Breeding duck populations and habitat in Wisconsin. No. 68 1973

March, James R.; Martz, Gerald F.; Hunt, Richard A.
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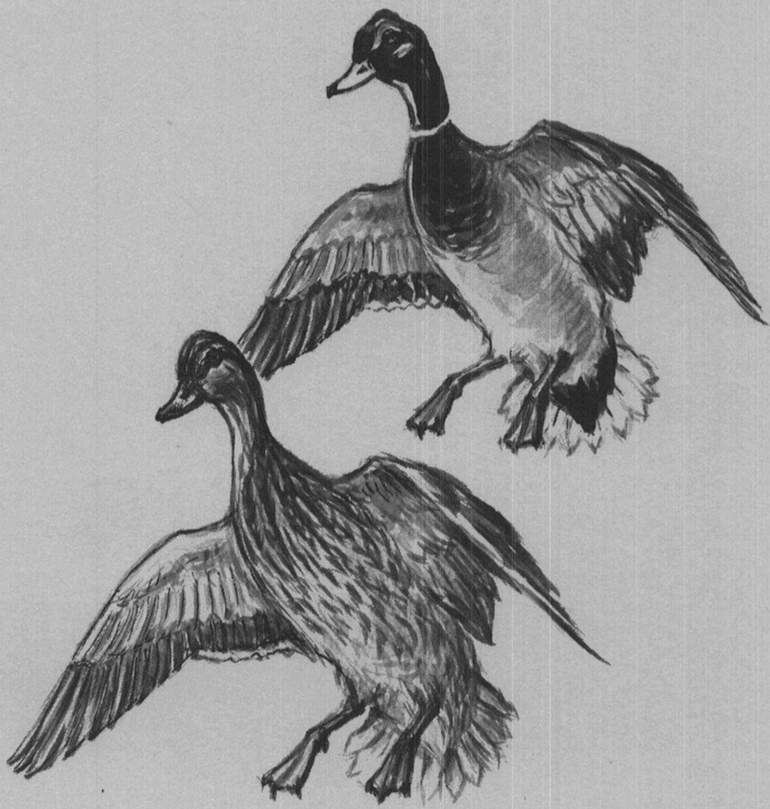
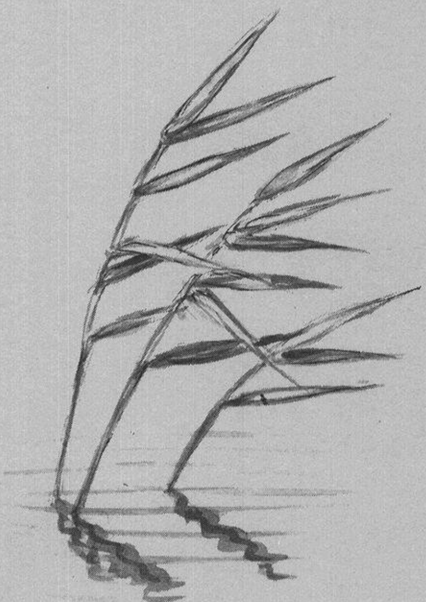


BREEDING DUCK POPULATIONS AND HABITAT IN WISCONSIN



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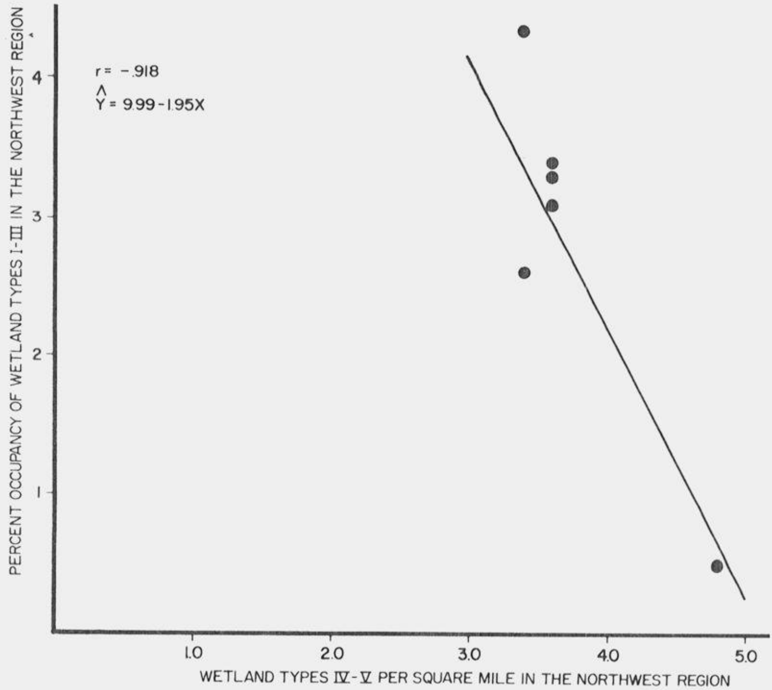

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ABSTRACT

This report summarizes information on the size, distribution and species composition of breeding duck populations in Wisconsin during 1965-66 and 1968-1970. Annual habitat inventories and occupancy of wetlands by breeding ducks are included. Current breeding populations and wetland densities are compared with those in 1948-1956, the period covering the last statewide surveys of this type. Sampling procedures are presented in detail, with major emphasis given to improving future population and habitat surveys.

Based on a stratified random sampling scheme, 46,200 square miles (3 regions: SE/Central, Northwest and Low Density) were surveyed by air for numbers of breeding ducks and wetlands along 30-mile transects. Breeding duck populations on 5 state-owned waterfowl management areas were also surveyed by air. Ground censuses made along selected aerial transect routes were used to calculate air:ground ratios for adjusting aerial indexes for ducks present but not seen from the air.

Weighted mean breeding duck densities averaged 1.2 birds per square mile (uncorrected for missed birds). Highest density (1.4 ducks per square mile) was found in 1965 and also 1970. The average 1966, 1968-1970 weighted mean density (plus 95 percent confidence limits) was 1.1 ± 0.2 ducks per square mile. Highest regional densities were found in the SE/Central and Northwest regions.

Annual air:ground ratios for mallards, blue-winged teal and all other ducks combined ranged between .19 and .25, .13 and 21 and .14 and .38, respectively.

Total breeding population estimates (14 species) for the 3 regions averaged 266,000 ducks. When population estimates from southwest Wisconsin are included (to cover regions not surveyed), the population averaged 275,400 ducks.

Mallards were the most abundant breeding ducks. Blue-winged teal were second in abundance, followed by wood ducks.

The SE/Central region had the largest average regional population estimate for all ducks (148,300 birds) and also had the largest average populations of mallards, blue-winged teal, wood ducks, shovelers, green-winged teal, redheads, pintail and ruddy ducks. Average populations of black ducks, ring-necked ducks and mergansers were largest in the Low Density region.

