	0	0.12	0.00	0	0.06	0.00	0
Total	10.25	4.54	44 ± 4	9.12	2.01	22 ± 4	6.85	1.50	22 ± 5

*Indicates success of pair to hatch brood and reach water, not the percent that reach flight stage. Pairs/sq. mile are those estimates made in May of each year.

**95% confidence limits at $P \leqslant 0.05$.

TABLE 10. *Average brood size on the SWSA, 1973-75.*

Species	Year	Age Class			Indicated Duckling Mortality from Class I to III
		I	II	III	
Mallard	1973	8.3 ± 2.2*(12)**	6.5 ± 1.6 (11)	5.6 ± 2.2 (7)	—
	1974	6.3 ± 1.3 (17)	5.6 ± 1.3 (19)	7.2 ± 1.6 (10)	—
	1975	7.5 ± 1.3 (16)	5.6 ± 0.8 (25)	6.1 ± 1.1 (17)	—
	Avg.	7.2 ± 0.8 (45)	5.8 ± 0.6 (55)	6.3 ± 0.81(34)	-13%
Blue-winged Teal	1973	7.6 ± 0.8 (79)	7.9 ± 0.8 (79)	5.3 ± 1.5 (15)	—
	1974	5.8 ± 1.0 (37)	5.8 ± 0.8 (59)	5.8 ± 1.3 (20)	—
	1975	7.1 ± 1.0 (41)	7.0 ± 0.8 (38)	7.3 ± 1.0 (21)	—
	Avg.	7.1 ± 0.4(157)	7.0 ± 0.4(176)	6.2 ± 0.8 (56)	-13%

*95% confidence limits at $P \leqslant 0.05$.

**Sample size in parentheses.

TABLE 11. *Average duck brood size in southeastern Wisconsin.*

Species	Years	Age Class			Indicated Mortality Class I to III	Study
		I	II	III		
Mallard	1951-56	7.8 ± 0.5*	7.2 ± 0.3	7.0 ± 0.3	-10%	Jahn and Hunt 1964
	1962-74	7.2 ± 0.2	6.5 ± 0.2	6.5 ± 0.2	-10%	March 1976
	1973-75	7.2 ± 0.4 (45)**	5.8 ± 0.3 (55)	6.3 ± 0.4 (34)	-13%	This Study
Blue-winged Teal	1951-56	8.0 ± 0.3	7.1 ± 0.2	6.9 ± 0.4	-14%	Jahn and Hunt 1964
	1962-72	7.9 ± 0.2	6.2 ± 0.2	6.3 ± 0.2	-20%	Unpublished (DNR Files)
	1973-75	7.1 ± 0.2 (157)	7.0 ± 0.2 (176)	6.2 ± 0.4 (56)	-13%	This Study

*Standard error of the mean.

**Sample size in parentheses.

TABLE 12. *Yield of young*/100 acres of wetlands (Types III, IV, and V) and precipitation for the 12 months prior to the breeding season, SWSA, 1973-75.*

Parameter	1973	1974	1975	1970-78 Avg.
Species				
Mallard	13	11	11	
Blue-winged Teal	65	24	16	
Others	8	2	2	
Total	86(31)**	37(28)	29(21)	
Precipitation (in inches)*** (12 months prior to May 1)	43.56	36.81	32.49	31.08

*Based on pair densities and pair success from this study (Tables 13 and 14), Class III brood size for mallards and blue-winged teal from this study (Tables 13 and 14) and Class III brood size for other species—shoveler, pintail, wood duck, and green-winged teal—from Bellrose (1976).

**Figures in brackets are the number of pairs/100 acres of wetlands.

***U.S. Dept. of Commerce, Climatological Data (1973-78).

TABLE 13. *Mallard duckling production and its potential effect on the female breeding population in subsequent years, SWSA, 1973-75.*

Year	No. of Breeding Pairs or Hens*	Percent of Pairs Producing a Brood	Overall Mean Class III Brood Size 1973-75	No. of Class III Ducklings	No. of Class III Females
1973	1080	31	6.3	2110	1060
1974	950	31	6.3	1860	930
1975	1010	27	6.3	1720	860

Year	No. of Adult Females in Fall**	No. of Adult Males in Fall**	Im./Ad. in Fall Pop.	Immature Females Surviving to Next Spring**	Adult Females Surviving to Next Spring**	Total Females Surviving to Next Spring	Percent of Immature Females required to home to reach next year's population estimate***
1973	910	990	1.1	700	670	1370	40
1974	800	870	1.1	610	590	1200	70
1975	850	930	1.0	570	630	1200	70****

*Data from random plot censuses; numbers rounded in data and calculations for convenience.

**Calculations based on Sept. 1 - August 30 survival estimates from Anderson (1975) of IF = 0.499, AF = 0.580 (Wis.) and summer survival of AF = 0.82-0.84, AM = 0.91-0.92 (Continental).

EXAMPLE: Calculations to reach the number of immature females surviving to spring.

Yearly Survival (Aug.-Aug.) = 0.499
Summer Mortality (May-Aug.) = 0.16
Survival Aug.-May = 0.499 + 0.16 = 0.66

No. Class III Females X Aug. to May Survival = No. Immature Females Surviving in spring
(1060) (0.66) (700)

***All adult females surviving to spring are assumed to home although this probably is not the case.

****Amount of homing required for the population to remain the same as the previous spring.

TABLE 14. *Blue-winged teal duckling production and its potential effect on the female breeding population in subsequent years, SWSA, 1973-75.*

Year	No. of Breeding Pairs or Hens*	Percent of Pairs Producing a Brood	Overall Mean Class III Brood Size 1973-75	No. of Class III Ducklings	No. of Class III Females
1973	3260	53	6.2	10710	5360
1974	3080	21	6.2	4010	2010
1975	2090	20	6.2	2590	1300

Year	No. of Adult Females Surviving in Fall**	No. of Adult Males Surviving in Fall**	Im./Ad. in Fall Pop.	Immature Females Surviving to Next Spring***	Adult Females Surviving to Next Spring***	Total Females Surviving to Next Spring	Percent of Immature Females required to home to reach next year's population estimate****
1973	2740	3000	1.9	2360	1730	4090	60
1974	2590	2830	0.7	880	1630	2510	50
1975	1760	1920	0.7	570	1110	1680	170*****

*Data from random plot censuses; numbers rounded in data and calculations for convenience.

**Assumes summer survival of blue-wings equal to that of mallards in previous table when in reality it is probably less than mallard survival.

***Using annual mortality rates from Prairie Pothole regions (Bellrose 1976) survival rates are assumed to be: AM = .583, AF = .473, IF = .283.

****All adult females surviving to spring are assumed to home although for blue-wings this is surely not the case.

*****Homing required for the population to remain the same as that of the previous spring.

In summary, the short term (3 yr) data available seem to point to a precarious situation for the mallard population on the SWSA. The mallard population appears to be reproducing at a rate which could maintain itself only in the better years and only if surviving hens home to the study area to a very high degree. Since spring pair counts indicated little change in the breeding pair densities in 1973-75 (2.14, 1.87, and 2.01 pairs/sq mile), pioneering must be required to maintain mallard populations in the majority of years. The minimum level of pioneering required is dependent on the survival rates of resident females and the proportion that home to the area.

Blue-winged teal populations on the study area declined over the 3-yr period (Table 14). The superior water conditions of 1973 attracted above-average numbers of blue-winged teal and provided excellent brood conditions. The percentage of blue-winged teal pairs producing a brood was high and the calculated fall production ratio equaled 1.9 young/adult. Pair success dropped drastically from 53% in 1973 to 20% in 1974. Subsequent fall ratios were 0.7 in both 1974 and 1975. Several factors influenced this decline in production. Poorer brood water conditions prevailed in both 1974 and 1975. A larger proportion of the 1974 population would have been homing first-year females which are known to renest less frequently (Strohmeyer 1967) and, therefore, could also have been responsible for some of the decline in production.

Bellrose (1976) indicated that blue-winged teal kill data for 1961-72, corrected for differential vulnerability, yielded an annual production mean of 0.81 young/adult, with a range of 0.54-1.3. Production on the SWSA fell within this range in 2 years and exceeded it in 1973.

Data in Table 14 indicate that only the 1973 production would have resulted in enough hens the following spring to have numerically replaced the portion of the 1973 breeding hen population which was lost to various mortality factors or which failed to return or nest locally.

The extent to which blue-winged teal home is quite speculative. Two studies in Manitoba found little homing by adult female blue-wings and none by juveniles (Sowls 1955; McHenry 1971). If this was the case on the SWSA, the column in Table 14 on estimated homing required has little meaning except to point out that even with all adults homing to the study area, pioneering of hens from outside the study area would have had to occur in the springs of 1974 and 1975. Without pioneering, 50-100+% of the juvenile hens (and all adults) would have had to home to the SWSA.

Blue-winged teal are quite flexible in choosing breeding areas and poor at homing, but are excellent in adapting to favorable water conditions (Bellrose 1976). Such was the case on the SWSA during 1973 where teal were able to take advantage of the excellent water conditions. Larger numbers of breeding pairs were attracted to the area and the pairs produced well.

WETLAND HABITAT

Availability and Losses

The SWSA encompasses an area of fertile soils and wetlands equally capable of producing ducks or corn. This study documents only a small segment of a continuum of change occurring on the study area. Similar changes are happening over much of southeastern Wisconsin. Dodge, Columbia, Fond du Lac, and Green Lake counties have been recognized to contain 10% of the inland aquatic habitat of importance to ducks and coots in Wisconsin (Jahn and Hunt 1964). The SWSA contains approximately 4-6 wetlands/sq mile or 68-75 acres (170-188 ha) /sq mile (Table 15). Wetlands represented 11-12% of the total SWSA (Table 16). Sixty percent of the wetland area is in the form of lakes and Type II wetlands. Type III and IV wetlands comprised only 2% of the total land area.

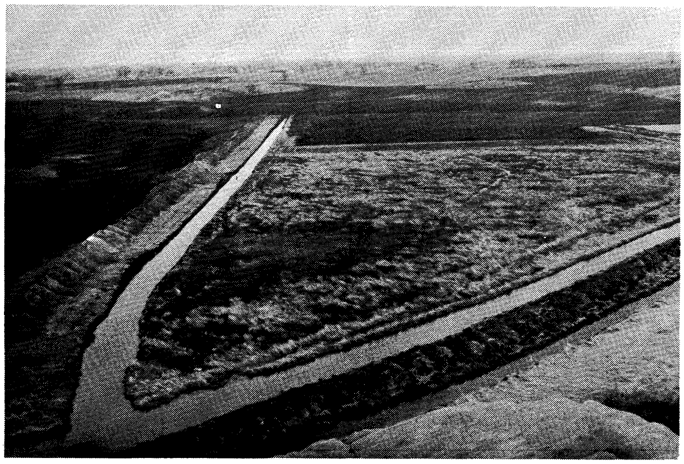
Changes occurring on the SWSA are primarily the result of increasingly intensive farming practices. Land use is centered around corn production (Table 17). A 5.5% increase in the acreage of cultivated lands during 1973-75 was primarily the result of planting approximately 8,000 more acres (3,200 ha) of corn. The acreage planted to peas, muck farms, hay, and short-term idle cropland also increased. The increase in idle cropland reflects increased land in rotation programs, yet these acres were of little value to wildlife because of sparse cover conditions resulting from yearly rotations to crops.

New lands placed under cultivation were primarily wetlands and undisturbed nesting cover (usually marginal farmland). Fallow plowed areas, small grain acreages, and pastures were also converted to corn and hay. The wet conditions in fall 1972 and spring 1973 probably increased the acreages with undisturbed nesting cover due to the extended period during which these areas could not be plowed. Therefore, the 1973 acreages of undisturbed cover may have been abnormally high, but this could not be documented.

A great deal of the conversion of wetlands to cropland was made possible by the drier conditions of 1974 and 1975. Dragline operations, tiling, and plowing were undertaken on lands wet in 1973 and recognized by the farmers as problem wet areas to be gotten rid of before another equally wet season occurred. Rising livestock feed costs and increasing land values during the 3 yr also added to the efforts to increase production on all lands. Wetland pastures are also disappearing as farmers change to bunk feeding methods and feed silage and green-chopped forage.

Wetlands decreased by approximately 3,200 acres/yr (9%; 1,280 ha), or about 1,000 acres/yr (400 ha) during 1973-75. Decreases in wetland acreages by types can be seen in Table 16. Losses of Types II, III, IV, and VI combined equaled 8.3% or more than one square mile per year (655 acres; 262 ha). At these rates, the more easily drained wetlands (Types II, III, and VI) may all be lost in as short a period as the next 25-30 yr. If this rate of loss were applied to the previous 20 yr, the acreage lost would total more than the important wetland portion of Horicon National Wildlife Refuge (12,275 acres; 4,910 ha) (Jahn and Hunt 1964).

Wetland development (additions) during the 3-yr study on the SWSA totaled 10 acres (4 ha). This effort was in the form of dug ponds and was primarily done to increase water available for stock watering and fishing. In several instances, these ponds became reservoirs into which adjacent wetlands were drained, making them a negative factor in terms of values to wildlife.


Drainage of a Type II wetland. A loss of 9% in wetland acreage occurred during the 3-yr study.

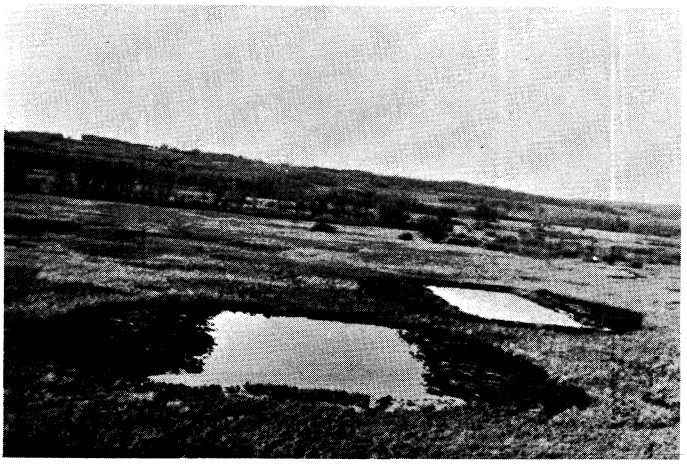

Creation of dug ponds has done little to replace wetlands lost between 1973 and 1975.

TABLE 15. *Wetland densities expressed as numbers and acreage per square mile, SWSA, 1973-75.**

Wetland Type	No./Sq. Mile				Acres/Sq. Mile			
	1973	1974	1975	Avg.	1973	1974	1975	Avg.
I	1.45	0.34	0.26	0.68	4.11	3.53	1.65	3.10
II	1.11	1.11	1.11	1.11	25.56	24.26	23.47	24.33
III	0.48	0.48	0.48	0.48	9.31	9.07	8.77	9.05
IV	0.06	0.06	0.06	0.06	3.52	3.52	3.52	3.52
V								
Lakes	0.08	0.08	0.08	0.08	19.45	19.45	19.45	19.45
Ponds	0.56	0.56	0.56	0.56	0.50	0.51	0.52	0.51
VI	0.24	0.24	0.24	0.24	8.52	8.52	7.25	8.10
Streams	0.74	0.74	0.74	0.74	1.84	1.84	1.84	1.84
Ditches	0.88	0.88	0.88	0.88	1.95	1.95	1.95	1.95
All Temporary Wetlands**	3.28	2.17	2.09	2.51	47.38	45.38	41.14	44.60
Total	5.60	4.49	4.41	4.83	74.76	72.65	68.42	71.90

*From random plot censuses; excludes wetland types present but dry.

**Includes wetland types I, II, III, and VI.

TABLE 16. *Acreage and percent of total SWSA in available wetland types, 1973-75.*

Wetland Type	1973		1974		1975	
	Acreage	Percent of Total SWSA	Acreage	Percent of Total SWSA	Acreage	Percent of Total SWSA
I	2071	0.6	1779	0.6	832	0.3
II	12882	4.0	12227	3.8	11829	3.7
III	4692	1.5	4571	1.4	4420	1.4
IV	1774	0.6	1774	0.6	1774	0.6
V						
Dug Ponds	252	<0.1	257	<0.1	262	0.1
Lakes	9803	3.0	9803	3.0	9803	3.0
VI	4292	1.3	4294	1.3	3654	1.1
Streams	927	0.3	927	0.3	927	0.3
Ditches	984	0.3	984	0.3	984	0.3
Total	37680	11.7	36616	11.4	34485	10.8

TABLE 17. *Land use and its changes on the SWSA, 1973-75.*

Cover Types	Percent of Total Area			Percent Change 1973-1975	
	1973	1974	1975	Total Area	Acreage
Cultivated Lands	54.1	56.0	56.5	+2.4	+5.5
Corn	41.6	42.5	43.8	+2.2	+6.3
Small Grains	6.3	6.8	5.9	–0.4	–5.3
Peas	2.5	2.9	3.2	+0.7	+26.0
Muck Farms	0.2	0.1	0.3	+0.1	+22.0
Other Crops	1.1	0.6	0.8	–0.3	–26.0
Idle Cropland	1.3	1.5	1.9	+0.6	+53.0
Fallow Plowed	0.9	1.4	0.5	–0.4	–44.0
Pasture	4.0	3.8	3.8	–0.2	–3.2
Miscellaneous	4.5	4.4	4.5	0.0	0.0
Woodlots	5.5	5.5	5.5	0.0	0.0
Potential Nesting Cover	20.1	19.0	19.0	–1.1	–4.9
Hay	10.7	11.7	12.2	+1.5	+14.0
Strip Cover*	1.8	1.8	1.8	0.0	0.0
Undisturbed Nesting Cover**	7.6	5.5	5.0	–2.6	–33.0
Wetlands	11.7	11.4	10.8	–0.9	–8.5

*Roadsides, fencelines, and ditch banks.

**Includes cropland and pasture idled long enough to revert to grass, forb or shrub cover suitable for nesting.

TABLE 18. *Physical analysis of bottom soils on scattered wetlands and important nearby waterfowl areas in southeastern Wisconsin.*

Soil Components	Percent Composition of Soils									
	On Scattered Wetlands by Wetland Type						On Horicon Marsh*	On Lake Sinissippi*	On Theresa Marsh**	On Grand River Marsh***
	I	II	III	IV	V	Avg.				
Sand	34	38	33	44	46	39	41	30	31	52
Silt	50	59	63	50	50	54	57	63	54	48
Clay	16	9	5	6	4	8	2	6	15	0

*Beule and Janisch (1974).

**Klopatek (1974).

***Beule and Janisch (1975).

TABLE 19. *Chemical analysis of bottom soils on scattered wetlands and important nearby waterfowl areas in southeastern Wisconsin.*

Area or Type	Percent OM	Ca (lb/acre)	Mg (lb/acre)	SO_4-S (lb/acre)	Salts (mhos x 10^3)	NO_3-N (ppm)
Scattered Wetlands						
Type I	13.0	7900	2350	380	0.73	60.5
Type II	26.3	8900	1990	760	1.48	20.3
Type III	11.2	5750	1270	310	0.70	11.4
Type IV	22.8	6730	1800	660	1.27	20.3
Type V	21.8	4900	1740	530	1.12	17.5
Dug Pond	3.0	2000	600	120	0.29	5.5
Theresa Marsh*	53.2	8600	1670	1072	1.78	4.0
Horicon Marsh**	50.2	8130	1670	410	1.13	—
Lake Sinissippi**	16.2	7270	1530	540	1.25	—
Grand River Marsh***	56.4	12500	3600	70	1.26	—

*Klopatek (1974).

**Beule and Janisch (1974).

***Beule and Janisch (1975).

WETLAND CHARACTERISTICS

Wetland Soils

The soils of the SWSA are rich silt loams. These soils are formed by a combination of the rich glacial till and the grassland and oak savanna ecosystems which previously existed on the area (Thwaites 1956; Curtis 1959).

Bottom soils samples from 5 wetland types were very similar in physical makeup (Table 18). The semi-permanent to permanent Type IV and Type V wetlands contained bottom soils of a more sandy nature. The physical makeup of the bottom soils on scattered wetlands were similar to that on other important waterfowl areas in southeastern Wisconsin (Table 18). Grand River Marsh, also a productive waterfowl area in the region, has soils with a higher proportion of sand.