State management areas, with an average breeding density of 16 ducks per square mile, represented only 0.3 percent of the square miles included in the 3 regions but held about 4 percent of the total unadjusted breeding population index.

August-May precipitation in the 3 regions averaged 20.6 inches. Weighted mean density of wetlands with surface water averaged 12.5 per square mile. The unweighted average of 1966, 1968-1970 mean annual regional densities (plus 95 percent confidence limits) was 11.8 ± 1.2 wetlands per square mile. Highest average regional wetland density was found in the Low Density region.

Temporary (Types I-II, VI) or semipermanent (Type III) ponds or marshes averaged 47 percent of the total wetlands, while permanent types (IV-V) averaged 17 percent.

Observed occupancy of all wetlands by breeding ducks averaged 3.8 percent. Occupancy in all regions was highest on Type IV and V wetlands. Occupancy rates in the SE/Central and Northwest regions were higher than those in the Low Density region.

Annual weighted mean breeding duck densities were not significantly correlated ($P \leq 0.10$) with annual weighted mean wetland densities or annual occupancy rates. Weighted mean annual wetland densities also were not significantly correlated with the annual occupancy rates or the average annual August-May precipitation.

Although less than 1 percent of the North American duck population currently breeds in Wisconsin, the state ranked among the 10 best breeding ground states in the 3 western flyways of the United States. Production potential in Wisconsin was estimated at 310,000 to 500,000 ducklings annually.

Wisconsin duck populations followed the same general upward trends in 1968-1970 as the continental indexes, but differed from 1965-68 continental trends.

Observed breeding densities and adjusted population estimates for 1949-1950 and 1965-1970 both indicated that total duck populations in Wisconsin have not changed markedly in the past 25 years. Mallards, shovelers, green-winged teal and pintail apparently have increased in the state while blue-winged teal, black ducks and ring-necked ducks have declined.

Although there was considerable variability between transects, changes in either weighted mean breeding duck density or weighted mean wetland density of 20 percent between years should have been detectable.

Major sources of variation in breeding duck counts were thought to be differences in duck densities and habitat types, observer and pilot biases, species composition, water abundance and weather conditions.

The pattern of wetland occupancy in Wisconsin suggests that either there were too few ducks to utilize the available habitat, many wetlands were unattractive to breeding ducks or use of temporary wetlands was underestimated.

Density of wetland Types III-V in Wisconsin apparently has changed little since the 1955 inventory.

Aerial surveys are recommended as the best method of monitoring future breeding populations and habitat abundance in Wisconsin. Acquisition or protection of wetlands, development of state and federal lands for maximum duck production and beaver management are suggested as ways of sustaining or increasing Wisconsin duck populations and habitat.

BREEDING DUCK POPULATIONS AND HABITAT IN WISCONSIN

By
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INTRODUCTION

Prior to 1965, the only statewide breeding duck surveys in Wisconsin were made in 1949 and 1950. At that time, the state had an estimated breeding population of between 133,500 and 280,500 ducks and 1,170,698 acres of inland habitat important to waterfowl (Jahn and Hunt, 1964). In addition, breeding population trends were monitored from 1951 through 1956 by annually censusing individual wetlands in various parts of Wisconsin. These wetlands were purposely selected for their better quality habitat and known use by breeding ducks.

The early work led to several important conclusions. First, past surveys concluded that the Wisconsin breeding populations and production potential were small in relation to total continental and Mississippi Flyway duck numbers. Jahn and Hunt (1964) reported densities of 1.1-1.4 ducks per square mile counted in 1949 and 1950. Because of these low densities, the Bureau of Sport Fisheries and Wildlife would not include Wisconsin in its annual aerial counts of waterfowl breeding grounds (J. D. Smith, in litt., May 10, 1961). A. S. Hawkins, when Mississippi Flyway Representative, concluded from the standpoint of overall duck production, that Wisconsin could not have a major effect on national and flyway populations except as local production affected Wisconsin hunting (A. S. Hawkins, in litt., January 30, 1961). Secondly, available banding and population data indicated that in total, ducks reared in Wisconsin did not make a substantial contribution to the state's harvest. Jahn and Hunt (1964) estimated that local ducks comprised only 9-18 percent of Wisconsin's total harvest.

In recent years, the Bureau of Sport Fisheries and Wildlife has included Wisconsin populations under adjustments to North American breeding duck indexes that are made to account for regions not covered by annual surveys. For example, 400,000 ducks have been added to the annual mallard index to cover all breeding grounds not represented by aerial survey (Benning and Martinson, 1971).

In the early 1960's, evidence from the Bureau of Sport Fisheries and Wildlife's duck-wing collections and from more intensified banding programs, began to accumulate which made it necessary to reconsider the conclusions drawn from the early breeding ground surveys in Wisconsin.

Blue-winged teal *(Anas discors)*, mallards *(Anas platyrhynchos)* and wood ducks *(Aix sponsa)* were the 3 most abundant ducks breeding in Wisconsin during the early surveys (Jahn and Hunt, 1964). Age ratios for these same 3 species in the Wisconsin duck kill from 1961 through 1970 averaged 4.6, 2.6 and 1.7 immatures per adult for blue-winged teal, mallards and wood ducks, respectively (Carney and Godin, 1962; Smart, 1966; and Croft and Carney, 1971). These age ratios were consistently higher to immatures than age ratios for the 3 species from the Mississippi Flyway Overall. Also, the Wisconsin ratios compared favorably with those reported in the kill from other breeding grounds in the United States (Carney and Godin, 1962; Smart, 1966; and Croft and Carney, 1971) and from some of the Canadian provinces (Benson, 1968; 1970; and Cooch and Kaiser, 1972).

Banding and migrational studies (Gollop, 1963; Jahn and Hunt, 1964; Lensink, 1964; Bellrose, 1968; Bellrose and Compton, 1970; and Geis, 1971) suggest that only limited numbers of mallards from production areas outside Wisconsin are shot in the state. Wood duck band recoveries (Kaczynski and Geis, 1961; Jahn and Hunt, 1964; Cringan, 1971; and Benson, 1972) also show no indication of a major influx of that species into Wisconsin from outside breeding grounds. Small numbers of birds apparently do enter the state from Iowa and Minnesota (Kaczynski and Geis, 1961; and Jahn and Hunt, 1964).

Blue-winged teal banding studies (Lensink, 1964; Lee et al., 1964; and Lobdell and Sorenson, 1968) suggest a greater dependence on ducks reared outside Wisconsin than found for mallards or wood ducks. Manitoba, Minnesota and the two Dakotas appear as two of the more important production areas for blue-winged teal shot in Wisconsin. Although migrant blue-winged teal are important to Wisconsin hunters, birds raised locally also make up a large segment of the state's kill (Lobdell and Sorenson, 1968).