The percent organic matter in the bottom soils of the study area ranged widely (Table 19), with the largest proportion found in the soils of Type II wetlands. This is due to the very high productivity of reed canary grass *(Phalaris arundinacea)* on these seasonally wet meadows. Klopatek (1974) found that similar areas on the Theresa Marsh Wildlife Area produced approximately 9 tons/acre (20 m tons/ha) of reed canary grass. This was a higher above-ground yield of material than on areas specifically fertilized and managed for canary grass production.

The organic content of the soils of Type I wetlands (13%) is only half that found in Type II's and depends on the cropping practices being used as most of these areas are cultivated. Harvest of either hay or grains removes most of the organic materials leaving little to add to the soil. The spreading of manure replaces some of the organic materials removed.

Soils of Type III wetlands were lower in organic materials (11%) than soils of Types IV and V (22-23%). The more variable water conditions on Type III areas may allow for increased oxidation of bottom materials in dry years, reducing the build-up of organic materials. The more permanent Type IV and Type V areas have soils with increasing amounts of organic materials. The more stable impoundments characteristic of state wildlife areas show even greater organic accumulation, exceeding 50% of the bottom soils (Table 19). The fertility of these organic soils is indicated by the 15 tons/acre (33.8 m tons/ha) net production of cattail on Theresa Marsh (Klopatek 1974).

Bottom areas rich in organic debris were found to contain a greater abundance of invertebrates than areas poor in debris (Tebro 1955; Hartley 1971).

Further analyses of soil nutrients are presented in Table 19. Kloptek (1974) found that soil nutrient levels on Theresa Marsh were higher than levels required for most agricultural crops. Data on Theresa Marsh (Table 19) can then be used as a rough index to the fertility of SWSA wetlands.

Bottom soil fertility in dug ponds is extremely low. This is the result of the recent removal of the fertile upper soil when the ponds were dug.

Type I and Type II wetland soils have high levels of calcium, magnesium, and nitrate which may be the result of runoff from agricultural lands. Bottom soil nutrient variability is the result of complex water, soil, and plant interactions. Comparing soils of different wetlands is confounded by their differing plant associations and their roles in nutrient cycling. On Theresa Marsh, emergent macrophytes were felt to be the controlling influence on the available soil nutrients during the growing season (Klopatek 1974). Only a few studies of waterfowl marshes in other areas have reported bottom soil nutrient conditions (Kadlec 1960; Jessen et al. 1964). In northwestern Minnesota, Jessen et al. (1964) reported that better quality wetlands had bottom soils of similar magnesium content (1,613 lb/acre; 1.8 m tons/ha) and slightly higher calcium levels (9,975 lb/acre; 11.3 m tons/ha).

Water Quality

General water chemistry data for the wetland types are presented as overall averages of sampling done during the 3 waterfowl breeding seasons of 1973-75 (Table 20). Available water quality data from 4 wildlife areas in southeastern Wisconsin are presented in Table 21 for comparison purposes.

Total alkalinity has frequently been used as an index to general water fertility (Moyle 1956; Kadlec 1960; Jessen et al. 1964; Ordal 1964; Drewien and Springer 1969). Total alkalinities for all wetlands tested on the study area were high (170-303 ppm), except for those waters characteristic of the dug ponds (39 ppm). Total alkalinity readings of below 40 ppm were considered "low" by Moyle (1956) and are usually associated with sparse vegetation. The total alkalinities from 10 potholes in agricultural areas of the Manitoba parklands averaged 248 ppm (Dwyer 1970). Seasonal wetlands of the drift plain of North Dakota were found to have waters with a mean total alkalinity of 223 ± 71 mg/1 (ppm) (Swanson et al. 1974).

Specific conductance is a measure of the total amount of ionized material in the water and provided adequate indication of average salinity of surface waters in North Dakota (Stewart and Kantrud 1972). All surface waters examined on the SWSA, with the exception of those in Type I wetlands, fall into the "freshwater" category ($<$40-500 μmhos/cm) of Stewart and Kantrud (1972). The specific conductance of waters of SWSA Type I wetlands would put them into the "slightly brackish" category. Very little variation in specific conductance among study area wetland types is evident with the exception of dug ponds. Such is not the case in the prairie pothole regions where mean specific conductance ranged from 295 to 37,500 μmhos/cm (Stewart and Kantrud 1972). Specific conductance of waters in the Manitoba parklands also varied from 366 to 2,288 μmhos/cm (Dwyer 1970).

High annual precipitation, integrated drainage that allows outflow of nutrients during high water, high humidity with resulting low evaporation rates, and the less frequent total drying out of the more permanent marshes all work to keep nutrient concentrations and specific conductance in SWSA marsh waters much lower than those in the prairie breeding grounds.

The SWSA area waters are much lower in sulfates (Table 20) than waters in Minnesota (26-1,120 ppm; Jessen et al. 1964) and North Dakota (105-17,170 ppm; Swanson et al. 1974). *Ceratophyllum* beds on Theresa Marsh produced greater than 14,000 macroinvertebrates/sq m with sulfate levels of around 28 ppm (Ringger 1973).

Total nitrogen and total phosphorus appear quite high on study area wetlands with 1.67-3.50 ppm and 0.10-0.55 ppm, respectively. Moyle (1956) reported that the best waterfowl lakes in Minnesota were those with concentrations of nitrogen at 0.5 to $>$1.0 ppm total nitrogen and 0.05 to $>$0.10 ppm total phosphorus.

The inter-relationships between water chemistry, associated vegetation, invertebrate populations, breeding duck and duckling invertebrate food requirements, and finally, physical availability of invertebrates to ducks make it impossible to directly estimate carrying capacity solely on the basis of water chemistry.

TABLE 20. *Average summer (April - August) water chemistry parameters measured on scattered wetlands in southeastern Wisconsin, 1973-75.*

Test	Wetland Type					
	I	II	III	IV	V	Dug Pond
Total Alkalinity*	303	269	170	237	173	39
Conductance	575	411	381	452	411	103
Total Hardness	381	381	243	303	225	79
pH	8.1	7.8	7.6	7.6	8.0	7.7
NO_2	.032	.027	.032	.013	.012	.018
NO_3	.34	1.20	.95	.24	.17	.29
NH_3	.25	.24	.15	.23	.14	.67
Orgn. N	1.53	1.69	2.12	2.28	1.38	2.56
Tot. N	2.14	2.94	3.13	2.77	1.67	3.50
PO_4	.55	.17	.15	.25	.03	.10
Tot. P	.55	.45	.26	.49	.10	.23
SO_4	43	26	23	18	18	15
Cl	28	20	15	17	13	5
Ca	66	66	43	49	32	12
Mg	53	65	29	41	38	7
Na	7	11	7	8	8	2
K	5	4	5	5	5	6
Fe	.84	1.48	1.22	1.53	1.02	1.25
Mn	.30	.40	.26	.55	.12	.18

*Test results all in ppm except conductance (μmhos/cm) and pH.

TABLE 21. *Average summer (April - August) water chemistry parameters measured on important state-owned waterfowl areas in southeastern Wisconsin.*

Area	Alkalinity (ppm)	Conductance* (μmhos/cm at 25°C)	pH	Turbidity (JTU)	Color	Organic Nitrogen (ppm)
Horicon Marsh*	244	768	8.0	94	359	3.39
Grand River Marsh**	256	571	7.8	24	118	—
Theresa Marsh**	318	778	7.9	30	136	—
Eldorado Marsh**	257	712	7.5	23	131	—

*Data supplied by R. Johnson for 1971 (unpubl.) DNR Files - Horicon.

**Data furnished by J. D. Beule and T. Janisch for the year 1971 (unpubl.) DNR Files - Horicon.

Characteristic Vegetation

The primary plants identified on SWSA wetlands and their occurrence in the different wetland types are listed in Table 22. Type I wetlands were not included as few developed wetland vegetation. In wet years Type I's did support important waterfowl food plants such as foxtails *(Setaria* spp.), barnyard grasses *(Echinochloa* spp.), smartweeds *(Polygonum* spp.), and panic grasses *(Panicum* spp.). These plants provided seed for the next spring, even in some fall-cultivated areas. Streams also were not sampled due to their large variation in size, stability of flow, and related vegetation.

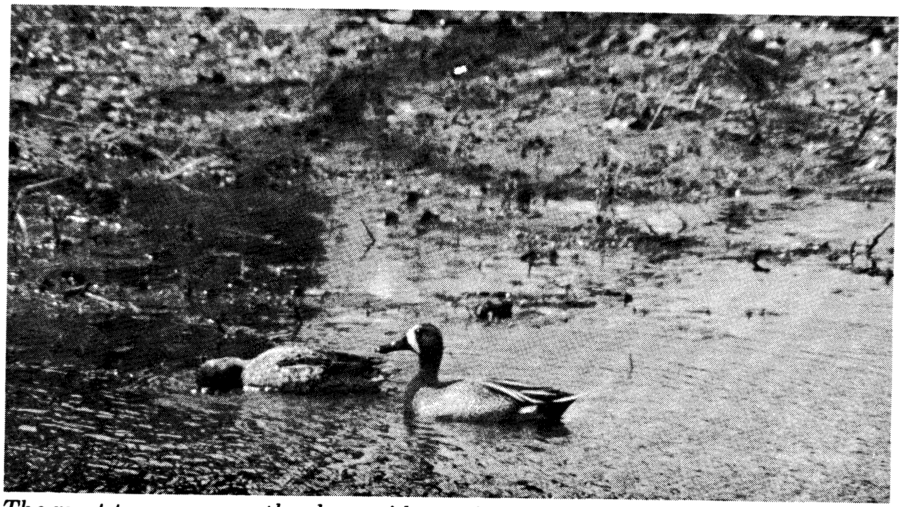
Emergent vegetation provided adequate cover for pairs and broods except in the deep water areas of dug ponds, and Type IV and V wetlands.

Nearly all of the plants listed in Table 22 provided either important seeds, vegetation, and/or invertebrate habitats which furnished foods for breeding pairs and ducklings. The importance of these plants as seed sources will be dealt with further in the section entitled "Feeding Ecology of Breeding Ducks and Broods". Pools sheltered by emergent plant species and filled with floating and submergent vegetation rich in invertebrates provided excellent brood rearing areas.

Vegetation of all types, whether it provides shelter or food, plays an integral part in these small scattered wetland ecosystems.

TABLE 22. *Vegetation present on the SWSA wetland types.*

Scientific Name	Common Name	Wetland Type				
		II	III	IV	V	Ditch
Emergent and Moist Soil Vegetation						
Alisma plantago-aquatica	Water Plantain	X	X			X
Asclepias incarnata	Swamp Milkweed	X	X			X
Calamagrostis spp.	Reed-bentgrasses				X	
Carex spp.	Sedges	X	X	X	X	X
Dulichium arundinaceum	Pond Sedge	X	X			
Eleocharis spp.	Spike Rushes	X	X	X		X
Equisetum spp.	Horsetails	X	X		X	
Festuca spp.	Fescue-grasses	X				
Galium spp.	Bedstraws				X	
Glyceria spp.	Manna-grasses	X				
Iris versicolor	Blue flag Iris	X	X			
Leersia oryzoides	Rice Cut Grass			X		
Lycopus americanus	Common Water Horehound	X				
Lysimachia thyrsiflora	Tufted Loosestrife	X			X	
Mentha arvensis	Wild Mint	X				X
Menyanthes trifoliata	Buckbean	X				
Phalaris arundinacea	Reed Canary Grass		X	X	X	X
Phragmites australis	Reed				X	
Polygonum amphibium	Water Knotweed	X	X	X	X	
P. lapathifolium	Heartsease					X
Potentilla palustris	Marsh Cinquefoil	X				
Rumex spp.	Docks				X	X
Sagittaria cuneata	Wapato			X		
S. latifolia	Common Arrowhead	X		X	X	X
S. rigida	Stiff Arrowhead		X			
Salix spp.	Willows	X				
Scirpus acutus	Hard-stemmed Bulrush	X	X	X	X	
S. atrovirens	Dark Green Rush					X
S. hudsonianus	Bulrush	X				
S. validus	Great Bulrush		X	X		X
Scutellaria epilobiifolia	Marsh Skullcap	X				
Sium suave	Water Parsnip			X	X	X
Sparganium americanum	American Bur Reed		X			
S. chlorocarpum			X			
S. eurycarpum	Common Bur Reed		X	X	X	
Sphenopholis spp.	Wedgegrass	X	X			
Typha spp.	Cattails	X	X	X	X	
Zizania aquatica	Wild Rice			X		
Floating and Submergent Vegetation						
Algae		X	X	X	X	X
Ceratophyllum demersum	Coontail			X	X	
Chara vulgaris	Muskgrass		X			
Elodea canadensis	Common Waterweed				X	
Fissidens spp.	Water Moss		X		X	
Lemna minor	Small Duckweed		X	X	X	X
L. trisulca	Forked Duckweed		X	X	X	
Myriophyllum spicatum	Water-milfoil				X	
Nuphar variegatum	Yellow Pond-lily				X	
Nymphaea odorata	Fragrant Water-lily			X		
Potamogeton crispus	Curly Pondweed				X	
P. gramineus	Grass-leaved Pondweed	X	X			
P. pectinatus	Comb Pondweed			X	X	
P. pusillus	Small Pondweed		X	X	X	
P. vaginatus						X
Proserpinaca palustris	Mermaid Weed					X
Ranunculus flabellaris	Yellow Water Crowfoot	X				
R. sceleratus	Cursed Buttercup		X			
R. trichophyllus	White Water Crowfoot			X		
Riccia fluitans		X	X	X	X	
Ricciocarpus natans		X	X			
Sphagnum spp.	Peat Mosses	X		X		
Spirodela polyrhiza	Great Duckweed			X	X	
Utricularia intermedia	Flat-leaved Bladderwort				X	
U. vulgaris	Great Bladderwort	X	X	X	X	
Vallisneria americana	Eel Grass			X		
Wolffia spp.	Water-meals			X	X	



The most temporary wetlands provide needed food resources.

Waterfowl Food Resources

Net and bottom sampling for invertebrates and seeds was carried out on all types of wetlands in conjunction with a study of food habits of ducks. Average numbers and average biomass estimates (ml/sq m) of invertebrates and seeds found in the various wetland types are presented in Tables 23-26. Presence and abundance of a particular item in no way infers that the food was directly available for consumption by ducks. Variation in bottom depth, organism size and mobility, location of food in bottom substrate, variations in species of invertebrates emerging, duck food gathering ability and physical adaptations, and even food preferences of ducks make "presence" and "availability" two completely different parameters. The presence of known and heavily utilized waterfowl foods will be used here as an estimate of wetland values in terms of food reservoirs for waterfowl.

Fifty eight taxa of invertebrates were found present on area wetlands. Six taxa were singled out as having provided the greatest proportions of foods by volume when considering all breeding female mallards and blue-winged teal and all age classes of ducklings of both species. These were the classes Gastropoda, Pelecypoda, and Oligochaeta and the orders Amphipoda, Coleoptera, and Diptera. Tables 23, 24, 25, and 26 include these classes and orders and are broken down into the most important families.

Ranking wetlands by biomass (ml/cu m) of invertebrates present generally gives quite different results than ranking them by density (number/cu m) of invertebrates present. Similarly ranking by all invertebrates present versus the total of the 7 most important taxa gives quite different results.

Type V lakes ranked first in both all invertebrates present and in total biomass of the 7 most important taxa (Table 23). Type V lakes also have the highest density of all invertebrates and also the 7 most important taxa (Table 24). All other comparisons failed to yield any simple relationships between density or biomass of all invertebrates or those most heavily utilized and wetland types.

Type IV wetlands are considered the best brood rearing areas due both to their permanency and to their available cover. Type IV's ranked second in biomass of all invertebrates, but were only seventh when considering the biomass of the most heavily utilized food taxa. When ranking wetlands by invertebrate density, Type IV's were fourth for all invertebrates and third for totals of the most heavily utilized taxa.

Types I, III, and IV wetlands, dug ponds, and ditches have fairly uniform biomasses (2.0-3.7 ml/cu m) of the 7 most heavily utilized taxa.

Dredge samples of bottom materials (Tables 25 and 26) added more information on the presence of bottom fauna and seeds. Invertebrates and seeds of the bottom areas are readily available in shallow Types I, II, and VI, but may be unavailable on Types III, IV, and V wetlands, ditches, and streams except in the shallowest portions or in years of low water levels.

Type IV wetlands, dug ponds, and ditches ranked consistently high in both biomass and density of bottom invertebrates, when considering either all invertebrates or just those most heavily used by ducks.

Also notable were the high biomasses and numbers of gastropods present as benthos in Type II and Type IV wetlands.

On the SWSA, the wetlands with the most organic bottom soils (Types II and IV) had the greatest biomass of gastropods. A higher density of chironomids, however, was found in the dug pond soils which contained only 3% organic material. This was not expected since larvae of certain chironomid species are known detritivores (Hilsenhoff 1975). Chironomids may not be a valid index to the food resources associated with particular bottom type values. Emergence of individual species may result in temporarily low numbers being associated with a particular bottom material. Although 9 chironomid genera were identified on Theresa Marsh, only 2 genera were predominantly found in the benthos; the rest were on submerged vegetation (Ringger 1973).

More amphipods were also found in association with the low organic soils of the dug pond bottoms on the study area. This may be due to the permanent nature of these wetlands and the tendency for amphipods to be a species of more permanent waters (Swanson et al. 1974).

The relationships between different bottom substrates and invertebrate populations have not been adequately studied in marshes. Little can be inferred about these relationships from our study area ponds.

Although total nutrient loads in waters of the SWSA are generally lower than in saline marshes of the prairies, vegetation and invertebrate populations thrive in all available waters of the study area. Bottom samples from study area wetlands averaged between 3,960 and 50,260 invertebrates/sq m of bottom. The SWSA wetlands provided from 4,500 to 27,000 invertebrates/cu m of water in the zone from the surface to 15 cm deep.

Seeds were very numerous in bottom samples from all wetland types except dug ponds (Table 26). *Polygonum* (smartweed) was the most uniformly abundant genus both in number and volume in all wetland types except Type VI and dug ponds. *Polygonum* was also one of the genera most heavily utilized by ducks. *Phalaris arundinacea* (reed canary grass) seeds were present on nearly all wetlands in high densities but these lighter seeds provided lower biomass than smartweed seed. On Type II and III wetlands, 6 genera of plants *(Polygonum, Eleocharis, Echinochloa, Setaria, Rumex, Phalaris)* provided approximately 150,000-170,000 seeds/sq m on easily accessible shallow bottom areas.

TABLE 23. *Average biomass of heavily utilized* invertebrate foods of waterfowl on the SWSA and total biomass of all invertebrates collected in net samples at feeding sites.*

	ml/cu m of Food Items by Wetland Type								
					V				
Food Item	I (8)**	II (8)	III (4)	IV (4)	Dug Ponds(2)	Lakes (7)	VI (5)	Ditches (3)	Streams (3)
Gastropoda	2.6	4.3	0.8	22.0	1.1	3.7	6.9	1.8	1.8
Sphaeriidae	0.3	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.9
Amphipoda	0.1	0.0	0.0	0.1	0.2	0.5	0.0	0.0	0.7
Chironomidae	0.4	0.7	0.4	0.1	0.9	1.1	0.5	0.7	0.7
Ceratopogonidae	tr***	0.1	0.1	0.1	0.0	0.8	0.0	0.0	0.1
Coleoptera	0.4	0.1	0.7	0.1	0.0	2.2	0.2	0.1	0.8
Oligochaeta	tr	tr	0.3	0.0	0.0	0.5	0.1	0.0	1.6
Total	3.7	5.4	2.3	2.4	2.0	8.9	7.7	2.6	6.6
All Invertebrates	6.9	11.1	8.9	19.6	5.5	37.9	11.5	2.8	15.7

*Appeared in greatest proportions by volume in esophagus samples of blue-winged teal and/or mallards in this study.

**Number of areas sampled.

***tr = < 0.1 ml/cu m.

TABLE 24. *Average numbers of heavily utilized* invertebrate foods of waterfowl on the SWSA and total number of all invertebrates collected in net samples at feeding sites.*

	No./cu m of Food Items by Wetland Type								
					V				
Food Item	I (8)**	II (8)	III (4)	IV (4)	Dug Ponds(2)	Lakes (7)	VI (5)	Ditches (3)	Streams (3)
Gastropoda	460	60	10	1310	50	1790	440	30	320
Sphaeriidae	40	20	0	0	0	3190	0	0	40
Amphipoda	0	0	0	10	150	340	0	0	220
Chironomidae	120	90	290	130	740	880	390	390	720
Ceratopogonidae	0	10	20	130	0	190	0	0	30
Coleoptera	10	60	20	10	0	50	10	0	70
Oligochaeta	220	40	200	0	0	2490	70	0	1820
Total	850	280	540	1590	940	8930	910	420	3220
All Invertebrates	4770	20200	10200	13000	4550	26770	7620	1030	15200

*Appeared in greatest proportions by volume in esophagus samples of blue-winged teal and/or mallards in this study.

**Number of areas sampled.

TABLE 25. *Average biomass of heavily utilized* foods of waterfowl on the SWSA and total biomass of all invertebrates and all seeds collected in Eckman Dredge samples at feeding sites.*

	ml/sq m of Food Items by Wetland Type								
					V				
Food Item	I (8)***	II (8)	III (4)	IV (4)	Dug Ponds(2)	Lakes (7)	VI (5)	Ditches (3)	Streams (3)
Invertebrates									
Gastropoda	9.9	92.3	7.8	128.0	26.0	10.4	14.0	13.0	0.0
Sphaeriidae	0.3	3.6	0.5	0.8	1.0	tr	0.0	1.4	0.0
Amphipoda	0.1	0.1	0.0	0.3	12.0	1.3	tr	0.0	0.0
Chironomidae	3.3	1.9	8.3	2.0	14.0	3.9	0.4	0.5	1.0
Ceratopogonidae	tr**	0.2	0.5	0.0	0.0	1.3	tr	tr	0.0
Coleoptera	1.3	0.1	2.4	5.2	0.0	1.6	1.5	0.0	2.1
Oligochaeta	2.0	4.3	10.7	12.8	2.0	5.8	14.9	46.0	0.2
Total	16.9	102.5	30.2	149.1	55.0	24.3	30.8	60.9	3.3
All Invertebrates	22.1	110.0	46.0	155.9	72.0	40.9	32.8	67.0	13.3
Seeds									
Polygonum spp.	12.9	15.3	15.3	7.5	6.8	9.9	0.8	6.2	128.0
Eleocharis palustris	3.8	0.1	65.0	0.0	0.0	0.0	7.5	tr	0.0
Echinochloa spp.	8.0	0.1	0.3	0.0	0.0	0.0	tr	0.0	0.0
Setaria lutesens	1.3	0.0	1.8	0.0	0.0	0.2	0.0	0.0	0.0
Rumex spp.	0.3	0.1	1.5	tr	0.0	0.5	0.3	tr	0.4
Phalaris arundinacea	0.1	10.1	4.8	13.6	6.2	3.7	2.0	27.7	2.0
Total	26.4	26.7	88.7	21.1	13.0	14.3	10.0	34.0	30.4
All Seeds	30.8	80.0	154.0	101.0	22.0	154.0	117.0	36.0	405.0

*Appeared in greatest proportions by volume in esophagus samples of blue-winged teal and/or mallards in this study.

**tr = <0.1 ml/sq m.

***Number of areas sampled.

TABLE 26. *Average numbers of heavily utilized* foods of waterfowl on the SWSA and total numbers of all invertebrates and all seeds collected in Eckman Dredge samples at feeding sites.*

	No./sq m of Food Items by Wetland Type								
					V				
Food Item	I (8)**	II (8)	III (4)	IV (4)	Dug Ponds(2)	Lakes (7)	VI (5)	Ditches (3)	Streams (3)
Invertebrates									
Gastropoda	1660	3730	160	13010	1820	540	3510	1260	0
Sphaeriidae	30	640	10	20	410	10	0	290	0
Amphipoda	0	10	0	60	3280	290	20	0	0
Chironomidae	950	480	3810	2030	9100	2390	410	3050	520
Ceratopogonidae	0	80	220	0	0	1040	10	10	0
Coleoptera	30	10	130	30	0	70	100	40	150
Oligochaeta	400	2370	9970	740	2510	7400	8030	10510	210
Total	3070	7320	14300	15890	17120	11740	11980	15160	880
All Invertebrates	5060	7310	20100	16230	17340	20640	13650	50260	3960
Seeds									
Polygonum spp.	4790	3300	4260	3610	460	3470	90	2300	43420
Eleocharis palustris	6500	270	117000	0	0	0	16000	10	0
Echinochloa spp.	1540	20	310	0	0	0	10	130	0
Setaria lutescens	360	0	270	0	0	40	0	0	0
Rumex spp.	70	10	780	10	0	150	60	100	280
Phalaris arundinacea	40	4420	3420	4000	2660	1740	920	10170	1380
Total	13300	8020	126040	7620	3120	5400	17080	12610	45080
All Seeds	16370	170360	147560	43640	6960	14070	49540	13090	59470

*Appeared in greatest proportions by volume in esophagus samples of blue-winged teal and/or mallards in this study.

**Number of areas sampled.

If wetlands are compared by biomasses of the most heavily utilized seeds, wetland Types I, II, and III, ditches, and streams contain the largest volumes. When compared by densities of the most heavily utilized seeds, Types I, III, and VI wetlands, ditches, and streams have much higher numbers of seeds than Types II and IV wetlands, dug ponds, and lakes.

Such ranking may not have ecological significance since the sampling was done over the entire breeding season and observed pair use followed water availability patterns very closely. The temporary Types I, II, and VI wetlands, when they were flooded in April and early May, were used extensively by all species. When these temporary areas became dry, the birds were forced to use Types III and IV wetlands, ponds, lakes, streams, and ditches. Birds would immediately resume feeding in the temporary wetlands if they were reflooded by rains in late May or June. The availability of seeds plays an important role in wetland use and potential waterfowl value. The use of seeds by laying mallards and prelaying blue-winged teal during the period in which temporary Types I, II, and VI wetlands contained water will be emphasized in the section entitled "Feeding Ecology of Breeding Ducks and Broods."

Although availability of a food resource is a complex interaction between its presence, water levels, and the physical adaptations and abilities of the feeding ducks, a measurement of presence alone gives a general indication of the value of a particular habitat. Future sampling in different geographical areas and areas of much lower or higher indicated fertility should increase the value of these data for comparison purposes.

All evidence from water and soil chemistry tests, invertebrate densities, and plant populations present on wetlands of the study area indicates that fertility and the associated food resources on these wetlands are not limiting factors to waterfowl populations.

WETLAND UTILIZATION BY BREEDING DUCKS AND BROODS

Breeding Pair Occupancy

The occupancy rates of southeastern Wisconsin wetlands have been previously estimated to be quite low. Jahn and Hunt (1964), using data from cross-country road transects, determined that occupancy of all types of wetlands in the Eastern Ridges and Lowlands averaged 18% during 1948-50. Statewide fixed-wing surveys flown during 1965-70 indicated only 5.7% occupancy for all wetland types in SE/Central Wisconsin (March et al. 1973). These same surveys indicated that only 8.5% of the Type III wetlands were occupied by breeding pairs. However, since only 1/8 to 1/3 of the ducks actually present were seen from the air (March et al. 1973), occupancy rates were under-estimated to an unknown degree.

The generally low occupancy rates left two possibilities to consider. Either many of the wetlands were not suitable breeding pair habitat or there were not enough pairs to utilize the habitat. The former possibility was considered worthy of further research since regional breeding population estimates (March et al. 1973) indicated increasing populations in SE/Central Wisconsin during 1968-70.

The present study was designed to look at occupancy rates and attempt to relate them to wetland habitat conditions. During this study, the occupancy rates of wetland types by breeding ducks were determined by both random plot censuses and by helicopter surveys. Occupancy rates as determined from beat-outs of random 1/4-sections during May and June are presented in Table 27. Since the wetlands were visited only twice to determine breeding pair use, the results are felt to be minimum estimates of occupancy.

The overall occupancy rate for all types of wetlands combined was 56.1%. This is almost 10 times the occupancy rate for SE/Central Wisconsin wetlands surveyed in 1965-70 (March et al. 1973), and about 3 times the overall 18% occupancy determined by Jahn and Hunt (1964) for the Eastern Ridges and Lowlands.

An average overall occupancy rate of 55% was determined for potholes in the Alberta parklands during 1953-65 (Smith 1971). Occupancy of ponds in the Saskatchewan parklands averaged 46% over the period 1952-64, and ranged from 20% to 71% (Stoudt 1971). For the 3-year period studied, SWSA wetlands were occupied, on the average, at rates quite similar to the occupancy rates occurring in the parklands, but SWSA occupancy rates showed less year-to-year fluctuation.

The more stable water areas (4 Type IV wetlands and 4 lakes) were all utilized by breeding pairs during all 3 yr. All wetlands except Type I's were most heavily utilized in the extremely wet 1973 breeding season. It appears that the abundance of Type I wetlands in 1973 was so great that even the largest population of ducks present in the 3 yr was only able to utilize 45.8% of these readily used feeding areas. Pairs did favor the larger Type I wetlands in all years as the average size of those used by pairs was larger than the average size of all Type I wetlands present (Table 28).

It would appear that when an abundance of flooded fields (Type I wetlands) are present, they are selected by feeding ducks at random since most seemed well supplied with seeds and invertebrates. On the same day in May 1974, 6 Type I wetlands were sampled for invertebrates and seeds. Of these wetlands, 3 were occupied by ducks; the 3 other areas were chosen because they contained no ducks on that day. The results of net and bottom samples indicated that the unoccupied wetlands had larger average surface invertebrate populations and contained nearly as many seeds as the occupied areas (Table 29). The areas sampled were 1 to 3 in deep where the samples were taken so all bottom foods were within reach of feeding ducks. Food habits to be discussed later show these seed supply areas to be quite important to both laying mallards and prelaying blue-winged teal.

Comparing total wetlands present and the percent of these occupied in each year indicates a direct relationship (Fig. 6). As the total number of wetlands decreased over the 3 yr, the occupancy rate for all wetlands also declined. For this to occur, either some of the wetlands became less attractive to pairs or the duck population declined to a point where fewer of the remaining wetlands were required for their needs. It appears that both factors affected occupancy rates on the study area.

The large decrease in the use of the permanent dug ponds and streams (Table 27) by breeding pairs appears to be the direct result of the 25-30% decrease in pairs using the study area (1973-75), since these areas retained sufficient water in all years.

The other factor contributing to reduced occupancy was the degradation of Type II and III wetlands into habitat less desirable to breeding ducks.

Breeding pair occupancy dropped from 75% in 1973 to 50% in 1975 for Type III wetlands (Table 30). In the 3 yr, all unoccupied Type III wetlands were either dry or so choked with cattail that they provided no openings in which pairs could establish territories or seek food (Table 30).

The average size of the Type III wetlands occupied by pairs was approximately 18 acres whereas the average size of all Type III's present in the study area was approximately 14 acres

Occupancy of all wetlands types averaged 56% for the random plot censuses. This was at least 3 times that of previous estimates in southern Wisconsin and was similar to occupancy rates in the Canadian parklands.

TABLE 27. *Annual breeding duck occupancy of the various wetland types, SWSA, 1973-75.**

	No. Studied			Percent Occupied by Breeding Ducks			
Wetland Type**	1973	1974	1975	1973	1974	1975	Avg.
I	72	17	13	45.8	58.8	53.8	52.8
II	55	55	55	52.7	34.5	34.5	40.6
III	24	24	24	75.0	58.3	50.0	61.1
IV	4	4	4	100.0	100.0	100.0	100.0
V							
Dug Ponds	28	28	28	85.7	92.9	57.1	78.6
Lakes	4	4	4	100.0	100.0	100.0	100.0
VI	12	12	12	8.3	8.3	0.0	5.5
Streams	37***	37	37	70.3	73.0	54.0	65.8
Ditches	44***	44	44	81.8	59.1	59.1	66.7
Total	280	225	221	62.1	57.9	48.4	56.1

*Occupancy as determined during random plot censuses (May-June).

**Shaw and Fredine (1956).

***Numbers represent only the number of segments present on random plots. Segments varied in length from approximately 0.25 to 0.75 mile in length.

TABLE 28. *Average acreages of wetlands present and occupied by breeding pairs and broods, SWSA, 1973-75.*

	1973			1974			1975			Avg.		
	Total	Occupied by		Total	Occupied by		Total	Occupied by		Total	Occupied by	
Wetland Type	Present	Pairs	Broods	Present	Pairs	Broods	Present	Pairs	Broods	Present	Pairs	Broods
I	2.2	3.3	5.4	3.0	6.7	4.6*	1.3	2.6	2.3*	2.2	4.2	4.1
II	20.0	22.5	24.1	16.6	15.3	34.6	20.6	26.0	68.6	19.1	21.3	42.4
III	13.2	18.2	14.1	14.2	18.3	6.2	14.5	18.0	17.0	14.0	18.2	12.4
IV	43.8	43.8	43.8	43.8	43.8	57.7	43.8	57.7	57.7	43.8	48.4	53.1
V												
Ponds	0.5	0.4	0.3	0.8	0.8	2.3	0.8	1.6	5.3	0.7	0.9	2.6
VI	35.3	23.7	23.8	45.2	13.0	—	40.1	32.0	—	40.2	22.9	—

*1 wetland only having duck broods.

(Table 28). In most cases the larger areas were also some of the more permanent Type III's on the study area.

Two Type III wetlands were sampled on the same morning in May 1975. One was occupied by pairs of ducks, the other was unoccupied. The unoccupied wetland had more than 10 times more invertebrates in its surface waters than did the occupied wetland and 3 times more seeds on its bottom (Table 29). Food supply was apparently not the major factor affecting use by breeding pairs.

The use of Type II wetlands also declined from 1973 (52.7%) to 1975 (34.5%) (Table 31). In 1973 and 1974, 25.5% and 10.9% of the unoccupied Type II's were not dry or vegetation choked, but were still not utilized by breeding pairs. By 1975, however, areas not occupied in 1974 were all dry, indicating these were probably of marginal value to pairs in 1974 due to their poorer water conditions. It appears that, as suggested for Type I wetlands, Type II wetlands provided more feeding area than was required in 1973. Also due to the temporary nature of Type II wetlands, only a few of the Type II's that originally held pairs remained suitable pair habitat throughout the entire 1973 breeding season. The average size of both occupied and unoccupied Type II wetlands were very similar, indicating no size preference by pairs (Table 28).

The occupancy of dug ponds was very high during all 3 yr, averaging 78.6%. The lowest occupancy was in 1975 which was also the year with the lowest breeding population of ducks.

Type VI wetlands (shrub carr) were the least used by pairs (5.5% occupancy) of all wetland types available (Table 27). Shrub cover dominated these areas. Openings occurred most often as ditches, cattail clumps, or sedge openings. Most of these openings were choked with emergent vegetation, severely limiting their use by breeding pairs.

Streams and ditches were also heavily utilized by breeding pairs. Occupancy ranged from 54.0% to 73.0% of the stream segments studied, and 59.1% to 81.8% of the ditch segments. Again, the highest use of ditches was during the 1973 breeding season when higher populations were present and all wetlands were at optimum water levels.

Occupancy rates for mallards can be compared to areas outside Wisconsin on a mallards-per-May-pond basis (Table 32). It must be realized that such a comparison does not take into consideration the proportion and suitability of the various wetland types. Table 32 does, however, seem to indicate that strictly on a numerical basis, Wisconsin wetlands attract as many

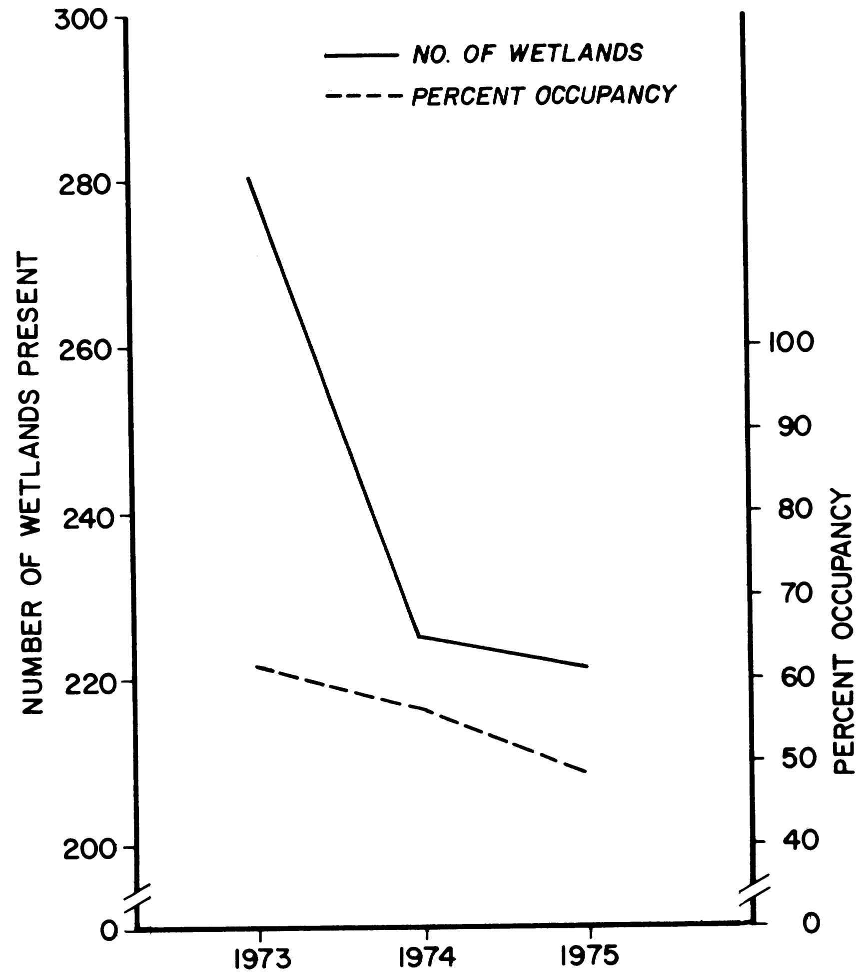


FIGURE 6. *Relationship between total wetlands present on the random 1/4-section study blocks and the percent occupancy of these wetlands, SWSA, 1973-75.*

TABLE 29. *Average invertebrate and seed availability on occupied and unoccupied wetlands, SWSA, May 1975.*

Wetland Type and Occupancy		Net Sample (no./cu m)		Bottom Sample (no./sq m)	
		Invertebrates	Seeds	Invertebrates	Seeds
Type I					
Occupied	(3)	<100	2100	5100	193900
Unoccupied	(3)	25200	1000	4100	168000
Type III					
Occupied	(1)	2200	<100	0	53400
Unoccupied	(1)	27800	700	3600	150700

TABLE 30. *Percent of Type III wetlands used by duck pairs and the percent unoccupied because of adverse habitat, SWSA, 1973-75.*

Wetland Occupancy and Conditions	1973	1974	1975	Avg.	At least 1 of 3 Years
Occupied	75.0 (18)*	58.3 (14)	50.0 (12)	61.1	75.0
Unoccupied	25.0 (6)	41.7 (10)	50.0 (12)	38.9	25.0
Dry	4.2 (1)	16.7 (4)	45.8 (11)	22.2	
Vegetation Choked**	20.8 (5)	25.0 (6)	4.2 (1)	16.7	

*Number of wetlands.