Based on the importance of young-of-the-year in the Wisconsin kill and the apparent limited input of ducks from outside breeding grounds, locally reared ducks of certain species appeared to be furnishing a larger part of the state's kill than was previously reported by Jahn and Hunt (1964). Since breeding population estimates over a series of years were essential to measuring the actual contribution of local production to the Wisconsin duck kill, a new statewide survey of breeding ducks clearly was needed.

Such a survey was also needed to check the duck densities reported earlier. Breeding surveys during 1948-1956 were not based on random samples and the earlier aerial counts were not corrected for birds missed from the air. A new survey based on a statistically reliable sampling design could conceivably produce different results from those obtained earlier.

In addition, current population and production information was needed to guide those agencies responsible for setting waterfowl management policies. Even if the last surveys had been statistically reliable, by 1965, the data were fifteen years old. Numbers of ducks and quality and abundance of waterfowl habitat had undoubtedly fluctuated since the early 1950's.

Lastly, new statewide data were needed to support the Department of Natural Resources' program of wetland acquisition. By July, 1969, an estimated 268,000 acres of wetlands were under DNR ownership and over two-thirds of this land had been acquired specifically for waterfowl (King, 1971). Current acquisition goals call for the purchase of an additional 179,000 acres of wildlife lands at an estimated cost of about $10.5 million (Tyler and Helland, 1969). Investments of this magnitude necessitate knowing current and potential waterfowl production on, and use of, wetlands.

Because of the need for up-to-date information on Wisconsin's breeding duck populations and habitat, a statewide survey was initiated in 1965. Subsequent surveys were run again in 1966, 1968, 1969 and 1970. No survey was conducted in 1967 because of personnel changes in the waterfowl project.

Objectives of these five surveys were: (1) to provide reliable estimates of the size, distribution and species composition of the duck populations breeding in Wisconsin from 1965 through 1970, (2) to inventory available habitat and determine occupancy of wetlands by breeding ducks and (3) to review sampling procedures in order to improve the results of future population censuses and habitat inventories.

GLOSSARY

CENSUS*– *complete* tally or count of all of the animals (or habitat types) in a given area or sample of that area.

COUNT – An *incomplete* tally of the animals in a specified area.

ESTIMATE – A representation of the *total* numbers in a population, obtained from one or more *indexes* to the size of that population.

INDEX – A count or ratio which is a *fraction* of a given population and is an *indication* of the size of that population.

SURVEY – An examination of the size or condition of a population. The examination may include counts and censuses as well as observations.

*Definitions of terms taken in part from Giles (1969).

METHODS

AERIAL SURVEYS

Sampling Scheme

Major Regions

Approximately 46,200 square miles of Wisconsin's total area of 56,154 square miles were sampled by aerial surveys (Figs. 1 and 2). Only the "Driftless Area" in southwestern Wisconsin – approximately 9,700 square miles – and Milwaukee County were excluded. The Driftless region was omitted because of its shortage of habitat and lower duck densities (as determined from 1949-1956 surveys). Although it has some wetlands, Milwaukee County was omitted because it is primarily urban.

The initial survey in 1965 was designed as a stratified random sample. Transects 30 miles long and ¼-mile wide (totalling 7.5 square miles each) were used as the basic sampling units. All routes ran east-west. For analysis purposes, it was desirable that the routes should average 10 breeding ducks each.

Allocation of the 1965 transects was based on availability of aquatic habitat and numbers of breeding ducks in various regions summarized in Jahn and Hunt, (1964). Initial regional boundaries were similar to those for 3 major physiographic provinces – the Eastern Ridges and Lowlands, the Central Plains and the Northern Highlands (Jahn and Hunt, 1964). On the basis of the 1949-1956 surveys, a greater number of transects were assigned to the Eastern Ridges and Lowlands where higher breeding densities were expected.

Starting points for individual transects were located by random selection of town, range, section and a 0.1-mile interval along the eastern side of each section. A table of random digits was used to select locations from a list of all possible town, range and 0.1-mile interval designations. Sections were chosen from a randomized list of section numbers. Odd-numbered transects ran east from their starting point and even-numbered transects ran west. To reduce chances of re-counting flushed birds, transects could not be closer than three miles to each other. Transects were doubled-back at the eastern and western edges of each region but the doubled-back segments were not allowed to lie closer than 2 miles from the initial segment.

Sixty transects were selected for the 1965 survey. This sample was considered to be large enough to maintain sampling error within ± 20 percent of the overall mean observed breeding density at the 95 percent level of significance.

The raw results from the total area sampled in 1965 had a calculated standard error of ± 22 percent (P=0.05), expressed as a percent of the mean number of ducks seen per square mile (Martz, 1965). From the breeding densities obtained, transects were divided into those transects with 0-1.50 breeding ducks observed per square mile and those with 1.50 or more breeding ducks per square mile. The higher densities were predominantly in the northwestern, southeastern and central counties (i.e., the Eastern Ridges and Lowlands). To reduce variability in population indexes, transects with 1.50 or more ducks per square mile were included in 2 regions – the SE/Central (about 14,800 square miles; 22 transects) and the Northwest (about 5,200 square miles; 8 transects). Transects with 1.50 or fewer breeders per square mile were placed in a "Low Density" region (about 26,200 square miles; 30 transects). Initial regional boundaries and transect locations are shown in Fig. 1.

To improve the sampling efficiency, before the 1966 survey, regional boundaries were further modified and the number of transects within each region adjusted. The Northwest region was expanded to include 500 square miles of the Low Density region designated in the 1965 survey. Duck densities and habitat in the segment transferred were more similar to those in the Northwest. Boundaries between the SE/Central and Low Density regions were also changed slightly although total area in each region remained the same. One transect in the Low Density region was added to the SE/Central region because of its habitat was more similar to that in the SE/Central region. A complete new set of transects was not selected within each region. Instead, in the SE/Central region, 6 of the original transects flown in 1965 were randomly eliminated and 11 new transects were randomly selected. These new routes, together with the 16 remaining from the 1965 survey, plus the one transect transferred from the Low Density region, made up the 28 transects censused in the SE/Central region during

1966 and 1968-1970. In the Low Density region, flight time was reduced by the random elimination of 12 of the transects flown in 1965. Two new transects were randomly chosen in the region. The 19 transects flown in the Low Density region during the 1966 and 1968-1970 surveys represented 17 originally used in 1965 plus these 2 new routes. Seven of the 8 transects flown in 1965 in the Northwest region were also flown in 1966 and 1968-1970. Because of regional boundary changes, 1 old transect was discarded and 1 new one selected, making the number of transects flown in 1966 and 1968-1970 the same as the number flown in 1965. Fig. 2 shows regional boundaries and transect locations for the 1966 and 1968-1970 surveys, and Table 1 summarizes regional area, sampling intensity and number of transects. Hereafter, data from the 1965-66 and 1968-1970 surveys will be summarized as 1965-1970. Likewise, data from the 1966 and 1968-1970 surveys will be referred to as 1966-1970.