**Solid stands of cattail with no openings.

TABLE 31. *Percent of Type II wetlands used by duck pairs and the percent unoccupied because of adverse habitat, SWSA, 1973-75.*

Wetland Occupancy and Conditions	1973	1974	1975	Avg.	At least 1 of 3 Years
Occupied	52.7 (29)	34.5 (19)	34.5 (19)	40.6	61.8
Unoccupied	47.3 (26)	65.5 (36)	65.5 (36)	59.4	38.2
Dry	10.9 (6)	49.1 (27)	65.5 (36)	41.8	
Vegetation Choked	10.9 (6)	5.5 (3)	0.0 (0)	5.5	
Unknown	25.5 (14)	10.9 (6)	0.0 (0)	12.0	

TABLE 32. *Mallard pairs per pond on the SWSA compared with the parklands and prairies of Canada and the north central United States.*

Area	Years	Avg. Mallard pairs/pond	Author
SE Wisconsin	1973-75	0.49	this study
Parklands			
Redvers, Sask.	1952-66	0.43	Stoudt unpublished (cited by Dzubin 1969)*
Lousana, Alb.	1952-66	0.82	Smith unpublished (cited by Dzubin 1969)
Southey, Sask.	1952-54	0.18	Leitch unpublished, Sterling unpublished (cited by Dzubin 1969)
Prairies			
South Dakota	1951-53	0.33	Stoudt unpublished (cited by Dzubin 1969)
North Dakota	1951-53	0.35	Stoudt unpublished (cited by Dzubin 1969)
Caron, Sask.	1950-55	0.51	Leitch unpublished (cited by Dzubin 1969)
Success, Sask.	1955	0.69	Reeves et al. unpublished (cited by Dzubin 1969)
Kindersly, Sask.	1952	1.10	Gollop unpublished (cited by Dzubin 1969)

*Citations by Dzubin gained by him through permission of original authors to cite unpublished data.

TABLE 33. *The percent of wetlands on the SWSA occupied in mid-May as determined by helicopter surveys, 1973-75.*

	Wetland Type									
					V					
Year	I	II	III	IV	Ponds	Lakes	VI	Streams	Ditches	All
1973	14.6	17.3*	38.6	45.8	32.6	71.4	— *	24.8	16.4	21.1
1974	8.3	22.7	38.0	61.5	18.9	100.0	17.6	15.4	17.8	16.9
1975	18.8	20.6	35.9	71.4	22.5	57.1	13.3	15.5	13.0	19.0
Avg.	13.9	21.7**	37.5	59.6	24.7	76.2	15.5**	18.6	15.7	18.9

*Types II and VI were combined in 1973 as Type II.

**Averages for Types II and VI are only from 1974 and 1975 data.

TABLE 34. *The percent of wetlands occupied in SE/Central Wisconsin as determined by statewide fixed-wing surveys, 1973-75.**

	Wetland Type								
Year	I	II	III	IV	V	VI	Stream	Ditch	All
1973	11.4	7.6	12.0	38.9	18.2	0.0	9.6	10.8	11.5
1974	24.5	16.5	22.7	50.0	37.4	0.0	9.0	15.7	21.8
1975	21.9	13.2	19.5	50.0	29.5	0.0	6.6	14.1	22.0
Avg.	19.3	12.4	18.1	46.3	28.4	0.0	8.4	13.5	18.4

*Data from statewide aerial survey file (unpublished) DNR - Horicon.

mallards per pond as several of the well-known Canadian parkland and prairie breeding grounds.

Observed occupancy was determined by helicopter surveys (Table 33) and fixed-wing surveys (Table 34) for the SWSA and SE/Central Wisconsin, respectively, during 1973-75. Although the SWSA only takes in a portion of SE/Central Wisconsin, both surveys covered similar wetland habitat within southeastern Wisconsin. Both aerial methods produced results showing overall wetland occupancy by pairs to be in the neighborhood of 18-19% or only 1/3 the rate found by ground beat-outs (Table 27). This great difference can largely be attributed to the difficulty in spotting blue-winged teal from the air. Ground searches of the aerial transects indicate average 1973-75 visibility rates for blue-winged teal were 43% for helicopter surveys (SWSA) and 28% for fixed-wing surveys (Haug and Libby, 1973, 1974, 1975 unpublished, DNR Files, Horicon). Average visibility rates for mallards were essentially the same for helicopter surveys (82%) as for fixed-wing surveys (79%). Although the helicopter survey was twice as efficient at spotting teal, neither aerial survey gave an accurate estimate of wetland occupancy when only 1/2 or less of all teal present were seen from the air.

Helicopter surveys over-estimated the densities of SWSA wetlands. This method indicated 3 times the number of wetlands (Table 35) actually mapped during random plot censuses on the ground (Table 15). Problems with recounting streams, ditches, and different parts of the same wetland may account for part of the discrepancies between wetland density estimates derived from aerial surveys and "true" counts made on the ground. Recounting may only explain a small part of the problem since easily recognized Type III and IV wetlands alone appear 3 times as abundant on aerial surveys as the actual number mapped on the ground.

Statewide fixed-wing surveys of SE/Central Wisconsin indicated twice the density of wetlands in that region compared to the random plot censuses on the SWSA (Table 36).

The over-estimation of wetland density accounts in part for the low wetland occupancy rates attained by aerial surveys.

The combination of the over-estimation of the number of wetlands plus seeing less than 1/2 of the blue-winged teal (the most abundant breeder) makes aerial occupancy estimates of little value when determining the "true" occupancy rate. However, such estimates may be useful as an index to year-to-year changes in bird distribution between wetland types.

Brood Occupancy

Estimates of duck brood usage of the various wetland types on the SWSA are reported in Table 37. It is important to note that all available wetland types were used by broods with the exception that Type VI wetlands were utilized only during 1973 and then not by either mallards or teal. Type I wetlands which are usually poor brood habitat were used the most in 1973. Streams were also utilized by broods to a greater extent in 1973. Increased use of both the least permanent (Type I's) and the most permanent wetland types (streams) resulted from a combination of better overall water availability (as related to better brood survival) and increased blue-winged teal populations in 1973. A greater percentage of the blue-winged teal pairs were successful at producing a brood in 1973 (53%) than in the following 2 yr (20-21%), increasing the number of broods available to occupy all types of wetlands (Table 9).

Lakes and Type IV wetlands were clearly the most heavily utilized by broods followed by Type II wetlands, streams, dug ponds, ditches, Type I and II wetlands, and Type VI wetlands. The average occupancy rate of all types of wetlands by all species of duck broods equalled 18.6%

Species preferences for certain wetlands as brood habitat were not easily identified from the data since teal were always at least twice as abundant as mallards. In both 1974 and 1975, mallard broods were observed to use streams and ditches more heavily than blue-winged teal. Only in 1975 did mallards utilize Type II and Type III wetlands to a greater extent than bluewings (Table 37). This was due in part to a severe decline in blue-wing broods, from 3.44/sq mile in 1973 to 0.82/sq mile in 1975 (Table 9).

TABLE 35. *Wetlands per square mile as determined by May helicopter surveys of the SWSA, 1973-75.*

	Wetland Type							
Year	I	II & VI	III	IV	V	Streams	Ditches	Total
1973	7.3	2.3	2.2	0.3	1.1	1.4	2.8	17.6
1974	6.3	3.2	0.9	0.2	0.9	1.4	4.1	17.0
1975	1.1	2.9	1.0	0.1	1.0	1.2	4.4	11.7
Avg.	5.0	2.8	1.4	0.2	1.0	1.3	3.8	15.4

TABLE 36. *Wetlands per square mile in SE/Central Wisconsin as determined by statewide fixed-wing surveys, 1973-75.**

	Wetland Type						
Year	I, II, VI	III	IV-V	VII-VIII	Streams	Ditches	Total
1973	5.6	1.1	1.4	0.7	1.4	0.9	11.1
1974	3.0	0.9	1.7	0.5	1.2	1.5	8.8
1975	3.4	1.1	1.7	0.7	1.2	1.9	10.1
Avg.	4.0	1.04	1.62	0.67	1.29	1.44	10.0

*Data from Haug and Moss 1977.

TABLE 37. *Observed duck brood use of SWSA wetlands, 1973-75.**

		Percent Utilized by Broods											
		1973			1974			1975			Avg.		
Wetland Type	No. Studied	Mall.	BW Teal	All Species	Mall.	BW Teal	All Species	Mall.	BW Teal	All Species	Mall.	BW Teal	All Species
I	72**,17,13	6.9	11.1	13.8	5.9	5.9	5.9	0.0	7.7	7.7	4.2	8.2	9.1
II	55	1.8	9.1	9.1	0.0	12.7	12.7	3.6	1.8	5.5	1.8	7.9	9.1
III	24	12.5	25.0	33.3	12.5	29.2	33.3	25.0	20.8	29.2	16.7	25.0	31.9
IV	4	50.0	100.0	100.0	50.0	50.0	100.0	25.0	50.0	75.0	41.7	66.7	91.7
V													
Dug Ponds	28	7.1	25.0	25.0	10.7	21.4	25.0	3.6	7.1	10.7	7.1	17.8	20.2
Lakes	4	75.0	100.0	100.0	75.0	75.0	100.0	75.0	100.0	100.0	75.0	91.7	100.0
VI	12	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8
Streams	37***	16.2	35.1	43.2	16.2	0.0	16.2	10.8	8.1	13.5	14.4	14.4	24.3
Ditches	44***	4.5	11.4	13.6	11.4	9.1	15.9	13.6	6.8	13.6	9.8	9.1	14.4
Total	280**,225,221	8.6	18.6	21.8	10.2	13.3	19.6	10.4	9.5	14.5	9.7	13.8	18.6

*Occupancy as determined during random plot censuses (June-August).

**Number present in 1973, 1974, and 1975, respectively.

***Numbers represent only the number of segments present on random plots. Segments surveyed varied from 0.25 to 0.75 mile in length.

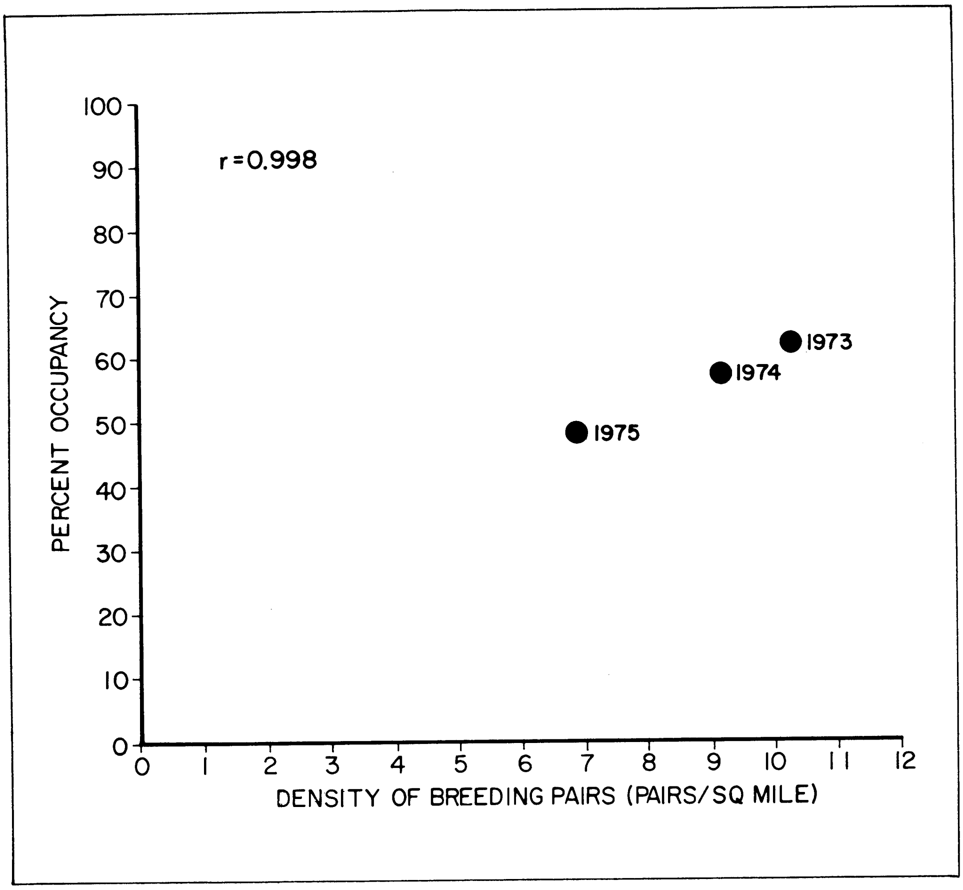


FIGURE 7. *Relationship between the annual breeding pair densities of all species of ducks and the annual occupancy of all wetland types by breeding pairs, SWSA, 1973-75.*

Wetland Utilization Relationships

Relationships between pair densities and the occupancy rates of all wetland types and between pair densities and the occupancy rates of each individual wetland type were tested for significance using standard linear correlation analyses (Snedecor and Cochran 1974). The use of only three data points (3 yr) allows only 1 degree of freedom (n = 2) and a very large standard error of regression. In order for correlations to be significant, correlation coefficients must be ≥ 0.97 for P = 0.05 and ≥ 0.975 for P = 0.10.

The small number of points can also result in confidence limits about the correlation coefficients that become very broad, making the validity of relationships suggested by these coefficients questionable.

Annual occupancy of all wetland types combined was significantly correlated at P = 0.05 with the annual breeding pair densities of all species combined (Fig. 7). This correlation, although weak due to sample size, seems to indicate that occupancy of SWSA wetlands increased as the number of pairs attracted to the study area increased. This is supported by the fact that more marginal habitats such as dug ponds and streams received greater use in wet years when larger numbers of breeding pairs were attracted to the study area. March et al. (1973) found the same correlation between occupancy of wetlands and breeding pair densities.

No significant relationships ($P \leq 0.05$) were found between breeding pair densities and occupancy of wetlands of individual Types I, II, III, VI, dug ponds, streams, and ditches (Appendix B).

On the SWSA, water fertility and food resources seemed to vary from wetland to wetland, but all its wetlands apparently had adequate food supplies to support waterfowl. More intensive studies of specific wetland types with pairing of wetlands of similar size, vegetation, and water depths, would be required to determine if pair or brood densities are more directly related to food resources. Preliminary results suggest that Type IV wetlands on the SWSA contained as much as 8 times and 100 times more invertebrates by volume, in surface waters and bottom materials, respectively, than wetlands on the more northerly located Sandhill Wildlife Area (Eric Nelson pers. comm.). Additional comparisons of this type are also needed to indicate any relationships between food resources and breeding duck densities in other regions of Wisconsin.

Water supplies, dictated by annual precipitation, and the resulting presence or absence of adequate water for breeding pairs and broods stood out as the number one determining factor in wetland utilization within the Scattered Wetlands Study Area.

FEEDING ECOLOGY OF BREEDING DUCKS AND BROODS

In this study, the food habits of blue-winged teal and mallards were studied in an attempt to determine if locally breeding waterfowl were being selective of their foods to the point of: (1) utilizing specific foods in higher proportions than they occurred in the environment; and (2) selecting certain wetlands or wetland types in response to the availability of certain foods. Little has been published on food habits of waterfowl in Wisconsin, particularly the food habits of breeding ducks. Early food habits studies (Stollberg 1950; Zimmerman 1953) concentrated on fall-shot birds and used the gizzard contents in their analyses. Only the esophagus or esophagus-proventriculus contents are presented here to avoid over-emphasis of the hard seed portion of the diet which results when gizzard contents are used (Dirschl 1969; Perret 1962; Bartonek and Hickey 1969; Swanson and Bartonek 1970).

Foods of Breeding Blue-winged Teal

Blue-winged teal were collected on all wetland types. Early attempts at collecting strictly on the random plots found that pair densities were too low to obtain adequate samples of birds. As a result, collecting was done over the whole of the study area. Even use of the entire SWSA, when plagued by problems with wetland access and the use of firearms in heavily populated areas, produced only small samples. However, these samples are felt to adequately indicate food preferences and provide insight into the available and utilized foods on the major types of available SWSA feeding sites.

Although contents of the esophagus, proventriculus, and gizzard were removed from feeding ducks collected for food samples, only esophagus or esophagus-proventriculus data are presented. This avoids over-emphasis of the hard seed portion of the diet which results when food analyses are based on gizzard contents.

Net samples of invertebrates revealed biomass estimates ranging from 5.5 ml/cu m to 39.9 ml/cu m.

Blue-winged teal diets varied considerably in the percent of animal materials consumed by prelaying and laying females. Prelaying females consumed 58.7% animal foods and 41.3% plant foods. Laying hens consumed 92.8% animal foods and 7.2% plant foods (Appendix Table C-1). The differences can, in part, be explained by examining the areas utilized for feeding sites during the prelaying and laying peaks. Most feeding early in the breeding season focused on flooded corn fields and reed canary grass *(Phalaris arundinacea)* bottoms. These areas provided easy access to seeds over very extensive acreages. By the time laying began, areas with readily available seed sources were dry and the birds shifted to the Type III, IV, and V wetlands where depth on all but the edges would prevent bottom feeding to any extent. Net samples indicated these areas contained a much larger biomass of invertebrates than the flooded Type I wetlands (Tables 23 and 25). Krapu (1974) found pintail hens also switched to a higher proportion of animal foods in their diet as they began laying. He also noted an increased consumption of dipterans that corresponded to the drying of temporary ponds, forcing feeding hens to use seasonal and permanent wetlands. Gadwall hen diets showed similar increased proportions of animal foods during laying (Serie and Swanson 1976).

Males taken throughout the spring and post-laying females had diets consisting of 95.3% and 99.9% animal materials, respectively (Appendix Table C-1). Serie and Swanson (1976) also found only slight differences in the proportions of plant and animal foods consumed by male and female breeding gadwalls.

Further comparisons of diet may be made by examining separate order and family categories in Appendix Table C-1. Student's t-tests of arcsin transformed percent by volume data were used to compare diets of prelaying hens, laying hens, and breeding males. These t-tests were run only for the phylum Mollusca, classes Crustacea and Insecta, order Diptera, and total seeds. Statistically significant differences ($P \leq 0.05$) were detected only between the diets of prelaying and laying hens. The diets of laying hens contained significantly greater amounts of insects (specifically dipterans) than diets of prelaying hens.

The calculated proportions of major food categories in the diet of breeding blue-winged teal are presented graphically in Figure 8.

All four categories of breeding teal utilized insects and molluscs heavily. Seeds were utilized in the greatest proportion (33%) by prelaying hens that fed in flooded cultivated fields, pastures, river bottoms and hayfields early in the breeding season. These areas were dry by the time laying began. The most obvious and statistically significant shift in diet occurred when laying hens relied heavily on dipterans for their diet (62%) (Appendix Table C-1). Heavy utilization of insects by dabbling ducks during the laying period has previously been reported for blue-winged teal (Swanson et al. 1974), pintails (Krapu 1974), and gadwalls (Serie and Swanson 1976).

Foods eaten by breeding teal in relation to foods available are examined in Appendix Tables C-2 through C-4. Net sweep samples from the surface area (first 15.2 cm of depth) and bottom samples were used to identify the relative abundance of available foods in each zone, following quite closely the methods of previous authors (Bartonek and Hickey 1969; Sugden 1973).

Selectivity by feeding waterfowl has been described as the point at which a food item appears as a greater proportion of the diet than the proportion this food item constitutes of available foods (Bartonek and Hickey 1969; Sugden 1973; Serie and Swanson 1976).

Prelaying blue-winged teal consumed 43 different types of food out of a possible 69 found in bottom and net samples (Appendix Table C-2). The importance of using several techniques for appraising food item occurrence is shown by the fact that 15 of the 43 consumed food items (35%) occurred only in bottom samples and 3 occurred only in net samples with 25 occurring in both. In the case of prelaying teal, use of only net samples to estimate environmentally available foods would have resulted in missing an estimation of the availability of components that

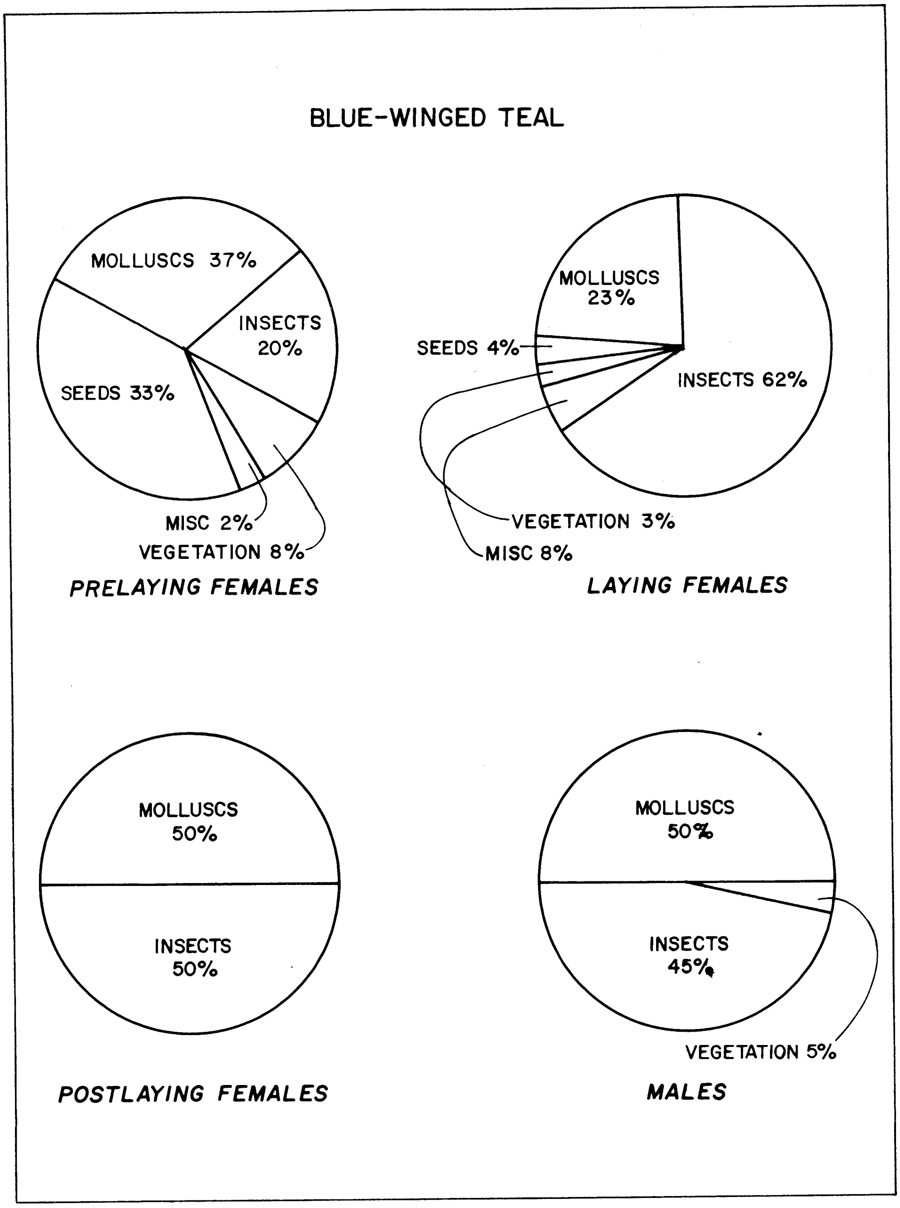


FIGURE 8. *Proportion by volume of major foods consumed by breeding blue-winged teal on the SWSA, 1973-75.*

made up over 18% of the diet. These items were mainly seeds and several families of insects. All sources of food should be sampled and a combination of methods used (i.e., net samples, bottom samples, vegetation samples, and perhaps even traps for emerging terrestrial insects) when attempting to quantify available foods.

Paired t-tests of major categories of foods indicated that consumption of molluscs, insects and dipterans was in proportions similar to that available (Appendix Table C-2). Crustaceans were taken in proportions significantly less than indicated by availability, suggesting either rejection or non-availability due to small size. When seed use by teal was compared with net sample results, a significant positive selection was indicated. However, when esophagus contents were compared with bottom availability, prelaying teal were only utilizing seeds in proportion to their availability. Again, this points out the need for bottom sampling when determining selectivity. Overall, prelaying blue-winged teal hens appeared to be consuming foods in proportions similar to those available in their environment.

Similar t-tests of foods eaten by laying hens indicated hens utilized molluscs, crustaceans, and seeds in proportions similar to their availability (Appendix Table C-3). Conversely, hens were highly selective of insects, taking them in significantly higher proportions than found in the environment. As with prelaying hens, copepods and cladocerans were not utilized, indicating they are probably too small to be eaten. Swanson et al. (1974) indicated the spacings of a teal's bill lamellae would prohibit utilization of foods smaller than 1.5 mm, eliminating all but the largest crustaceans from the diet of blue-winged teal.

No comparisons were made among the small sample of food items eaten by postlaying hens.

Male blue-winged teal also utilized molluscs, insects, and seeds in proportions that were not significantly different from their availability (Appendix Table C-4). A direct comparison of the percent insects and percent dipterans seems to indicate selection for insects. However, variability among esophagus contents from individual birds sampled resulted in loss of statistical inference at an acceptable level of significance.

Foods of Breeding Mallards

Mallards were collected throughout the study but only 4 laying hens and 3 prelaying hens were obtained. Although all birds were collected while actively feeding, the esophagi of the 3 prelaying hens were nearly empty. However, their proventriculi contained adequate samples of both hard and soft food items. The prelaying food items are therefore presented as a combination of esophagus and proventriculus (gullet) contents. Small sample sizes and the use of proventriculus contents prevented any statistical comparisons between prelaying and postlaying data. The data presented in Appendix Table C-5 do, however, indicate food sources utilized by breeding mallards.

Mallards collected during this study ate a less varied diet than blue-winged teal. Breeding mallards consumed 24 types of foods while prelaying bluewings alone utilized 43 different types (Appendix Table C-5). Prelaying mallards consumed 25% animal and 75% vegetable materials, while laying mallards utilized 48% animal and 52% vegetable materials. Again it should be noted that the prelaying (proventriculus) data are not directly comparable with the laying (esophagus) data. Seeds and insects were the two major sources of food for prelaying mallards while seeds, annelids, and molluscs were heavily utilized by laying hens (Fig. 9). Due to the early start of nesting by SWSA mallards, the more ephemeral wetlands (i.e., temporarily flooded fields and bottoms) were still available as feeding sites well into the nesting season. All of the mallards collected were feeding either in temporarily flooded crop fields which provided weed seeds and earthworms, or in bottom lands which provided grass seeds and molluscs.

Prelaying mallards fed on molluscs, insects, and seeds in proportions not statistically different from proportions of the same foods found in net and bottom samples (Appendix Table C-6). The proportion of seeds in samples was different from the proportion of seeds utilized at $P \leq 0.10$ for net samples but not for bottom samples. In these shallow, temporary waters where birds could easily feed on the bottom, a comparison of availability of seeds from bottom samples would be most realistic. On that bases prelaying hens were feeding on foods in relation to their availability and were not being selective. Seeds (75%) and insects (19%) were the two food sources most heavily utilized. Barnyard grass *(Echinochloa pungens)* was the most important food from flooded upland sites, while rice cut grass *(Leersia oryzoides)* was the more important seed source in flooded bottoms.

The diets of laying mallard hens were heavily dependent on seeds (52%), molluscs (19%), and annelids (24%) (Appendix Table C-7). Insects contributed less than 1% to the diets, even though net and bottom samples indicated insects were readily available. Crustaceans represented 6% of the diet. Crustaceans eaten were only the larger isopods (sowbugs) and amphipods (scuds). The more numerous but much smaller copopods and cladocerans were apparently too small to be utilized by the mallard. Paired t-tests of the data on molluscs, crustaceans, annelids, insects, and seeds detected no significant differences between the proportions eaten and the proportions available. Apparently laying mallards were not being selective but fed on these foods according to their availability.

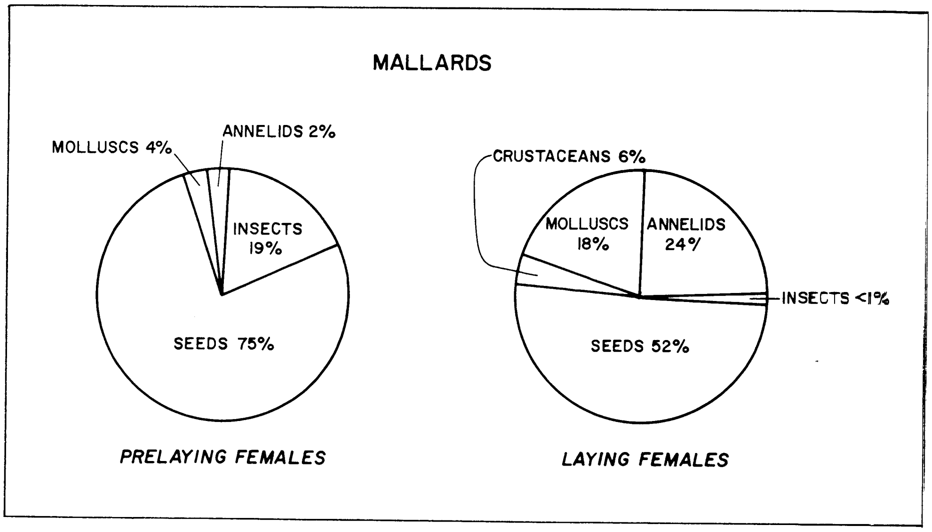
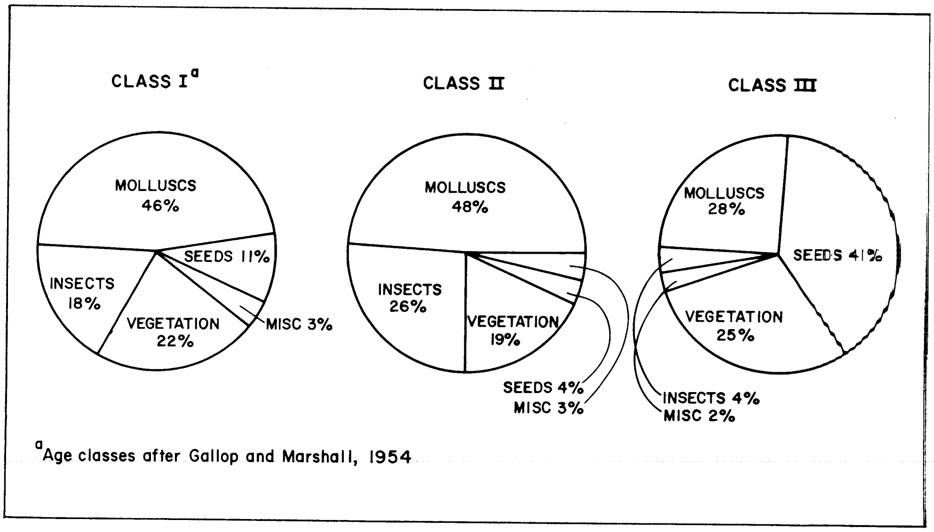


FIGURE 9. *Proportion by volume of major foods consumed by breeding mallards on the SWSA, 1973-75.*



^{a}Age classes after Gallop and Marshall, 1954

FIGURE 10. *Proportion by volume of major foods consumed by blue-winged teal ducklings on the SWSA, 1973-75.*

Foods of Blue-winged Teal Ducklings

Blue-winged teal ducklings were collected on the SWSA during 1973-75. Esophagus contents were identified and results were combined for age classes I, II, and III.

Molluscs were found to be a major portion of the diet of all age classes of blue-winged teal ducklings (Fig. 10). Leafy vegetation remained important to developing ducklings, but the amount of insects consumed seemed to decline as they reached Class III. Use of seeds increased when Class III ducklings began feeding on the new seeds of pondweeds (*Potamogeton* spp.) (Appendix Table C-8).

The diets of Class I and Class II ducklings were quite similar (Appendix Table C-8). Paired t-tests for molluscs, crustaceans, insects, seeds, and vegetation indicated no significant differences in diet. The Class III duckling diet was significantly lower in insects. Although the aggregate percents by volume of seeds in Class II and Class III duckling diets differed by 36.8%, the difference was not significant at $P \leq 0.05$.

The diets of all three classes of ducklings were compared to samples taken from their feeding sites to determine if ducklings were selectively feeding on certain foods and rejecting others (Appendix Tables C9-C11). Although bottom samples are included, there were only a few wetlands on which ducklings could have reached bottom materials.

Class I blue-winged teal ducklings fed on molluscs in significantly higher proportions than those occurring in either net ($P = 0.05$) or bottom samples ($P = 0.01$) (Appendix Table C-9). Crustaceans and insects were eaten in proportions similar to those available. The seed proportion in the diet, although significantly different than the seed proportion in bottom samples, closely approximated the proportions found in net samples. Again, the net samples are thought to be the best comparison due to the deeper waters of brood ponds and the corresponding depth of collection sites (1-3 ft). Leafy vegetation, which was superabundant by the time broods appeared, was utilized in proportions much smaller than its availability. This indicated a significant rejection (P = 0.05) of leafy vegetation by Class I ducklings.

Class II blue-winged teal ducklings selected for molluscs in their diets; the difference between the proportions of molluscs in diets and net samples was significant at P = 0.01 (Appendix Table C-10). Crustaceans, insects, and seeds were taken in proportions similar to those found in net and bottom samples. Net samples indicated much larger available proportions of vegetation than were utilized.

Class III blue-winged teal took molluscs, crustaceans, insects, and seeds in proportion to their availability (Appendix Table C-11). They did, however, consume vegetation in proportions significantly smaller than those available. *Polygonum* spp. and *Potamogeton* spp. seeds were utilized by Class III ducklings, but Class II ducklings did not eat these seeds even though they were also available to them.

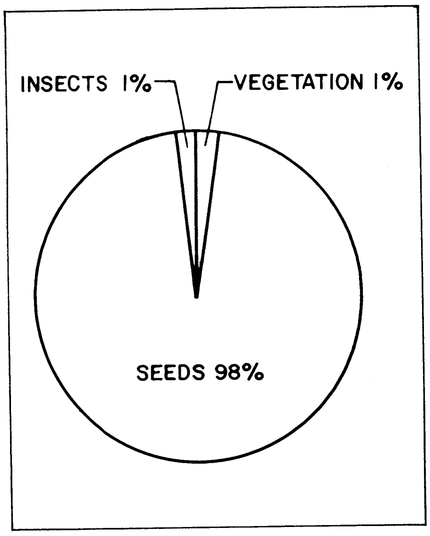


FIGURE 11. *Proportion by volume of major foods consumed by Class I mallard ducklings on the SWSA, 1973-75.*

Foods of Mallard Ducklings

Only 3 Class Ia mallard ducklings (all from one brood) were collected during the study. Little can be inferred from such a small sample, but the foods found in esophagus samples were quite different than expected. All 3 ducklings were eating primarily seeds and vegetation (Appendix Table C-12). Previous studies of mallard ducklings (Chura 1961) and pintail and gadwall ducklings (Sugden 1973) have shown Class Ia ducklings to feed almost exclusively on animal foods. Although Chura (1961) used numbers of items present rather than aggregate percent by volume, his method also indicated that mallards did not rely heavily on seeds until they reached Class IIb size. Only one SWSA duckling had ingested any insects. All of them had been eating pondweed seeds. Two had eaten *Lemna trisulca.* Reed canary grass seed *(Phalaris arundinacea)* and smartweed *(Polygonum lapathifolium)* were also utilized. In total, the aggregate percent by volume of the diets of these ducklings was 98% seeds, 1% vegetation, and 1% insects (Fig. 11).

Net samples taken at feeding sites indicated that although a wide variety of both plant and animal foods were present, *Potamogeton* seeds and *Lemna minor* were by far the most abundant of all available foods (Appendix Table C-12). Mallards were obviously utilizing the seeds in relation to their relative abundance. Insects also appeared to have been utilized in proportions quite similar to their proportions in net samples. These ducklings were late hatched. Collection of earlier hatched ducklings when new seed would not have been available could possibly have resulted in a quite different food consumption pattern.

SUMMARY and FUTURE CONSIDERATIONS

SURVEY METHODS

1. Helicopter surveys were only 1/3 as costly as random plot censuses, yet both produced similar estimates of breeding pair densities and indicated the same population trends.

2. Both survey methods should be initiated after 1 May to avoid migrant mallards and blue-winged teal.

3. Random plot censuses provided the best estimates of wetland occupancy. Helicopter surveys underestimated occupancy by 40-50% on Type III and IV wetlands and by as much as 75% on the small dug ponds. Fixed-wing surveys may underestimate occupancy of Type III wetlands by as much as 66%, and Type IV occupancy by 50%.

4. The random plot census method also provided the best estimates of wetland densities. Helicopter surveys produced estimates that were 3 times greater than the actual densities mapped on the ground, even for Type III and IV wetlands which had well-defined boundaries.

5. Land use changes and wetland losses can be accurately measured only by ground surveys.

WETLAND USE AND CHARACTERISTICS

1. Use of all of wetland types by breeding pairs was much higher (56%) than previously estimated for SE/Central Wisconsin.

2. Sixty-one percent of all Type III wetlands and 100% of all Type IV wetlands were utilized by breeding pairs.

3. Approximately half of the unoccupied Type III wetlands were dry and the other half were cattail-choked, leaving no openings for pairs or broods. These factors eliminated pair and brood use so completely from the unoccupied Type III wetlands that the food resources and other characteristics had little potential effect.

4. A minimum of 32% of all Type III wetlands, and 92% of all Type IV wetlands were occupied by broods.

5. With the exception of the very low total alkalinities of dug ponds, soil and water chemistry remained very similar between wetland types.

6. When considering the most heavily utilized invertebrates available in surface waters, Type I, III, IV and

VI wetlands, dug ponds, and ditches had very uniform available biomasses, at 2.0-3.7 ml/cu m.

7. Type I wetlands contained the highest seed biomass, and these seeds were heavily utilized by laying and prelaying mallards and prelaying blue-winged teal.

8. Future evaluations of potential brood or pair waters in SE/Central Wisconsin should be based on water permanence and cover dispersion, as fertility and food resources in most cases appear to be adequate to maintain production.

9. Future invertebrate and water sampling in other areas of the state is recommended so that results can be compared with waterfowl use and/or density, in order to determine the critical fertility and invertebrate densities required to maintain known pair densities or production.

Fertility and food resources appeared adequate on all areas studied. The yearly fluctuations in precipitation and the resulting presence or absence of water was apparently the major factor in determining which wetland types would be utilized by pairs and broods.

WETLAND LOSSES AND REPLACEMENT

1. Nine percent of the total wetlands were lost between 1973 and 1975.

2. Losses of wetland Types II, III, IV, and VI combined, equalled 8.3%/year or about 1 wetland/sq mile.

3. Creation of dug ponds has done little to replace these losses (ten 1-acre ponds were created).

4. Tiling of very small depressions in agricultural fields is continually reducing Type I feeding areas important to early breeding mallards and blue-winged teal.

5. Shallow depressions that constitute Type I wetland feeding areas are an integral part of wetland complexes and should be considered when buying wetland units.

PAIR DENSITIES AND PRODUCTION

1. Precipitation preceding the breeding seasons (prior 12 months) declined by 25% (11 in) from 1973 through 1975.

2. The number of pairs of all species per 100 acres declined 6% from 1973 through 1975.

3. Observed production declined 66%, or from 86 ducklings/100 acres of wetland in 1973 to 29 ducklings/100 acres of wetland in 1975.

4. The 1973-75 mallard pair densities remained constant at 2 pairs/sq mile.

5. Observed mallard production declined by 15% between 1973 and 1975.

6. Blue-winged teal pairs decreased (33%) from 6-7/sq mile in 1973 to 4-5/sq mile in 1975.

7. Observed production of blue-winged teal declined 75%, from 65 ducklings/100 acres of wetlands (1973) to 16 ducklings/100 acres of wetlands (1975).

8. Wetland abundance and permanency, as dictated by variations in precipitation, appears to be the major factor controlling waterfowl production on the SWSA.

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APPENDIXES

APPENDIX A: WETLAND CLASSIFICATION*

Type I — Seasonally flooded basins or flats

The soil is covered with water or is waterlogged during variable seasonal periods, but usually is well drained during the growing season. These areas seldom hold water long enough to establish wetland vegetation. These occur in both upland and lowland depressions during spring and other periods of heavy precipitation.

Type II — Inland fresh meadows

The soil is usually without standing water during most of the growing season, but is waterlogged. These are usually wet meadow areas in lowlands. The vegetation of these areas consists of sedges, grasses, and rushes.

Type III — Inland shallow fresh marshes

The soil is usually waterlogged during the growing season, often covered with as much as 6 in of water or more. These areas typically support marsh vegetation such as cattails, bulrushes, sedges, and arrowheads. These areas in southeastern Wisconsin have thick emergent cover with little open water.

Type IV — Inland deep fresh marshes

The soil is covered with 6 in to 3 ft or more of water during the growing season. Emergent vegetation includes cattails, burreeds, bulrushes, and wild rice. These areas in southeastern Wisconsin have large open water areas containing submergent and floating plants such as pondweeds, coontail, water milfoil and duckweeds.