In 1965, 450 square miles were actually counted by air. This represented a 1.0 percent sample of the total area in the 3 regions (Table 1). Following the reduction to 55 operational transects, 412.5 square miles or 0.9 percent of the total area were counted by air in 1966-1970. Sampling rates varied for the individual regions, being greater in the SE/Central and Northwest regions (Table 1).

Management Areas

In addition to the transects in the 3 regions, breeding ducks on 5 of Wisconsin's more important state-owned waterfowl management areas — Crex Meadows Wildlife Area, Eldorado Marsh Wildlife Area, the George W. Mead Wildlife Area, Sandhill Wildlife Demonstration

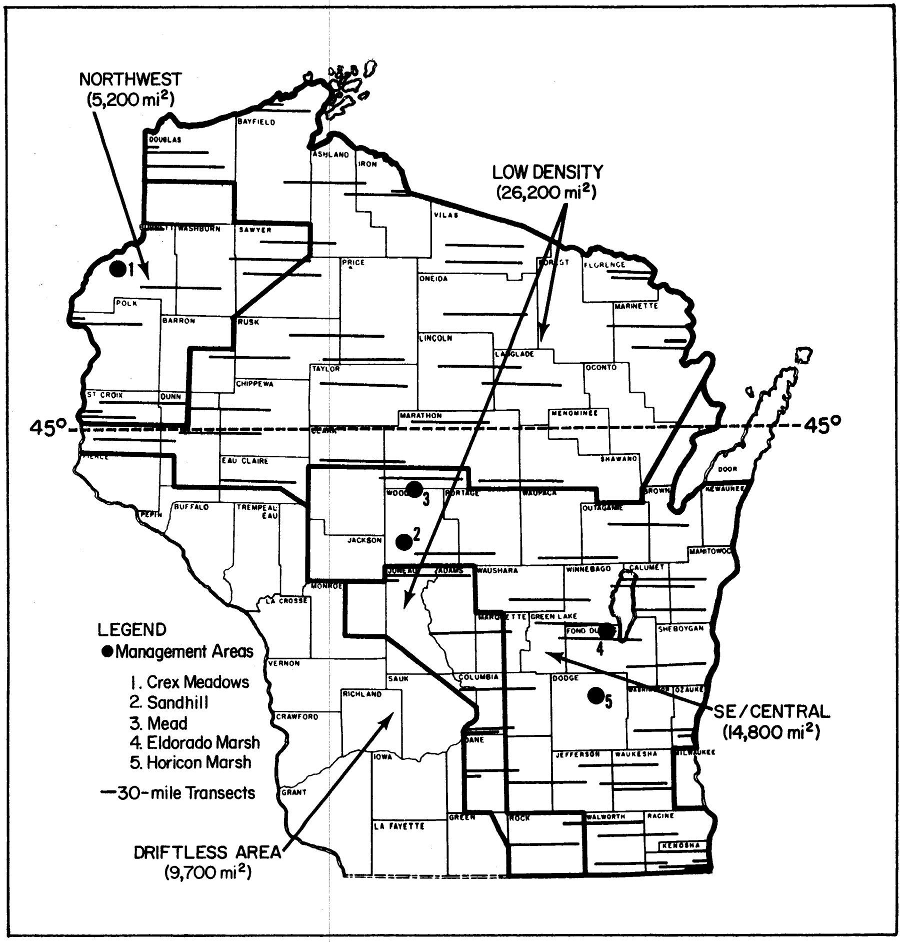


FIGURE 1
Regional boundaries used in the 1965 aerial survey and location of the 60 transects and 5 state management areas.

TABLE 1. *Distribution by Region of Transects and Area Surveyed*

Region	Square Miles	No. of Transects 1965	No. of Transects 1966-1970	Square Miles Sampled 1965	Square Miles Sampled 1966-1970	Percent Sampled 1965	Percent Sampled 1966-1970
SE/Central	14,800	22	28	165	210	1.1	1.4
Northwest	5,700*	8	8	60	60	1.2	1.0
Low Density	25,700*	30	19	225	142.5	0.8	0.6
Total	46,200	60	55	450	412.5	1.0	0.9

*In 1965, the Northwest Region included 5,200 square miles and the Low Density Region, 26,200.

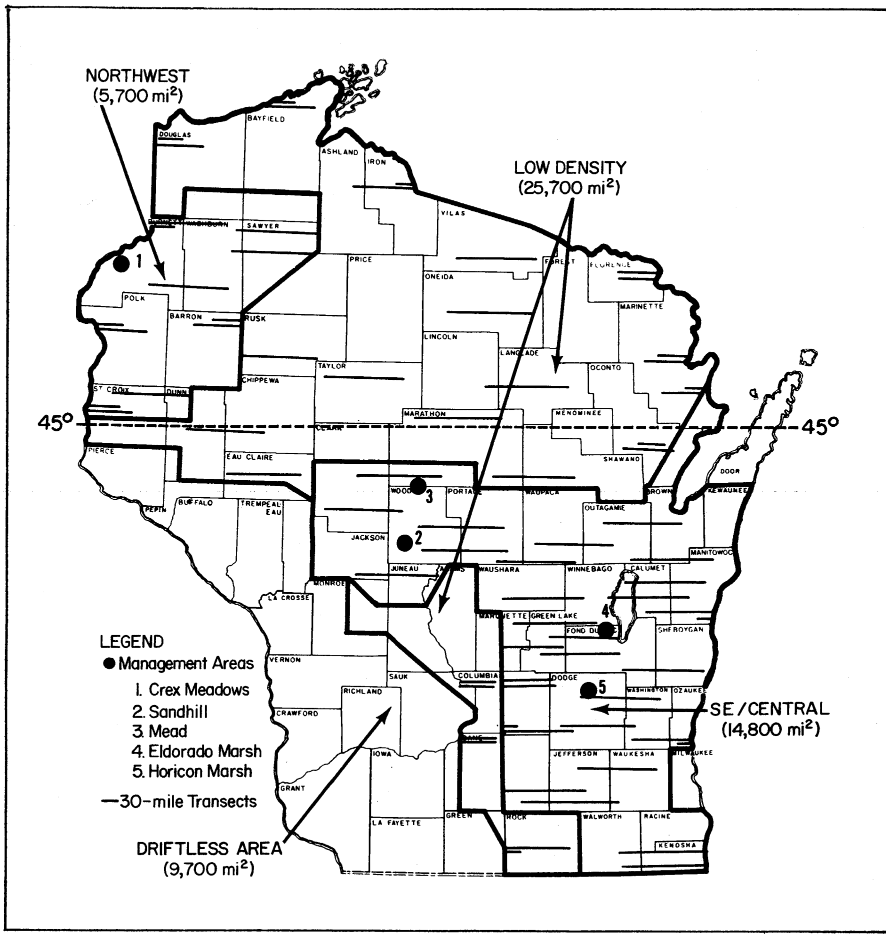


FIGURE 2
Regional boundaries used in the 1966-1970 aerial surveys and location of the 55 transects and 5 state management areas.