Type V — Inland open fresh water

Lakes, man-made ponds, runoff ponds and reservoirs are all included in this type. These all have large open water areas with emergent vegetation limited to shallow water edges.

Type VI — Shrub swamps (shrub carr)

The soil is usually waterlogged during the growing season. Vegetation includes alders, willows, dogwoods, sedges, and grasses. Most of these areas in southeastern Wisconsin represent wet meadow areas (Type II) that through the lack of fires and grazing and partial drainage attempts are allowed to become invaded by shrubs.

*This classification follows that of Shaw and Fredine (1956) with slight modification to describe typical wetlands of these types in southeastern Wisconsin.

APPENDIX B: RELATIONSHIPS BETWEEN BREEDING PAIR DENSITIES AND OCCUPANCY OF INDIVIDUAL WETLAND TYPES

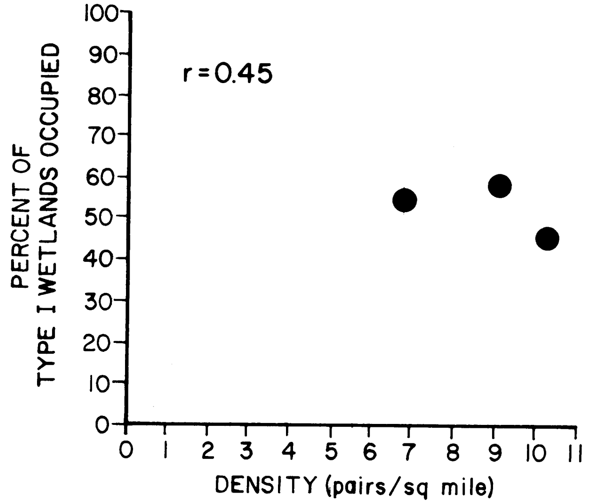

FIGURE B-1. *Relationship between the annual breeding pair densities of all species of ducks and the annual occupancy of Type I wetlands by breeding pairs, SWSA, 1973-75.*

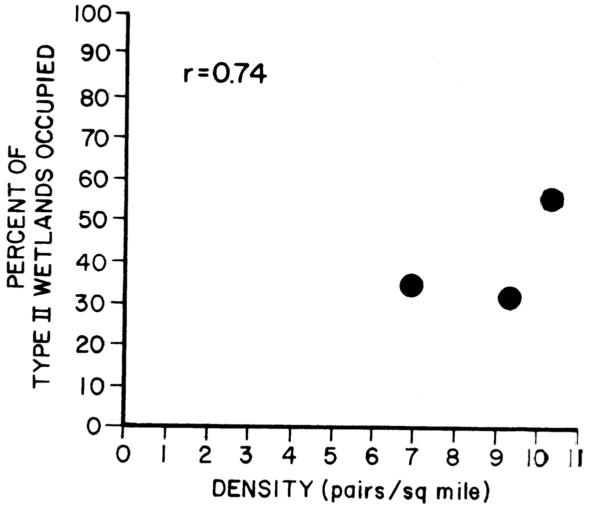

FIGURE B-2. *Relationship between the annual breeding pair densities of all species of ducks and the annual occupancy of Type II wetlands by breeding pairs, SWSA, 1973-5.*

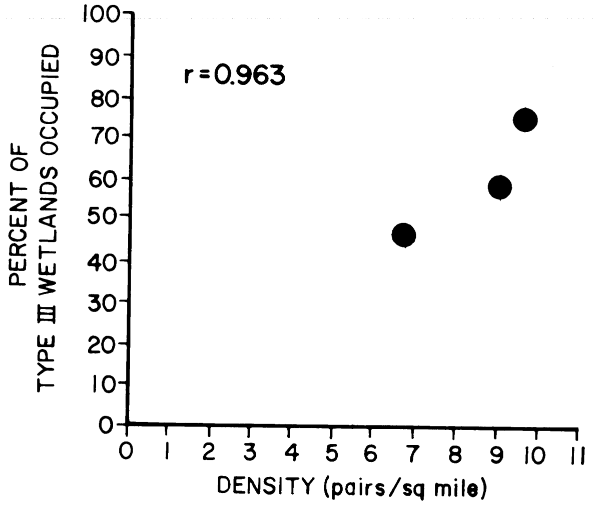

FIGURE B-3. *Relationship between the annual breeding pair densities of all species of ducks and the annual occupancy of Type III wetlands by breeding pairs, SWSA, 1973-75.*

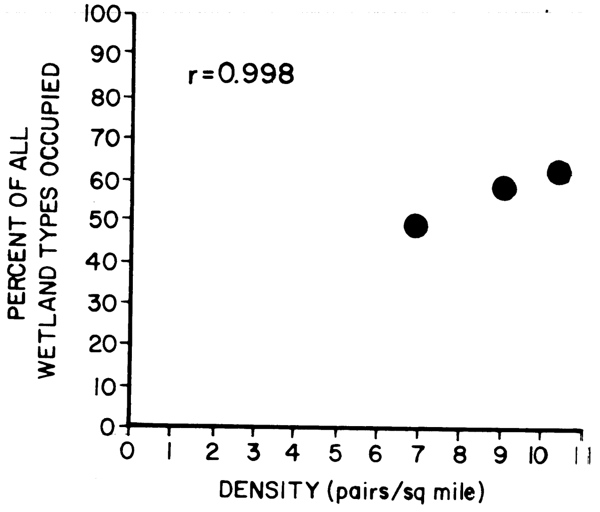

FIGURE B-4. *Relationship between the annual breeding pair densities of all species of ducks and the annual occupancy of all wetland types by breeding pairs, SWSA, 1973-75.*

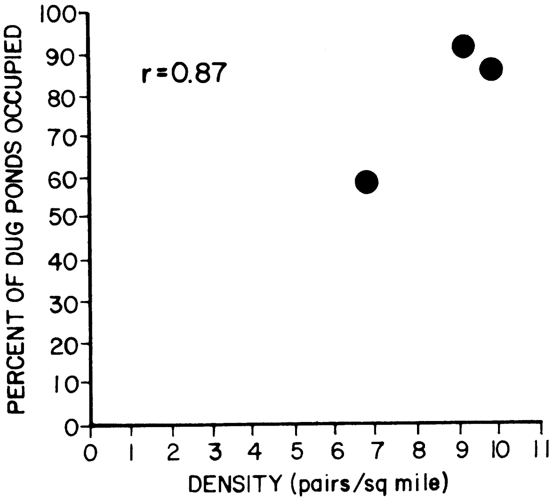

FIGURE B-5. *Relationship between the annual breeding pair densities of all species of ducks and the annual occupancy of dug ponds by breeding pairs, SWSA, 1973-75.*

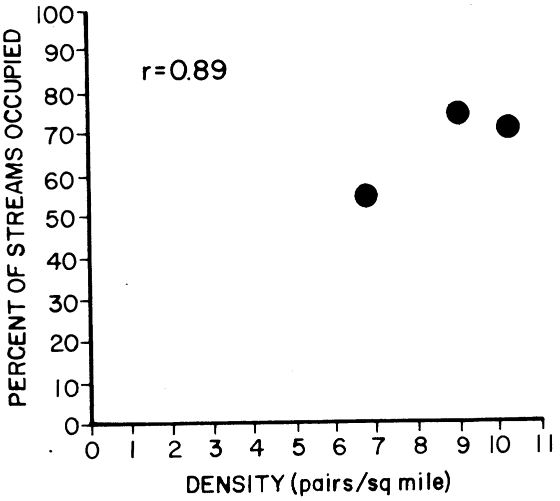

FIGURE B-6. *Relationship between the annual breeding pair densities of all species of ducks and the annual occupancy of streams by breeding pairs, SWSA, 1973-75.*

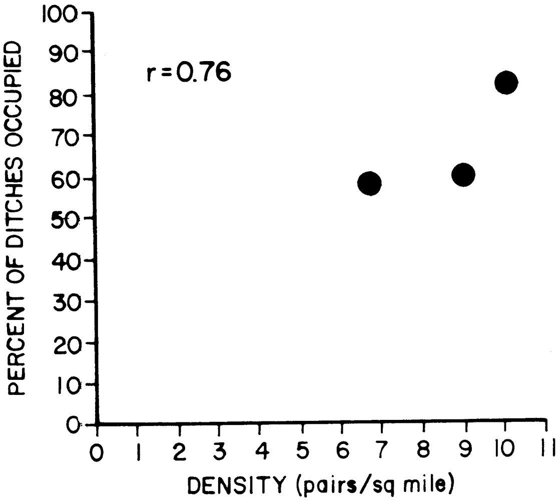

FIGURE B-7. *Relationship between the annual breeding pair densities of all species of ducks and the annual occupancy of ditches by breeding pairs, SWSA, 1973-75.*

APPENDIX C: ITEMIZATION OF FOOD ITEMS FOUND IN MALLARD AND BLUE-WINGED TEAL BREEDING ADULTS AND DUCKLINGS

TABLE C1. *Proportion by volume of foods in the esophagus of breeding blue-winged teal collected on the SWSA, 1973-75.*

		Aggregate Percent				
		Females				
Food Item	Common Name	Prelaying (11)	Laying (5)	Post-laying(2)	All (18)	Males (5)
ANIMALS						
Mollusca		36.6← (ns)[a] →	23.1	49.9	30.1	49.9(ns)[b]
Gastropoda	Snails	17.0	21.7	49.9	17.1	49.9
Lymnaeidae		10.6	7.7	49.9	8.9	20.7
Physidae		1.5	4.0		2.1	8.8
Planorbidae		4.9	10.0		6.1	20.4
Pelecypoda	Clams	19.6	1.4		13.0	
Sphaeriidae		19.6	1.4		13.0	
Annelida		1.3			0.9	
Oligochaeta	Segmented Worms	tr			tr	
Hirudinea	Leeches	1.2			0.8	
(cocoons)		tr				
Arthropoda						
Crustacea		0.6← (ns) →	8.1		3.5	
Branchiopoda						
Cladocera	Water Fleas				0.8	
(ephipia)	Winter Eggs	tr	2.6		0.8	
Ostracoda	Seed Shrimps		tr		tr	
Malacostraca						
Isopoda	Sowbugs	0.6	5.5		1.9	
Amphipoda	Scuds	tr	2.6		0.8	
Arachnida	Spiders	tr			tr	
Insecta		20.2← (0.05) →	61.6	50.0	36.1	45.4(ns)
Ephemeroptera	Mayflies	tr	tr		tr	
Baetidae		tr	tr		tr	
Odonata	Dragonflies, Damselflies	tr	5.0		1.5	
Agrionidae			2.6		0.8	
Coenagrionidae		tr	2.4		0.7	
Hemiptera	True Bugs	tr	0.7		tr	0.3
Belostomatidae		tr				
Pleidae			0.7		tr	
Lepidoptera	Moths	tr				
Trichoptera	Caddisflies				2.9	
Coleoptera	Beetles	3.0	12.1	50.0	11.4	
Chrysomelidae			3.2	18.8	3.1	
Coccinellidae				31.2	3.7	
Curculionidae		tr			tr	
Dytiscidae		tr	8.1		2.5	
Elmidae		tr			tr	
Haliplidae		2.0	0.7		1.5	
Hydrophilidae		0.7	tr			
Diptera	Flies	12.1← (0.05) →	40.3		19.2	45.1(ns)
Ceratopogonidae		3.8	9.6		5.1	7.0
Chironomidae		2.6	16.9		6.5	
Culicidae		1.6	tr		1.1	6.3
Ephydridae			9.3		2.7	
Stratiomyidae		0.7	3.3		1.1	31.8
Syrphidae		tr			tr	
Unidentified		3.4	1.1		2.5	
Total Animal		58.7	92.8	99.9	70.6	95.3
PLANTS						
Seeds		33.3← (ns) →	4.4		26.4	0.0
Alisma Plantago-aquatica	Water Plantain	tr	tr		tr	
Amaranthus spp.	Amaranths	tr	tr		tr	
Bidens spp.	Bur-marigolds	1.8			1.2	
Echinochloa pungens	Barnyard Grass	7.0			4.8	
Eleocharis palustris	Spike Rush	0.1	tr		tr	
Phalaris arundinacea	Reed Canary Grass	17.8	2.6		12.6	
Polygonum spp.	Smartweeds	3.2	0.6		5.2	
P. Hydropiper	Water Pepper	0.5			0.8	
P. hydropiperoides	Mild Water Pepper	2.6			0.5	
P. lapathifolium	Heartsease		tr		tr	
P. pensylvanicum	Pennsylvania Knotweed	4.6			3.8	

TABLE C1. *Continued.*

		Aggregate Percent				
		Females				
Food Item	Common Name	Prelaying (11)	Laying (5)	Post-laying(2)	All (18)	Males (5)
P. Persicaria	Lady's Thumb	tr				
P. punctatum	Smartweed	tr	0.6		tr	
Rumex crispus	Curly Dock	3.3			1.2	
Scirpus validus	Great Bulrush		tr		tr	
Zannichellia palustris	Horned Pondweed	tr			tr	
Vegetation		8.0	2.8	tr	3.0	4.7
Algae		3.2			2.1	
Lemna minor	Small Duckweed	tr		tr	tr	0.7
L. trisulca	Forked Duckweed			tr		
Unidentified		4.8	2.8		0.9	4.0
Total Plant		41.3	7.2	00.1	29.4	4.7

[a]Categories joined by arrows were tested for statistically significant differences using a paired t-test. N.s. indicates no statistically significant difference; 0.05 indicates the level of significance at which differences were found.

[b]The same tests were used to compare male diets with diets of laying females.

TABLE C2. *Foods contained in the esophagus of collected prelaying blue-winged teal and in the environmental samples taken from feeding sites, SWSA, 1973-75.*

		Esophagus (11)		Net (11)	Dredge (11)
Food Item	Common Name	% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
ANIMALS					
Mollusca		81.8	36.6	19.4(ns)[a]	35.4(ns)
Gastropoda	Snails	63.6	17.0	17.1	27.1
Lymnaeidae		54.5	10.6	7.1	14.0
Physidae		9.1	1.5	6.6	7.4
Planorbidae		36.4	4.9	3.4	5.7
Pelecypoda	Clams	36.4	19.6	2.3	8.3
Sphaeriidae		36.4	19.6	2.3	8.3
Annelida		27.3	1.3	3.3	12.2
Oligochaeta	Segmented Worms	18.2	tr	3.3	6.4
Hirudinea	Leeches	18.2	1.2	tr	5.1
(cocoons)		9.1	tr		0.6
Arthropoda					
Crustacea		18.2	0.6	32.1(0.01)	4.5(ns)
Branchiopoda					
Cladocera	Water Fleas			2.7	0.6
(ephipia)	Winter Eggs	9.1	tr	2.6	0.5
Ostracoda	Seed Shrimps			10.5	tr
Copepoda	Cyclops			8.8	0.3
Malacostraca					
Isopoda	Sowbugs	9.1	0.6	tr	2.8
Amphipoda	Scuds	9.1	tr	tr	tr
Arachnida	Spiders	9.1	tr	1.0	tr
Insecta		63.6	20.2	16.2(ns)	6.6(ns)
Ephemeroptera	Mayflies	9.1	tr		tr
Baetidae		9.1	tr		tr
Odonata	Dragonflies, Damselflies	9.1	tr		tr
Coenagrionidae		9.1	tr		tr
Lestidae		9.1	tr	1.7	tr
Hemiptera	True Bugs	9.1	tr	3.3	1.2
Belostomatidae		9.1	tr		
Corixidae				2.5	1.2
Gerridae				tr	
Hebridae				tr	
Macroveliidae				tr	
Mesoveliidae				tr	
Pleidae				0.8	

TABLE C2. *Continued.*

Food Item	Common Name	Esophagus (11)		Net (11)	Dredge (11)
		% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
Lepidoptera	Moths	9.1	tr	tr	tr
Trichoptera	Caddisflies	9.1	tr		1.4
Coleoptera	Beetles	18.2	3.0	0.9	0.7
Curculionidae		9.1	tr		tr
Dytiscidae		18.2	tr	tr	tr
Elmidae		9.1	tr	0.7	tr
Haliplidae			2.0	tr	
Hydrophilidae			0.7	tr	tr
Noteridae				tr	
Staphlinidae				tr	
Diptera	Flies	54.5	12.1	9.4(ns)	3.0(ns)
Ceratopogonidae		27.3	3.8	tr	tr
Chironomidae		36.4	2.6	6.6	2.3
Culicidae		9.1	1.6	tr	tr
Simuliidae			tr		
Stratiomyidae		9.1	0.7	0.3	tr
Syrphidae		9.1			
Tipulidae					tr
Unidentified		9.1	3.4	2.3	0.5
Total Animal		81.8	58.7	63.3	58.7
PLANTS					
Seeds		63.6	33.3	17.4(0.05)	34.5(ns)
Alisma Plantago-aquatica	Water Plantain	9.1	tr	tr	tr
Amaranthus spp.	Amaranths	9.1	tr	tr	tr
Ambrosia spp.	Ragweeds				tr
Bidens spp.	Bur-marigolds	9.1	1.8	4.3	1.2
Carex spp.	Sedges			0.8	tr
Chenopodium album	Lamb's Quarters				tr
Cirsium arvense	Field Thistle				tr
Echinochloa pungens	Barnyard Grass	9.1	7.0		tr
Eleocharis palustris	Spike Rush	9.1	0.1		4.9
Impatiens pallida	Yellow Jewelweed				tr
Leersia oryzoides	Rice Cut Grass			tr	tr
Panicum spp.	Panic Grasses				tr
Phalaris arundinacea	Reed Canary Grass	36.4	17.8	1.2	5.5
Poa spp.	Bluegrasses				tr
Polygonum spp.	Smartweeds	27.3	3.2	tr	10.6
P. amphibium	Water Knotweed				tr
P. aviculare	Common Knotweed			tr	tr
P. Hydropiper	Water Pepper	9.1	0.5		1.4
P. hydropiperoides	Mild Water Pepper	9.1	2.6		tr
P. lapathifolium	Heartsease			tr	1.1
P. pensylvanicum	Pennsylvania Knotweed	9.1	4.6		tr
P. Persicaria	Lady's Thumb	9.1	tr		4.2
P. punctatum	Smartweed	9.1	tr		3.1
P. scandens	Climbing False Buckwheat				tr
Potamogeton spp.	Pondweeds				tr
Potentilla spp.	Cinquefoils				tr
Rumex crispus	Curly Dock	9.1	3.3		tr
Sagittaria latifolia	Common Arrowhead			tr	1.3
Setaria lutescens	Yellow Foxtail Grass			0.8	1.2
Sium suave	Water Parsnip				tr
Taraxacum officinale	Dandelion				tr
Tragopogon dubius	Goat's-beard				tr
Zannichellia palustris	Horned Pondweed	9.1	tr	tr	
Vegetation		18.2	8.0	19.3	12.9
Algae		9.1	3.2	tr	
Ceratophyllum demersum	Coontail			6.0	
Fissidens spp.	Water Mosses			1.5	
Lemna minor	Small Duckweed		tr	3.0	7.1
L. trisulca	Forked Duckweed			2.0	
Ricciocarpus natans	Liverwort			3.7	
Spirodela polyrhiza	Great Duckweed			3.9	
Wolffia spp.	Water-meals			tr	
Unidentified			4.8	7.9	5.8
Total Plant		81.8	41.3	36.7	41.8

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[a] Categories followed by parentheses were tested for statistically significant differences using a paired t-test. Net and bottom samples were each tested against esophagus samples. N.s. indicates no statistically significant difference; 0.01 and 0.05 indicate the levels of significance at which differences were found.