Single-engine, tandem-seat Law Enforcement aircraft used for the 1965-1970 aerial surveys.

Area and Horicon Marsh Wildlife Area (Fig. 2) – were counted by air in 1965-66 and 1968-69. These projects were sampled to measure their breeding populations in terms of contribution to statewide duck numbers. Breeding population indexes from the management areas were not adjusted for ducks present but not seen, or added to the regional population estimates. Instead, the breeding populations on the management areas were assumed to be included in the regional population estimates which were based on the numbers of ducks seen on the transects, corrected for missed birds. One transect flown from 1966-1970 did cross the state-owned portion of Horicon Marsh (Fig. 2).

Although we recognized that state management areas had higher breeding densities than the surrounding countryside, the number of areas involved made it impractical to consider these areas separately from the rest of the state. At least 21 state management areas, each over 3,000 acres and totalling about 216,000 acres (Tyler and Helland, 1969), could be considered as important Wisconsin waterfowl production areas. The additional flight time needed to survey all these projects could not be justified on an annual basis. However, the inclusion of these areas as a separate "region" would undoubtedly have raised the statewide breeding population above the estimates obtained.

Survey Mechanics

General guidelines for the aerial censuses were taken from "Standard Procedures for Waterfowl Population and Habitat Surveys – the Prairies" (U. S. Bureau of Sport Fisheries and Wildlife, 1969). Procedures were modified to meet certain problems unique to the Wisconsin survey.

District Law Enforcement pilots and aircraft, accompanied by one biologist-observer, flew the annual aerial surveys. The biologist-observer was mainly responsible for spotting and identifying breeding ducks, plus recording habitat data. The pilot's assignment was primarily, to maintain the proper course, flight speed and altitude, and secondarily, to assist in spotting waterfowl. All breeding population and habitat data were recorded on a battery-powered tape recorder.

The 1965-66 surveys were made by author Martz, and the 1968-1970 surveys were made by author March. To complete each survey it was necessary to use five warden-pilots. Individual pilots flew transects that could be reached most efficiently from their base of operations. Because of scheduling problems, bad weather and pilot re-assignments, it was not always possible to fly each transect with the same pilot in consecutive years.

Single engine, high-winged aircraft with tandem seating were used on the surveys.

Transects were flown at an average ground speed of 85 mph and an altitude of 100-200 ft above ground level, depending on the terrain.

All transects were flown between 6:30 a.m. and 5:30 p.m., Central Daylight Time. Over three-fourths were completed between 8:00 a.m. and 3:00 p.m., Central Daylight Time.

Surveys started with the more southerly transects and progressed to the northernmost. Starting dates were based on breeding sequence data in Wisconsin summarized by Jahn and Hunt (1964) and on annual phenology. Earliest starting date was April 29 in 1969 and the latest, May 6 in 1966. All surveys were completed by May 20. Leaf-out was well advanced on the northern transects by the end of all surveys.

Annual aerial surveys required from 40-60 hours of flight time to complete. Total annual cost was about $1,300-$1,500, including salaries of the pilots and observers.

Breeding Duck Counts

The biologist-observer recorded all waterfowl seen by himself or the pilot within an 1/8-mile strip on either side of the aircraft. Whenever possible, ducks were identified to species and classified as either pairs, lone drakes, lone hens, groups of drakes or mixed flocks of drakes and hens. Pairs, lone drakes, and flocks of 2-5 drakes were counted as "indicated" breeding pairs. In most situations where the identity of a duck(s) was in question, the transect was interrupted and the bird(s) were circled until identified. Additional ducks seen on these break-offs were not recorded in the total number of pairs seen for that transect.

Counts, from which the size of the breeding population was estimated, were made of the following species of surface-feeding or dabbling ducks: black duck *(Anas rubripes)*, blue-winged teal, gadwall *(Anas strepera)*, green-winged teal *(Anas crecca carolinensis)*, mallard, pintail *(Anas acuta)*, shoveler *(Anas clypeata)* and wood duck. Similar counts were made of the following species of diving ducks: common merganser *(Mergus merganser)*, hooded merganser *(Mergus cucullatus)*, red-breasted merganser *(Mergus serrator)*, redhead *(Aythya americana)*, ring-necked duck *(Aythya collaris)* and ruddy duck *(Oxyura jamaicensis)*.

Diving ducks that were known to breed only rarely in Wisconsin, e.g. bufflehead *(Bucephala albeola)*, canvasback *(Aythya valisineria)*, common goldeneye *(Bucephala clangula)* and lesser scaup *(Aythya affinis)* were not counted. When groups of locally nesting species were encountered, flock structure, behavior and stage of migration were used to determine breeding status.

Wetland Censuses

All wetlands lying within the 1/8-mile strip on the right-hand side of the aircraft were censused. Three broad categories – ponds (including ponds, marshes and lakes), streams and ditches – were used to identify the kind of wetland. Each wetland in the pond category was subjectively classified to "type" according to a system similar to that used by Martin et al. (1953). Criteria were modified to fit local conditions and are described in Appendix A. Since "type" determination was made rapidly and from an altitude of 100 or more feet, classification was primarily based on estimated permanency rather than on the presence of a particular vegetation type. Wetlands which were occupied by breeding ducks were classified to type even if they were on the left-hand side of the aircraft.

AIR:GROUND COMPARISONS

Segment Selection

Aerial duck counts provided density data from which breeding population indexes (based on the number of ducks seen from the air) were calculated. To adjust these indexes for ducks present but not seen by the aerial crew, a visibility correction (air:ground ratio) was needed.

Air:ground data were first obtained in 1966 by making ground censuses of breeding ducks along predetermined routes or segments (58 linear miles) on 7 state waterfowl management areas. One to three days prior to their survey by air, a ¼-mile strip along these routes was censused from cars or on foot by game management personnel. Aerial counts were compared with ground censuses to obtain the air:ground ratio. No air:ground data were gathered from the actual 30-mile transects. At least 1 management area was located in each of the 3 regions surveyed. Four of the 5 pilots were involved in these segments.

Air:ground ratios calculated in 1966 were from areas with higher duck densities than the densities found on the transects in each region. In some cases, these ground censuses were not complete searches. Martinson and Kaczynski (1967) suggested that, as the duck density in a given area increases, the proportion recorded by aerial crews decreases. Air:ground ratios obtained in 1966 from management area segments having breeding densities at least 5 to 10 times greater than the densities observed along the transects flown that same year, may have exaggerated the number of ducks not seen from the air.

To make the 1968 air:ground data more representative of regional densities observed, one 10-mile and one 20-mile segment from 2 transects in the SE/Central region were searched from the ground following the regular aerial survey. Different pilots flew each segment. Segments were selected primarily on the basis of their accessibility.

Although the 1968 air:ground ratios were obtained from only 1 region, they were used to adjust breeding population indexes for all 3 regions. This was done with the assumption that the ratios for the SE/Central region were a reasonable approximation of air:ground ratios that would also be obtained in the Northwest and Low Density regions. Differences in habitat types and duck densities between regions made this a rather tenuous assumption.

Beginning in 1969, air:ground coverage was expanded to include segments in each region. A primary criteria in selecting the 1969-1970 segments was that sufficient ducks should be present to insure that some birds would be seen by the aerial crew. This made it necessary to select segments that had at least 1 or 2 wetlands per lineal mile and that had *observed* breeding densities of 1 or more ducks per square mile. All possible segments of the transects used in 1966 and 1968 that met the duck and habitat density criteria, that were accessible and that were at least 10 miles long, were determined. At least 2 of these segments per region, each from a different transect, were randomly selected for both air and ground coverage.

Seven segments, totalling 76 linear miles, were included in the 1969 air:ground comparisons. Segments were distributed as follows: the SE/Central region contained 3 segments totalling 30 linear miles, the Northwest region contained 2 segments totalling 20 miles and the Low Density region contained 2 segments totalling 26 miles. In 1970, 86 linear miles of segments from 8 transects were used. The additional segment was added in the SE/Central region, giving a total of 40 linear miles in that region. Total segments and length in the other regions remained the same as in 1969.

Four percent of the total area counted in the SE/Central region during 1969 was included in the air:ground coverage and 5 percent was included in 1970. Air:ground comparisons included 8 percent of the total area counted in the Northwest region during 1969 and 1970 and 5 percent, in the Low Density region.

Ground Censuses

On the segments selected for air:ground comparisons, all wetlands within the ¼-mile strip counted by air were also searched on foot for breeding ducks. (In 1966, some ground censuses were made from cars along dike roads or ditch banks.) Four- or five-man crews, usually working singly or in pairs, made the ground censuses. Ducks flushed by the ground crews were "marked down" whenever possible to avoid duplicate counts of reflushed birds. For wetlands lying partially outside the transect, only those ducks seen within the transect boundaries were counted. Ducks seen flying over the transect boundaries during ground censuses also were not added to the counts.

Aerial coverage of the air:ground segments of transects was made as part of the regular coverage of the entire transect. All ground censuses were made 1-3 days after the aerial survey of the segment.

The ground censuses made in 1969 and 1970 each required 34 or 35 man-days to complete at a total estimated cost of $1,300-$1,400. Cost would have been higher without some volunteer help.

REGIONAL CALCULATIONS

From the data gathered by means of aerial surveys and air:ground comparisons, regional breeding population indexes and estimates were determined.

The number of indicated "pairs" of breeding ducks observed per transect during aerial surveys was doubled to get the number of breeding ducks per transect. This number was then divided by 7.5 (the number of square miles in each 30-mile long and ¼-mile wide transect) to arrive at the number of breeding ducks per square mile (i.e., the breeding duck density). This figure was multiplied by the number of square miles in each region to expand to the number of breeding ducks per region, uncorrected for ducks missed by aerial counts (i.e., the breeding population index). To adjust this index for the number of ducks present but not seen from the air, air:ground ratios were used to correct the index and arrive at an estimate of the size of the breeding duck population for each region (i.e., the regional breeding population estimate).

Similarly, wetland density was determined by dividing the number of wetlands tallied per transect during aerial surveys by 3.25 square miles per transect (only one side counted).

OTHER POPULATION ESTIMATES

The bottomlands along the Mississippi River (within the Driftless Area), one of the largest continuous blocks of waterfowl habitat in Wisconsin, were not included in the aerial census. The major part of these bottoms are included in the Upper Mississippi River National Wildlife Refuge. We used the Bureau of Sport Fisheries and Wildlife's annual estimate of brood production to calculate breeding populations for this area. The Upper Mississippi NWR has an estimated 144,000 acres of potential production habitat (W. E. Green, pers. comm., 1971), of which about 45 percent lies within Wisconsin. Brood estimates for the entire refuge were doubled on the assumption that 50 percent of the pairs reared broods each year. This figure was again doubled and multiplied by .45 to obtain an estimate of the breeding duck population in the Wisconsin portion of the refuge. The assumption that 50 percent of the pairs rear broods was based on reproductive success data for Wisconsin breeding ducks taken from Jahn and Hunt (1964).

The 1949-1950 breeding density observed in a physiographic province of Wisconsin called the Western Uplands – 0.1 ducks per square mile (Jahn and Hunt, 1964) – was used as an index to estimate the size of current breeding populations in the rest of the Driftless Area, exclusive of the Mississippi River bottomlands. The number of ducks per square mile was multiplied by the size of the area (9,700 square miles) to get an annual breeding population index of about 1,000 ducks. This was adjusted by an air:ground ratio of .200 (the average ratio obtained for the 3 regions from 1966-1970) to obtain the breeding population estimate for this area.

Since few ducks breed in the Driftless Area, the density reported by Jahn and Hunt (1964) was considered a reasonable indication of 1965-1970 populations. However, because of the sampling procedures used in the 1949-1950 survey, the estimate of current breeding populations in the Driftless Area is probably a conservative one.

BREEDING POPULATIONS

POPULATION NUMBERS

Major Regions

Breeding Duck Densities

The weighted mean breeding duck density for the 3 regions combined averaged 1.2 ducks per square mile during 1965-1970 (Table 2). During the 4 years in which an identical sampling scheme was used (1966-1970), the weighted mean density was 1.1 ducks per square mile. Highest annual weighted mean density was 1.4 ducks per square mile in 1965 and 1970 and the lowest was 0.9 per square mile in 1968 (Table 2).