TABLE C3. *Foods contained in the esophagus of collected laying blue-winged teal and in the environmental samples taken from feeding sites, SWSA, 1973-75.*

		Esophagus (5)		Net (5)	Dredge (5)
Food Item	Common Name	% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
ANIMALS					
Coelenterata					tr
Mollusca		80.0	23.1	41.3(ns)[a]	34.8(ns)
Gastropoda	Snails	80.0	21.7	41.3	33.9
Lymnaeidae		60.0	7.7	18.3	19.5
Physidae		40.0	4.0	18.5	1.2
Planorbidae		80.0	10.0	4.5	13.2
Pelecypoda	Clams	40.0	1.4		0.9
Sphaeriidae		40.0	1.4		0.9
Annelida				0.7	20.6
Oligochaeta	Segmented Worms			0.7	19.5
Hirudinea	Leeches			tr	1.2
Arthropoda					
Crustacea		40.0	8.1	7.6(ns)	2.5(ns)
Branchiopoda					
Cladocera	Water Fleas			tr	tr
Ostracoda	Seed Shrimps	20.0	tr	tr	
Copepoda	Cyclops			3.4	1.7
Malacostraca					
Isopoda	Sowbugs	40.0	5.5	4.0	0.5
Amphipoda	Scuds	20.0	2.6	tr	tr
Arachnida	Spiders				tr
Insecta		100.0	61.6	24.4(ns)	19.3(ns)
Ephemeroptera	Mayflies	40.0	0.5	tr	0.8
Baetidae		20.0	0.5	tr	0.8
Odonata	Dragonflies, Damselflies	40.0	5.0	1.5	0.5
Agrionidae		20.0	2.6	1.5	0.5
Coenagrionidae		20.0	2.4		
Hemiptera	True Bugs	40.0	0.7	0.5	tr
Pleidae		40.0	0.7	0.5	tr
Lepidoptera	Moths	20.0	1.3	0.7	tr
Coleoptera	Beetles	100.0	12.1	3.0	0.6
Chrysomelidae		20.0	3.2		
Coccinellidae				tr	
(egg masses)					tr
Dytiscidae		60.0	8.1	1.6	
Haliplidae		20.0	0.7	0.9	0.6
Hydrophilidae		20.0	tr		
Diptera	Flies	100.0	40.3	18.4(ns)	17.2(0.01)
Ceratopogonidae		80.0	9.6	2.5	4.1
Chironomidae		80.0	16.9	15.1	10.3
Culicidae		20.0	tr	tr	tr
Ephydridae		20.0	9.3		
Simuliidae				tr	
Stratiomyidae		40.0	3.3	tr	1.7
Syrphidae				tr	0.8
Unidentified		20.0	1.1		tr
Total Animal		100.0	92.8	74.7	77.4
PLANTS					
Seeds		40.0	4.4	16.1(ns)	12.7(ns)
Alisma Plantago-aquatica	Water Plantain	20.0	tr		tr
Amaranthus spp.	Amaranths	20.0	tr		
Asclepias spp.	Milkweeds			tr	
Bidens spp.	Bur-marigolds			0.5	0.5
Digitaria Ischaemum	Smooth Crab Grass	20.0	tr	1.2	
Eleocharis palustris	Spike Rush	20.0	tr		
Leersia oryzoides	Rice Cut Grass				tr
Nymphaea tuberosa	White Water Lily				tr
Oenothera biennis	Common Evening Primrose			tr	
Panicum spp.	Panic Grasses				tr
Phalaris arundinacea	Reed Canary Grass	20.0	2.6		12.2
Polygonum spp.	Smartweeds	40.0	0.6		tr
P. lapathifolium	Heartsease	20.0	tr		
P. Persicaria	Lady's Thumb				tr
P. punctatum	Smartweed	20.0	0.6		
Potamogeton spp.	Pondweeds				tr
Rumex spp.	Docks			tr	tr
Scirpus validus	Great Bulrush	20.0	tr		
Sium suave	Water Parsnip			tr	tr

TABLE C3. *Continued.*

Food Item	Common Name	Esophagus (5)		Net (5)	Dredge (5)
		% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
Sparganium eurycarpum	Common Bur Reed			2.2	
Spartina pectinata	Prairie Cord Grass				tr
Taraxacum officinale	Dandelion			tr	tr
Unidentified		20.0		tr	
Vegetation		60.0	tr	9.2	9.3
Lemna minor	Small Duckweed			0.5	
L. trisulca	Forked Duckweed			4.9	7.4
Riccia fluitans ss	Liverwort			3.1	0.9
Ricciocarpus natans	Liverwort			0.7	
Utricularia vulgaris	Great Bladderwort				1.0
Unidentified		60.0	2.8		
Total Plant		80.0	7.2	25.3	22.0

[a] Categories followed by parentheses were tested for statistically significant differences using a paired t-test. Net and bottom samples were each tested against esophagus samples. N.s. indicates no statistically significant difference; 0.01 indicates the level of significance at which differences were found.

TABLE C4. *Foods contained in the esophagus of collected breeding male blue-winged teal and in the environmental samples taken from feeding sites, SWSA, 1973-75.*

Food Item	Common Name	Esophagus (4)		Net (4)	Dredge (4)
		% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
ANIMALS					
Mollusca		75.0	49.9	49.1(ns)[a]	56.2(ns)
Gastropoda	Snails	75.0	49.9	49.1	56.2
Lymnaeidae		50.0	20.7	32.0	33.9
Physidae		25.0	8.8	10.5	7.2
Planorbidae		50.0	20.4	6.6	15.0
Pelecypoda	Clams				tr
Sphaeriidae					tr
Annelida				tr	3.8
Oligochaeta	Segmented Worms			tr	1.5
Hirudinea	Leeches				2.3
Arthropoda					
Crustacea				2.7	3.2
Branchiopoda					
Cladocera	Water Fleas			0.5	0.4
(ephipia)	Winter Eggs			tr	
Ostracoda	Seed Shrimps			tr	
Copepoda	Cyclops			2.2	1.7
Malacostraca					
Isopoda	Sowbugs			tr	0.7
Amphipoda	Scuds				0.4
Arachnida	Spiders				tr
Insecta		75.0	45.4	8.2(ns)	8.9(ns)
Ephemeroptera	Mayflies				tr
Baetidae					tr
Odonata	Dragonflies, Damselflies				0.7
Coenagrionidae					0.7
Hemiptera	True Bugs	25.0	tr	tr	tr
Pleidae		25.0	tr	tr	tr
Lepidoptera	Moths			0.9	tr
Coleoptera	Beetles			2.7	tr
Coccinellidae				0.5	
Dytiscidae				2.2	
Elmidae					tr
Haliplidae					tr
Hydrophilidae					tr

TABLE C4. *Continued.*

Food Item	Common Name	Esophagus (4)		Net (4)	Dredge (4)
		% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
Diptera	Flies	75.0	45.1	4.6(ns)	7.7(ns)
Ceratopogonidae		75.0	7.0	2.5	2.5
Chironomidae				0.7	3.9
Culicidae		25.0	6.3	0.6	0.5
Ephydridae				tr	
Stratiomyidae		50.0	31.8	0.8	0.7
Syrphidae					tr
Thaumaleidae					tr
Total Animal		100.0	95.3	60.4	72.8
PLANTS					
Seeds		0.0	0.0	5.5(ns)	15.9(ns)
Alisma Plantago-aquatica	Water Plantain			tr	7.6
Asclepias spp.	Milkweeds				tr
Bidens spp.	Bur-marigolds			tr	tr
Digitaria Ischaemum	Smooth Crab Grass			1.5	
Galium spp.	Bedstraws				tr
Iris spp.	Irises				1.4
Leersia oryzoides	Rice Cut Grass			tr	tr
Lycopus americanus	Common Water Horehound			tr	
Lychnis alba	White Cockle			tr	
Mirabilis nyctaginea	Wild Four-o'clock			tr	tr
Nuphar variegatum	Yellow Pond-lily				tr
Phalaris arundinacea	Reed Canary Grass				2.9
Polygonum spp.	Smartweeds				1.1
P. lapathifolium	Heartsease				1.1
P. Persicaria	Lady's Thumb				tr
Potamogeton spp.	Pondweeds			tr	0.7
Rumex crispus	Curly Dock			tr	tr
Sagittaria latifolia	Common Arrowhead			tr	tr
Sium suave	Water Parsnip			tr	tr
Sparganium eurycarpum	Bur Reed			2.8	
Utricularia vulgaris	Great Bladderwort				1.3
Vegetation		50.0	4.7	34.1	11.3
Lemna minor	Small Duckweed	50.0	0.7	24.1	
L. trisulca	Forked Duckweed			6.2	10.2
Riccia fluitans	Liverwort			3.8	1.1
Ricciocarpus natans	Liverwort			tr	
Unidentified		50.0	4.0		
Total Plant		50.0	4.7	39.6	27.2

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[a] Categories followed by parentheses were tested for statistically significant differences using a paired t-test. Net and bottom samples were each tested against esophagus samples. N.s. indicates no statistically significant difference.

TABLE C5. *Proportion by volume of foods in breeding mallards collected on the SWSA, 1973-75.*

Food Item	Common Name	Esophagus-proventriculus	Esophagus
		Prelaying	Laying
ANIMALS			
Mollusca		4.0	18.2
Gastropoda	Snails	4.0	18.2
Lymnaeidae		4.0	17.7
Physidae			tr
Planorbidae		tr	tr
Annelida		1.6	23.9
Oligocheata	Segmented Worms	1.6	23.9
Arthropoda			
Crustacea			5.8
Malacostraca			
Isopoda	Sowbugs		0.9
Amphipoda	Scuds		4.9
Insecta		19.4	tr
Coleoptera	Beetles	19.4	
Coccinellidae			tr
Diptera	Flies		tr
Stratiomyidae			tr
Total Animal		25.0	48.3
PLANTS			
Seeds		75.0	51.7
Amaranthus spp.	Amaranths		tr
Bidens spp.	Bur-marigolds		tr
Echinochloa pungens	Barnyard Grass	28.0	22.7
Eleocharis palustris	Spike Rush	8.1	
Leersia oryzoides	Rice Cut Grass	34.7	
Phalaris arundinacea	Reed Canary Grass	1.3	4.1
Polygonum spp.	Smartweeds	1.3	10.5
P. Hydropiper	Water Pepper		tr
P. hydropiperoides	Mild Water Pepper	1.0	
P. lapathifolium	Heartsease	tr	
P. pensylvanicum	Pennsylvania Knotweed		4.9
P. Persicaria	Lady's Thumb		tr
Scirpus validus	Great Bulrush	0.6	
Setaria lutescens	Yellow Foxtail Grass		2.1
Zea Mays	Field Corn		1.7
Unidentified		tr	
Vegetation		tr	0.0
Total Plant		75.0	51.7

TABLE C6. *Foods contained in the esophagus-proventriculus of collected prelaying mallards and in the environmental samples taken from feeding sites, SWSA, 1973-75.*

		Esophagus-proventriculus (3)		Net (3)	Dredge (3)
Food Item	Common Name	% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
ANIMALS					
Mollusca		66.6	4.0	1 17.3(ns)[a]	5.5(ns)
Gastropoda	Snails	66.6	4.0	16.8	5.3
Lymnaeidae		66.6	4.0	16.8	2.5
Physidae					2.9
Planorbidae		33.3	tr	0.5	tr
Pelecypoda	Clams				tr
Sphaeriidae					tr
Annelida		33.3	1.6	tr	15.0
Oligochaeta	Segmented Worms	33.3	1.6	tr	14.8
Hirudinea	Leeches				tr
Arthropoda					
Crustacea				2.4	0.5
Copepoda	Cyclops			2.1	
Malacostraca					
Isopoda	Sowbugs			tr	0.5
Amphipoda	Scuds				tr
Arachnida	Spiders			tr	
Insecta		33.3	19.4	44.7 (ns)	2.8(ns)
Odonata	Dragonflies, Damselflies				0.5
Coenagrionidae					0.5
Trichoptera	Caddisflies				1.4
Coleoptera	Beetles	33.3	19.4	31.4	tr
Dytiscidae		33.3	19.4	31.3	
Elmidae					tr
Diptera	Flies			13.3	0.9
Chironomidae				0.7	0.8
Culicidae				7.5	
Stratiomyidae				5.0	tr
Total Animal		66.6	25.0	64.4	23.8
PLANTS					
Seeds		66.6	75.0	16.9 (ns)	62.8(ns)
Alisma Plantago-aquatica	Water Plantain	33.3	tr	0.8	0.7
Amaranthus spp.	Amaranths				tr
Bidens spp.	Bur-marigolds			4.6	0.8
Carex spp.	Sedges				1.4
Echinochloa pungens	Barnyard Grass	33.3	28.0		7.8
Eleocharis palustris	Spike Rush	33.3	8.1	2.1	10.7
Euphorbia spp.	Spurges				tr
Leersia oryzoides	Rice Cut Grass	33.3	34.7	9.1	16.6
Panicum spp.	Panic Grasses				tr
Phalaris arundinacea	Reed Canary Grass	66.6	1.3		0.6
Polygonum spp.	Smartweeds	66.6	1.3		17.8
P. Hydropiper	Water Pepper				10.3
P. hydropiperoides	Mild Water Pepper	33.3	1.0		
P. lapathifolium	Heartsease	33.3	tr		1.1
P. Persicaria	Lady's Thumb				6.4
Potamogeton spp.	Pondweeds				1.4
Rumex crispus	Curly Dock				6.4
Sagittaria latifolia	Common Arrowhead			tr	tr
Scirpus validus	Great Bulrush	33.3	0.6		
Sparganium spp.	Bur Reeds				tr
Unidentified		33.3	tr		
Vegetation		66.6	tr	18.2	11.1
Total Plant		100.0	75.0	34.8	75.9

[a] Categories followed by parentheses were tested for statistically significant differences using a paired t-test. Net and bottom samples were each tested against esophagus samples. N.s. indicates no statistically significant difference.

TABLE C7. *Foods contained in the esophagus of collected laying mallards and in the environmental samples taken from feeding sites, SWSA, 1973-75.*

Food Item	Common Name	Esophagus (4) % Occurrence	Esophagus (4) Aggregate % by Volume	Net (4) Aggregate % by Volume	Dredge (4) Aggregate % by Volume
ANIMALS					
Mollusca		25.0	18.2	36.7(ns)[a]	6.5(ns)
M Gastropoda	Snails	25.0	18.2	36.2	6.5
Lymnaeidae		25.0	17.7	32.9	4.1
Physidae		25.0	tr	2.3	2.4
Planorbidae		25.0	tr	1.0	tr
Pelecypoda	Clams			0.5	
Sphaeriidae				0.5	
Annelida		50.0	23.9	4.1(ns)	27.9(ns)
Oligochaeta	Segmented Worms	50.0	23.9	0.8	22.1
Hirudinea	Leeches			3.3	5.8
Arthropoda					
Crustacea		25.0	5.8	8.8(ns)	5.0(ns)
Branchiopoda					
Cladocera	Water Fleas				tr
Ostracoda	Seed Shrimps				tr
Copepoda	Cyclops			5.9	tr
Malacostraca					
Isopoda	Sowbugs	25.0	0.9	tr	0.7
Amphipoda	Scuds	25.0	4.9	2.9	4.1
Arachnida	Spiders			tr	tr
Insecta		25.0	tr	37.7(ns)	9.3(ns)
Plecoptera aa	Stoneflies			tr	
Ephemeroptera	Mayflies			5.9	tr
Baetidae				5.9	tr
Odonata	Dragonflies, Damselflies			1.2	
Agrionidae				1.2	
Hemiptera	True Bugs			5.2	1.3
Corixidae				2.9	tr
(egg masses)				2.3	1.3
Coleoptera	Beetles	25.0	tr	16.2	1.3
Coccinellidae		25.0	tr	16.2	tr
Dytiscidae					1.3
Diptera	Flies	25.0	tr	9.2(ns)	5.7(ns)
Chironomidae				6.3	5.7
Culicidae				2.9	
Stratiomyidae		25.0	tr		
Chordata					
Amphibia					
Ranidae					
Rana spp.	Tadpoles			1.1	
Total Animal		100.0	48.3	88.7	48.6
PLANTS					
Seeds		75.0	51.7	11.3 (ns)	51.4(ns)
Alisma Plantago-aquatica	Water Plantain				tr
Amaranthus spp.	Amaranths	25.0	tr		tr
Bidens spp.	Bur-marigolds	25.0	tr	tr	tr
Chenopodium album	Lamb's Quarters				tr
Echinochloa pungens	Barnyard Grass	75.0	22.7	3.3	9.6
Eleocharis palustris	Spike Rush				tr
Eragrostis spp.	Love-grasses				3.7
Euphorbia spp.	Spurges				2.0
Leersia oryzoides	Rice Cut Grass				tr
Phalaris arundinacea	Reed Canary Grass	50.0	4.1	4.8	9.5
Polygonum spp.	Smartweeds	75.0	10.5		13.0
P. amphibium	Water Knotweed				tr
P. Hydropiper	Water Pepper	50.0	tr		5.3
P. hydropiperoides	Mild Water Pepper				tr
P. pensylvanicum	Pennsylvania Knotweed	25.0	4.9		tr
P. Persicaria	Lady's Thumb	25.0	tr		6.7
Potamogeton spp.	Pondweeds				0.7
Rumex crispus	Curly Dock				0.7
Sagittaria latifolia	Common Arrowhead				7.5
Scirpus validus	Great Bulrush			2.2	
Setaria lutescens	Yellow Foxtail Grass	75.0	2.1		0.7
Zea Mays	Field Corn	25.0	1.7		
Unidentified				0.9	0.5
Vegetation		0.0	0.0	0.0	0.0
Total Plant		100.0	51.7	11.3	51.4

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[a] Categories followed by parentheses were tested for statistically significant differences using a paired t-test. Net and bottom samples were each tested against esophagus samples. N.s. indicates no statistically significant difference.

TABLE C8. *Proportion by volume of foods in the esophagus of blue-winged teal ducklings collected on the SWSA, 1973-75.*

Food Items	Common Names	Aggregate Percent Class I (7)	 Class II (13)	 Class III (9)
ANIMALS				
Mollusca		45.6 ←(ns)[a]→	48.3 ←(ns)→	28.2
Gastropoda	Snails	45.6	48.3	28.2
Lymnaeidae		26.9	9.6	4.6
Physidae		2.5	14.0	9.4
Planorbidae		15.5	9.9	14.2
Unidentified		0.7	14.8	
Annelida		0.5	1.0	
Hirudinea	Leeches	0.5	1.0	
Arthropoda				
Crustacea		2.7 ←(ns)→	1.1 ←(ns)→	2.4
Branchiopoda				
Cladocera	Water Fleas			tr
(ephipia)	Winter Eggs			tr
Malacostraca				
Isopoda	Sowbugs	0.5		
Amphipoda	Scuds	2.2	1.1	2.4
Insecta		17.5 ←(ns)→	26.4 ←(0.05)→	3.8
Plecoptera	Stoneflies		0.5	
Ephemeroptera	Mayflies		0.7	
Caenidae			0.7	
Odonata	Dragonflies, Damselflies	0.6	3.3	
Aeschnidae		0.6		
Agrionidae			3.2	
Coenagrionidae			tr	
Hemiptera	True Bugs	7.3	1.5	tr
Belostomatidae		2.5	tr	
Gerridae			0.7	
Mesoveliidae		3.6	tr	
Notonectidae			tr	
Pleidae		1.2	0.8	tr
Lepidoptera	Moths	9.1	1.3	
Coleoptera	Beetles	2.8	9.2	tr
Chrysomelidae			4.3	
Curculionidae			tr	
Dytiscidae		0.2	tr	
Haliplidae		2.0	0.7	
Helodidae		0.5		
Hydrophilidae			4.4	
Unidentified				tr
Diptera	Flies	0.3	10.0	3.7
Ceratopogonidae			0.7	
Chironomidae		0.1	4.6	3.7
Culicidae			tr	
Dixidae			tr	
Ephydridae		tr	tr	
Stratiomyidae			3.7	
Tabanidae		tr	tr	
Tipulidae		tr	tr	
Unidentified		1.5		
Total Animal		67.8	76.8	34.4
PLANTS				
Seeds		10.5 ←(ns)→	4.0 ←(ns)→	40.8
Bidens spp.	Bur-marigolds		tr	
Carex spp.	Sedges	tr		tr
Ceratophyllum demersum	Coontail		tr	
Polygonum spp.	Smartweeds	tr	0.5	5.5
P. Hydropiper	Water Pepper		tr	4.4
P. hydropiperoides	Mild Water Pepper			tr
P. lapathifolium	Heartsease	tr		0.8
P. Persicaria	Lady's Thumb		tr	
Potamogeton spp.	Pondweeds			34.6
Rumex crispus	Curly Dock		2.7	
Scirpus validus	Great Bulrush	1.5		
Vegetation		21.7 ←(ns)→	19.2 ←(ns)→	24.8
Lemna minor	Small Duckweed	13.9	11.2	3.6
L. trisulca	Forked Duckweed	7.8	tr	0.5
Wolffia spp.	Water-meals		8.0	20.7
Total Plant		32.2	23.2	65.6

[a] Categories joined by arrows were tested for statistically significant differences using a paired t-test. N.s. indicates no statistically significant difference; 0.05 indicates the level of significance at which a difference was found.

TABLE C9. *Foods contained in the esophagus of collected Class I blue-winged teal ducklings and in the environmental samples taken from feeding sites, SWSA, 1973-75.*

Food Item	Common Name	Esophagus (7)		Net (5)	Dredge (5)
		% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
ANIMALS					
Mollusca		85.7	45.6	5.16(0.05)[a]	6.1(0.01)
Gastropoda	Snails	85.7	45.6	5.02	5.5
Lymnaeidae		28.5	26.9	4.0	0.8
Physidae		28.5	2.5	1.4	1.3
Planorbidae		44.4	15.5	tr	3.4
Unidentified		28.5	0.7		
Pelecypoda	Clams			tr	0.6
Sphaeriidae				tr	0.6
Annelida		14.2	0.5	0.5	8.0
Oligochaeta	Segmented Worms			tr	1.5
Hirudinea	Leeches	14.2	0.5	tr	2.9
(cocoons)					3.7
Arthropoda					
Crustacea		14.2	2.7	tr(ns)	tr (ns)
Branchiopoda					
Conchostraca	Clam Shrimps			tr	
Ostracoda	Seed Shrimps			tr	
Copepoda	Cyclops			tr	
Malacostraca					
Isopoda	Sowbugs	14.2	0.5		tr
Amphipoda	Scuds	14.2	2.2	tr	tr
Arachnida	Spiders			tr	3.7
Insecta		44.4	17.5	15.6(ns)	11.0(ns)
Plecoptera	Stoneflies			tr	
Ephemeroptera	Mayflies			tr	
Baetidae				tr	
Odonata	Dragonflies, Damselflies	14.2	0.6	0.5	0.5
Aeschnidae		14.2	0.6	tr	
Agrionidae					tr
Coenagrionidae				tr	tr
Libellulidae				tr	tr
Hemiptera	True Bugs	55.6	7.3	7.9	tr
Belostomatidae		14.2	2.5		tr
Corixidae				6.1	tr
Mesoveliidae		28.5	3.6		
Pleidae		14.2	1.2	tr	tr
Lepidoptera	Moths	28.5	6.5	tr	tr
Trichoptera	Caddisflies			tr	
Coleoptera	Beetles	28.5	2.8	5.0	1.0
Coccinellidae					0.6
Dytiscidae		14.2	tr	2.6	tr
Elmidae				2.4	
Haliplidae		14.2	2.0	tr	
Helodidae		14.2	0.5		tr
Diptera	Flies	28.5	tr	1.7	9.1
Ceratopogonidae				tr	tr
Chironomidae		28.5	tr	0.7	8.4
Culicidae				tr	
Ephydridae		14.2	tr		tr
Muscidae					tr
Stratiomyidae				tr	tr
Tabanidae		14.2	tr		tr
Tipulidae		14.2	tr	tr	
Unidentified		28.5	1.5		
Total Animal		85.7	67.8	21.9	25.4
PLANTS					
Seeds		42.9	10.5	12.9(ns)	55.6(0.05)
Alisma Plantago-aquatica	Water Plantain				2.4
Amaranthus spp.	Amaranths				tr
Ambrosia spp.	Ragweeds				tr
Arctium minus	Common Burdock				tr
Asclepias spp.	Milkweeds				tr
Bidens spp.	Bur-marigolds			tr	1.9
Bromus inermis	Hungarian Brome				tr
Carex spp.	Sedges	14.2	tr		1.5
Ceratophyllum demersum	Coontail			3.6	
Cirsium arvense	Field Thistle				tr
Echinochloa pungens	Barnyard Grass				

TABLE C9. *Continued.*

Food Item	Common Name	Esophagus (7)		Net (5)	Dredge (5)
		% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
Euphorbia spp.	Spurges				tr
Helianthus tuberosus	Jerusalem Artichoke				tr
Impatiens pallida	Yellow Jewelweed				tr
Iris spp.	Irises				tr
Leersia oryzoides	Rice Cut Grass			tr	3.7
Linaria vulgaris	Butter-and-eggs				tr
Lycopus americanus	Common Water Horehound				tr
Panicum spp.	Panic Grasses				tr
Phalaris arundinacea	Reed Canary Grass	42.9	8.5		0.9
Polygonum spp.	Smartweeds	14.2	tr	tr	5.2
P. lapathifolium	Heartsease	14.2	tr		3.9
P. pensylvanicum	Pennsylvania Knotweed				0.8
P. Persicaria	Lady's Thumb				tr
P. punctatum	Smartweed			tr	0.5
Potamogeton spp.	Pondweeds				tr
Rumex crispus	Curly Dock			tr	tr
Sagittaria latifolia	Common Arrowhead				0.5
Scirpus validus	Great Bulrush	28.5	1.5		tr
Setaria lutescens	Yellow Foxtail Grass				1.9
Sium suave	Water Parsnip			tr	0.9
Sparganium eurycarpum	Bur Reed			tr	33.8
Taraxacum officinale	Dandelion				tr
Zannichellia palustris	Horned Pondweed				tr
Zizania aquatica	Wild Rice				tr
Vegetation		42.8	21.7	65.3 (0.05)	19.0(ns)
Ceratophyllum demersum	Coontail			10.0	tr
Elodea canadensis	Common Waterweed				tr
Lemna minor	Small Duckweed	42.9	13.9	48.4	1.8
L. trisulca	Forked Duckweed	28.5	7.8	4.3	17.2
Spirodela polyrhiza	Great Duckweed				tr
Utricularia vulgaris	Great Bladderwort				tr
Wolffia spp.	Water-meals			2.6	
Total Plant		71.4	32.2	78.2	74.6

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[a] Categories followed by parentheses were tested for statistically significant differences using a paired t-test. Net and bottom samples were each tested against esophagus samples. N.s. indicates no statistically significant difference; 0.01 and 0.05 indicate the levels of significance at which differences were found.

TABLE C10. *Foods contained in the esophagus of collected Class II blue-winged teal ducklings and in the environmental samples taken from feeding sites, SWSA, 1973-75.*

Food Item	Common Name	Esophagus (13) % Occurrence	Esophagus (13) Aggregate % by Volume	Net (7) Aggregate % by Volume	Dredge (7) Aggregate % by Volume
ANIMALS					
Mollusca		84.6	48.3	12.7(0.01)[a]	24.9(0.05)
Gastropoda	Snails	84.6	48.3	12.6	24.8
Lymnaeidae		30.8	9.6	1.3	6.7
Physidae		53.8	14.0	7.6	7.0
Planorbidae		69.2	9.9	3.7	11.1
Unidentified			14.8		
Pelecypoda	Clams			tr	tr
Sphaeriidae				tr	tr
Annelida		15.4	1.0	0.8	12.8
Oligochaeta	Segmented Worms			0.8	9.1
Hirudinea	Leeches	15.4	1.0	tr	3.7
Arthropoda					
Crustacea		15.4	1.1	6.3(ns)	1.0(ns)
Branchiopoda					
Cladocera	Water Fleas			1.8	tr
(ephipia)	Winter Eggs			tr	
Copepoda	Cyclops			4.5	0.9
Malacostraca					
Isopoda	Sowbugs				tr
Amphipoda	Scuds	15.4	1.1	tr	tr
Insecta		84.6	26.4	7.7(ns)	9.0(ns)
Plecoptera	Stoneflies	7.7	tr		
Ephemeroptera	Mayflies	15.4	1.4	tr	tr
Baetidae				tr	tr
Caenidae		15.4	0.7	tr	
Ephemerellidae				tr	
Odonata	Dragonflies, Damselflies	30.8	3.3	tr	
Agrionidae		15.4	3.2	tr	
Coenagrionidae		15.4	tr	tr	
Hemiptera	True Bugs	46.2	1.5	3.7	1.3
Belostomatidae		7.7	tr	tr	
Corixidae				2.8	
Gerridae		7.7	0.7	tr	
Mesoveliidae		15.4	tr		
Nepidae				tr	
Notonectidae		7.7	tr		
Pleidae		30.8	0.8	tr	1.3
Veliidae				tr	
Lepidoptera	Moths		1.3	tr	
Coleoptera	Beetles	69.2	9.2	2.6	1.8
Chrysomelidae		7.7	4.3		
Curculionidae			tr		tr
Dytiscidae		7.7	tr	2.2	0.5
Elmidae					tr
Haliplidae		30.8	0.7	tr	1.0
Hydrophilidae		38.5	4.4	tr	tr
Scarabeidae					tr
Diptera	Flies	61.5	10.0	4.7	2.7
Ceratopogonidae		23.1	0.7	tr	tr
Chironomidae		46.2	4.6	3.0	tr
Culicidae		15.4	tr		1.8
Dixidae		7.7	tr		
Ephydridae				tr	tr
Muscidae				0.5	
Stratiomyidae		23.1	3.7	1.0	tr
Tabanidae		15.4	tr		
Tipulidae		7.7	tr	tr	tr
Unidentified				tr	
Total Animal		100.0	76.8	31.2	46.7
PLANTS					
Seeds		61.5	4.0	5.7(ns)	53.3(0.01)
Alisma Plantago-aquatica	Water Plantain				3.9
Apocynum cannabinum	Indian Hemp				tr
Amaranthus spp.	Amaranths				tr
Asclepias spp.	Milkweeds				1.1
Bidens spp.	Bur-marigolds	15.4	tr	tr	0.8
Calamagrostis canadensis	Blue Joint Grass				tr
Carex spp.	Sedges				tr
Ceratophyllum demersum	Coontail	7.7	tr		tr
Echinochloa pungens	Barnyard Grass				tr

TABLE C10. *Continued.*

Food Item	Common Name	Esophagus (13) % Occurrence	Esophagus (13) Aggregate % by Volume	Net (7) Aggregate % by Volume	Dredge (7) Aggregate % by Volume
Echinocystis lobata	Wild Cucumber				tr
Elymus canadensis	Canada Wild Rye				tr
Impatiens pallida	Yellow Jewelweed				tr
Leersia oryzoides	Rice Cut Grass				tr
Mirabilis nyctaginea	Wild Four-o'clock			tr	
Nuphar variegatum	Yellow Pond-lily				tr
Phalaris arundinacea	Reed Canary Grass	15.4	0.8	tr	7.9
Polygonum spp.	Smartweeds	23.1	0.5		2.1
P. amphibium	Water Knotweed				tr
P. Hydropiper	Water Pepper	15.4	tr		
P. lapathifolium	Heartsease				0.8
P. Persicaria	Lady's Thumb	7.7	tr		tr
P. punctatum	Smartweed				1.0
Potamogeton spp.	Pondweeds			4.0	10.5
Rudbeckia hirta	Black-eyed Susan				tr
Rumex crispus	Curly Dock	7.7	2.7	tr	0.5
Sagittaria latifolia	Common Arrowhead				1.4
Sambucus canadensis	Elderberry				tr
Scirpus validus	Great Bulrush				9.8
Setaria lutescens	Yellow Foxtail Grass				tr
Sium suave	Water Parsnip				0.7
Solanum Dulcamara	Bittersweet Nightshade				tr
Sparganium eurycarpum	Bur Reed			tr	10.7
Vegetation		69.2	19.2	63.1(0.01)	0.0
Ceratophyllum demersum	Coontail	7.7		1.0	
Lemna minor	Small Duckweed	69.2	11.2	55.4	
L. trisulca	Forked Duckweed		tr		
Potamogeton foliosus	Leafy Pondweed			4.0	
Riccia fluitans	Liverwort			1.9	
Ricciocarpus natans	Liverwort			tr	
Wolffia spp.	Water-meals	23.1	8.0	tr	
Total Plant		69.2	23.2	68.8	53.3

[a] Categories followed by parentheses were tested for statistically significant differences using a paired t-test. Net and bottom samples were each tested against esophagus samples. N.s. indicates no statistically significant difference; 0.01 and 0.05 indicate the levels of significance at which differences were found.

TABLE C11. *Foods contained in the esophagus of collected Class III blue-winged teal ducklings and in the environmental samples taken from feeding sites, SWSA, 1973-75.*

		Esophagus (9)		Net (7)	Dredge (7)
Food Item	Common Name	% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
ANIMALS					
Mollusca		66.7	28.2	0.5 (ns)[a]	5.4(0.05)
Gastropoda	Snails	66.7	28.2	0.5	5.4
Lymnaeidae		22.2	4.6	tr	1.6
Physidae		22.2	9.4	tr	2.0
Planorbidae		44.4	14.2	tr	2.0
Annelida				tr	12.6
Oligochaeta	Segmented Worms			tr	7.2
Hirudinea	Leeches			tr	4.1
(cocoons)					1.0
Arthropoda					
Crustacea		33.3	2.4	1.3 (ns)	1.6(ns)
Branchiopoda					
Cladocera	Water Fleas	11.1	tr	tr	
(ephipia)	Winter Eggs	11.1	tr		tr
Copepoda	Cyclops			1.1	1.5
Malacostraca					
Amphipoda	Scuds	22.2	2.4	tr	tr
Insecta		44.4	3.8	2.1 (ns)	10.0(ns)
Ephemeroptera	Mayflies			tr	tr
Baetidae				tr	tr
Odonata	Dragonflies, Damselflies			tr	tr
Coenagrionidae				tr	tr
Lestidae				tr	
Hemiptera	True Bugs	22.2	tr	0.8	2.2
Belostomatidae				0.5	
Corixidae				tr	tr
Mesoveliidae					tr
Notonectidae				tr	tr
Pleidae		22.2	tr	tr	2.0
Lepidoptera	Moths			tr	
Coleoptera	Beetles	11.1	tr	tr	2.1
Dytiscidae				tr	tr
Elmidae					tr
Haliplidae					1.8
Hydrophilidae				tr	tr
Unidentified		11.1	tr		
Diptera	Flies	33.3	3.7	tr	5.6
Ceratopogonidae		11.1		tr	tr
Chironomidae		33.3	3.7	tr	3.5
Culicidae				tr	
Ephydridae				tr	tr
Stratiomyidae				tr	1.7
Tabanidae					tr
Total Animal		100.0	34.4	4.0	29.6
PLANTS					
Seeds		55.6	11.9	1.2 (ns)	70.4(0.01)
Alisma Plantago-aquatica	Water Plantain				tr
Amaranthus spp.	Amaranths				2.3
Ambrosia spp.	Ragweeds				tr
Asclepias spp.	Milkweeds				2.0
Bidens spp.	Bur-marigolds			tr	3.0
Brassica spp.	Mustards				tr
Carex spp.	Sedges	22.2	0.7	tr	tr
Centaurea spp.	Star-thistles				tr
Chenopodium album	Lamb's Quarters				tr
Echinochloa pungens	Barnyard Grass				tr
Eleocharis spp.	Spike Rushes				18.4
Fagopyrum spp.	Buckwheats				2.1
Hypericum ellipticum	St. John's-wort			0.8	
Leersia oryzoides	Rice Cut Grass			tr	tr
Lycopus americanus	Common Water Horehound			tr	
Melilotus spp.	Sweet Clovers				tr
Panicum spp.	Panic Grasses				tr
Phalaris arundinacea	Reed Canary Grass			tr	3.4
Polygonum spp.	Smartweeds	33.3	5.5	tr	9.1
P. amphibium	Water Knotweed			tr	
P. Hydropiper	Water Pepper	11.1	4.4		tr
P. hydropiperoides	Mild Water Pepper		tr		
P. lapathifolium	Heartsease	22.2	0.8		8.8

TABLE C11. *Continued.*

Food Item	Common Name	Esophagus (9)		Net (7)	Dredge (7)
		% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
P. Persicaria	Lady's Thumb				tr
P. punctatum	Smartweed				tr
Potamogeton spp.	Pondweeds	55.6	5.2		tr
Ranunculus spp.	Buttercups			tr	
Rumex maritimus	Golden Dock				tr
Sagittaria latifolia	Common Arrowhead				tr
Scirpus spp.	Bulrushes				1.2
Setaria lutescens	Yellow Foxtail Grass				tr
Silene noctiflora	Night-flowering Catchfly				tr
Sium suave	Water Parsnip				tr
Sparganium eurycarpum	Bur Reed			tr	26.5
Spartina pectinata	Prairie Cord Grass				tr
Zannichellia palustris	Horned Pondweed				tr
Vegetation		44.4	53.7	94.8(0.05)	0.0
Algae				24.7	
Ceratophyllum demersum	Coontail			tr	
Lemna minor	Small Duckweed	44.4	3.6	45.7	
L. trisulca	Forked Duckweed	22.2	0.5	9.3	
Potamogeton foliosus	Leafy Pondweed	22.2	29.4		
Spirodela polyrhiza	Great Duckweed			tr	
Wolffia spp.	Water-meals	33.3	20.7	15.1	
Total Plant		88.9	65.6	96.0	70.3

[a] Categories followed by parentheses were tested for statistically significant differences using a paired t-test. Net and bottom samples were each tested against esophagus samples. N.s. indicates no statistically significant difference; 0.01 and 0.05 indicate the levels of significance at which differences were found.

TABLE C12. *Foods contained in the esophagus of collected Class I mallards and in the environmental samples taken from feeding sites, SWSA, 1973-75.*

		Esophagus (3)		Net (1)	Dredge (1)
Food Item	Common Name	% Occurrence	Aggregate % by Volume	Aggregate % by Volume	Aggregate % by Volume
ANIMALS					
Mollusca				tr	1.3
Gastropoda	Snails			tr	1.3
Planorbidae				tr	1.3
Annelida				tr	16.0
Oligochaeta	Segmented Worms				12.8
Hirudinea	Leeches			tr	3.2
Arthropoda					
Crustacea				tr	
Copepoda	Cyclops			tr	
Malacostraca					
Amphipoda	Scuds			tr	
Insecta		33.3	1.0	2.0	5.7
Ephemeroptera	Mayflies	33.3	1.0	tr	
Baetidae		33.3	1.0	tr	
Odonata	Dragonflies, Damselflies			tr	0.9
Coenagrionidae				tr	0.9
Hemiptera	True Bugs			1.0	tr
Belostomatidae				0.5	
Corixidae				tr	
Mesoveliidae					tr
Pleidae				tr	tr
Lepidoptera	Moths			tr	
Coleoptera	Beetles			tr	2.2
Chrysomelidae					0.8
Dytiscidae				tr	0.6
Hydrophilidae					tr
Noteridae					0.6
Diptera	Flies			tr	3.2
Ceratopogonidae				tr	
Chironomidae				tr	0.6
Unidentified					2.6
Total Animal		33.3	1.0	2.2	23.7
PLANTS					
Seeds		100.0	98.3	12.4	75.5
Alisma Plantago-aquatica	Water Plantain				0.5
Ambrosia spp.	Ragweeds				1.3
Bidens spp.	Bur-marigolds			tr	19.8
Carex spp.	Sedges				tr
Leersia oryzoides	Rice Cut Grass				2.1
Panicum spp.	Panic Grasses				tr
Phalaris arundinacea	Reed Canary Grass	33.3	tr	tr	9.6
Polygonum spp.	Smartweeds	33.3	tr	tr	14.0
P. hydropiperoides	Mild Water Pepper			tr	
P. lapathifolium	Heartsease	33.3	tr		14.0
Potamogeton spp.	Pondweeds	100.0	97.7	12.4	tr
Rumex maritimus	Golden Dock			tr	0.6
Sagittaria latifolia	Common Arrowhead				1.3
Silene noctiflora	Night-flowering Catchfly				tr
Sium suave	Water Parsnip				0.6
Sparganium eurycarpum	Bur Reed				25.5
Taraxacum officinale	Dandelion				tr
Zannichellia palustris	Horned Pondweed				tr
Vegetation		100.0	0.7	85.4	0.8
Ceratophyllum demersum	Coontail			16.0	0.6
Lemna minor	Small Duckweed	33.3	tr	63.8	tr
L. trisulca	Forked Duckweed	66.7	tr	5.6	tr
Total Plant		100.0	99.0	97.8	76.3

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