Yearly differences in mean density during 1966-1970 were tested for significance using the nonparametric Friedman's Two-way Analysis of Variance by Ranks Test, with regional ranks weighted by area (D. R. Thompson, pers. comm., 1972). The 1965 data were excluded from this analysis because of the slight differences in sampling scheme between 1965 and 1966-1970. The overall test between years was significant at $P \leq 0.05$ (see Appendix B for details). Weighted mean densities for 1968 versus 1970 ($P=0.05$) and also 1969 versus 1970 ($P \leq 0.05$) were significantly different between years. The 1966 weighted density was significantly different from 1968 at $P \leq 0.10$.

Average 1965-1970 regional densities were highest in the SE/Central and Northwest regions (Table 2). Breeding densities in the Low Density region were only one-fifth to one-half those in the other regions. The SE/Central region had the highest breeding density in 3 of the 5 years. In 1966, the most ducks per square mile were seen in the Northwest region (Table 2), while in 1970, densities were equal in the SE/Central and Northwest regions.

Peak densities for the SE/Central and Northwest regions were observed in 1965 and for the Low Density region, in 1970 (Table 2). When the Friedman Test was applied to annual regional densities, differences within regions for all years (1966-1970) were significant at $P \leq 0.05$ for only the SE/Central region (Appendix B). This suggests that differences in annual duck density for the 3 regions combined resulted primarily from changes in density in the SE/Central region.

Breeding densities were significantly different between years at $P < 0.05$ in the SE/Central region for only 1966 versus 1970. At $P \leq 0.05$, in the Northwest region, only the 1968 versus 1970 densities were significantly different; in the Low Density region, the only significant difference at that level was between 1966 and 1968 densities.

Mallard densities were about three times greater in the SE/Central and Northwest regions than in the Low Density region (Table 2). In 2 of the 5 survey years, more mallards were seen per square mile in the SE/Central region than in the Northwest region although the average mallard density (1965-1970) for both regions was the same. Blue-winged teal were generally more abundant in the SE/Central region than in the Northwest region. Very few blue-winged teal were found in the Low Density region (Table 2). Densities of all other ducks combined were similar in the SE/Central and Northwest regions (Table 2). Again, the Low Density region had the fewest ducks per square mile of miscellaneous species, averaging only about one-third the densities found in the other regions.

Sampling Precision

Inspection of significant differences in breeding duck density (weighted) indicated by the Friedman Test (Appendix B) revealed the degree of mean differences in

TABLE 2. *Breeding Duck Densities by Region, 1965-1970*

Region and Species	Avg. No. Ducks Seen per Square Mile					Average	
	1965	1966	1968	1969	1970	1965-1970	1966-1970
SE/Central							
Mallard	1.1	0.6	0.8	1.0	1.1	0.9	0.9
Blue-winged teal	0.8	0.5	0.5	0.9	0.6	0.6	0.6
Others*	0.6	0.2	0.3	0.4	0.4	0.4	0.3
Total	2.5	1.3	1.5	2.2	2.1	1.9	1.8
Northwest							
Mallard	1.0	0.9	0.8	0.5	1.1	0.9	0.8
Blue-winged teal	0.8	0.4	0.3	0.5	0.5	0.5	0.4
Others*	0.5	0.3	0.1	0.2	0.5	0.3	0.3
Total	2.3	1.6	1.2	1.2	2.1	1.7	1.6
Low Density							
Mallard	0.2	0.4	0.2	0.2	0.6	0.3	0.4
Blue-winged teal	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Others*	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Total	0.5	0.7	0.4	0.4	0.8	0.6	0.6
All Regions (Weighted Mean)	1.4	1.0	0.9	1.1	1.4	1.2	1.1

*Includes all other identified and unidentified species of breeding ducks seen.

density capable of being detected. Thus, 1969 was different from 1970 at P≤0.05. Weighted mean ducks per square mile were 1.1 and 1.4, respectively. These values were within 11 percent of the average weighted density for these 2 years. Weighted mean densities in 1966 and 1968 which were different at P≤0.10, were within 9 percent of the average weighted density for these 2 years. These results suggested that statewide differences between years of 20 percent or less should be detectable (D. R. Thompson, pers. comm., 1972).

Although "reasonable" confidence limits could not be placed on annual weighted mean densities because of the variability within and between regions, limits were determined for the average weighted mean density for all 4 years. This was calculated as ±18 percent (using a stratified sampling approach, P=0.05; D. R. Thompson, pers. comm., 1972). By this method, an average weighted mean 1966-1970 density of 1.1 ± 0.2 breeding ducks per square mile was derived for the 3 regions combined (Appendix B).

Based on findings from the 1966-1970 surveys, optimum allocation of transects was determined using annual standard deviations and regional weights. The optimum regional allocation of transects would have been: 27 transects for the SE/Central region, 7 transects for the Northwest region and 21 transects for the Low Density region. Actual allocation was 28, 8 and 19 transects, respectively, for the SE/Central, Northwest and Low Density regions. This suggested that the original transect allocation qualified as a "stratified random" sample (D. R. Thompson, pers. comm. 1972).

Air:ground Ratios

Data were sufficient for mallards and blue-winged teal to compute separate air:ground ratios for the 2 species. Air:ground comparisons for all other ducks were too limited to obtain ratios for individual species. A single annual air:ground ratio was obtained for all other ducks by summing data for all species except mallard and blue-winged teal.

Although air:ground comparisons were made in each region during the 1966, 1969 and 1970 surveys, sample sizes were considered insufficient to compute separate regional air:ground ratios. In those years, regional results were combined to obtain annual air:ground ratios for mallards, blue-winged teal and other ducks.

Mallard air:ground ratios had a range of .19-.25 over the 4 years, 1966-1970 (Table 3). Ratios for blue-winged teal were generally lower than mallard ratios, ranging between .13 and .21. The air:ground ratio for all other ducks was the most variable, with a range of .14-.38.

Overall air:ground ratios from 1966-1970 (Table 3) were used to adjust the breeding population indexes in 1965 when no air:ground comparisons were made.

Breeding Population Estimates

The annual regional indexes were prorated into mallards, blue-winged teal and "other" ducks on the basis of the observed species composition of regional aerial transects. The unadjusted regional totals for mallards, blue-winged teal and all other ducks combined were summed to obtain annual "statewide" indexes for each group (Appendix C). These annual statewide indexes were adjusted for missed birds by dividing by annual air:ground ratios (Table 3). By combining adjusted results for mallards, etc., an annual total population estimate in the 3 regions was derived. Annual regional population estimate (Table 4) were obtained in a similar manner, only using regional indexes.

The total breeding population estimate in the 3 regions for 1965-1970 averaged 266,000 ducks. Highest estimated numbers – 351,000 ducks – were present in 1970 and the lowest, 208,900 in 1968 (Table 3). Mallards were the most abundant breeding species, averaging 124,400 ducks per year. Blue-winged teal were second in abundance with an average annual breeding population of 89,000 ducks. All other species of ducks combined averaged 52,600 birds annually. Peak population estimates for mallards and blue-winged teal were recorded in 1970 (Table 3). Numbers of other species combined peaked in 1965. Mallards and blue-winged teal were estimated in lowest numbers during 1966, but the low for other species combined occurred in 1968. Annual regional population estimates for all ducks combined are listed in Table 4.

Annual breeding population estimates followed the same trends as the annual weighted mean breeding duck densities (Fig. 3). Populations declined between 1965 and 1966, and also between 1966 and 1968 (populations presumably declined or remained stable between 1966 and 1967), then increased each year between 1968 and 1970.

Species Composition and Distribution

Average population estimates for all ducks observed on the aerial surveys are listed by species in Table 5. Mallards and blue-winged teal represented 50 percent and 30 percent, respectively, of all breeding ducks seen by aerial crews. However, mallards made up 47 percent and blue-winged teal comprised 34 percent of the totals when adjusted for ducks present but not seen. Using the adjusted breeding population estimates for "other" ducks (from Table 3), prorated on the basis of the annual species composition observed during aerial surveys of each region, the size of regional breeding populations was estimated for each of the 12 less common species.

TABLE 3. *Air:Ground Ratios and Breeding Population Estimates for All Regions Combined, 1965-1970*

Species and Year	Breeding Pop. Index	Air:Ground Ratio**	Breeding Pop. Estimate
1965			
Mallard	28,106	.23 (57/248)	122,200
Blue-winged teal	17,610	.17 (95/548)	103,600
Others*	16,796	.22 (58/260)	76,300
Total	62,512		302,100
1966			
Mallard	25,544	.25 (35/142)	102,200
Blue-winged teal	12,016	.18 (50/279)	66,800
Others*	9,896	.23 (47/202)	43,000
Total	47,456		212,000
1968			
Mallard	20,629	.20 (3/15)	103,100
Blue-winged teal	11,080	.13 (6/46)	85,200
Others*	7,821	.38 (3/8)	20,600
Total	39,530		208,900
1969			
Mallard	23,989	.19 (7/37)	126,200
Blue-winged teal	17,206	.21 (25/120)	81,900
Others*	9,061	.19 (4/21)	47,700
Total	50,256		255,800
1970			
Mallard	37,012	.22 (12/54)	168,200
Blue-winged teal	15,040	.14 (14/103)	107,400
Others*	10,553	.14 (4/29)	75,400
Total	62,605		351,000

*Includes all other identified and unidentified species of breeding ducks.
**Ratios for 1965 are based on overall air:ground ratios from 1966-1970.

TABLE 4. *Regional Breeding Population Estimates, 1965-1970*

	Breeding Ducks (in Thousands)					
Region	1965	1966	1968	1969	1970	Avg.
SE/Central	181.3	91.7	122.9	165.8	179.8	148.3
Northwest	59.4	40.8	38.4	35.6	70.5	48.9
Low Density	61.5	79.5	47.6	54.6	100.9	68.8
All Regions	302.2	212.0	208.9	256.0	351.2	266.0

In addition to mallards and blue-winged teal, 5 species – wood ducks, black ducks, ring-necked ducks, shovelers and green-winged teal – made up 1 percent or more of the total breeding ducks present in each region. All other species averaged less than 1,500 breeding birds annually (Table 5).

Annual breeding population estimates for the less common species were quite variable between years. In several years, less common species like ruddy ducks or gadwalls were not seen on the aerial counts even though breeding pairs were undoubtedly present in Wisconsin. One or two additional pairs seen on the aerial counts had a considerable effect on annual population estimates for the less common ducks. For this reason, *average* population figures from Table 5 for each species of ducks other than mallards or blue-winged teal are probably the "best" indicators of relative abundance in Wisconsin.

The size of the wood duck population was estimated at 9,200 breeding ducks (Table 5). Besides being quite secretive in their habits, wood ducks utilize tree-lined streams, wooded swamps, etc., which are almost impossible to census adequately. Stream habitats frequented by wood ducks are, therefore, probably under-represented in the aerial surveys and in the air:ground comparisons. The limited air:ground data for wood ducks suggest that less than 20 percent of the birds present were seen during the aerial count. Air:ground ratios used to correct for missed ducks of "other" species, including wood ducks (Table 3), assumed that between 14 and 38 percent of the birds present were seen. In applying this correction factor for all "other" ducks to wood ducks, we probably over-estimated our ability to count wood ducks by air in at least 3 of the 5 years. Since hooded mergansers are quite similar to wood ducks in their habitat, population estimates for this species may also be under-represented.

Average regional populations of total ducks were highest in the SE/Central and lowest in the Northwest (Table 4). The SE/Central region also had the highest average population estimates for mallards, blue-winged teal, wood ducks, shovelers, green-winged teal, pintail, redheads and ruddy ducks (Table 5). Black ducks, ring-necked ducks and mergansers were present in greatest numbers in the primarily forested Low Density region. Gadwall were recorded only in the Northwest region.

Unidentified ducks represented 14 percent of the birds observed on the 1965 flights. Repeated circling of unidentified ducks was adopted about mid-way through the 1965 survey (Martz, 1965) and continued on all subsequent surveys. This reduced the unidentified portion to 3-6 percent of the 1966-1970 aerial counts. Air:ground ratios for "other" species were used to correct the breeding population indexes of unidentified ducks. The breeding population estimate averaged about 16,300 unidentified birds (Table 5). However, if the 1965 estimate (38,600 unidentified ducks) is omitted, the unidentified category averaged only 10,100 ducks. Unknown ducks were not prorated to species on the basis of species composition observed on the aerial counts since mallards probably did not represent the major part of the unidentified ducks. Mallards were usually the most conspicuous and most easily recognized species from the air. Inconspicuous ducks such as blue-winged teal, green-winged teal or wood ducks, plus the less common species, probably made up the largest portion of the unknown birds. Species composition observed during ground censuses was also not used to prorate unidentified ducks by species because of the limited samples of birds other than mallards or blue-winged teal.

Management Areas

Observed breeding densities on the 5 state management areas surveyed by air averaged 16 ducks per square mile (Table 6). This density was approximately 14 times greater than the average weighted mean density for the 3 regions. Within their respective regions, densities on individual areas were 5 (Sandhill) to 8 (Horicon) times greater than mean densities in the surrounding countryside. Highest average density observed on a single management area was 34 ducks per square mile on Horicon Marsh. Visibility of breeding ducks may be better on Horicon Marsh than on the other areas since the marsh has the least amount of woody habitat. Eldorado Marsh, located closest to Horicon Marsh, had the second highest density. Sandhill and Mead, which are near one another geographically, had similar observed densities. Visibility may also have affected the number of ducks seen on Mead since that area has a greater amount of flooded brush, etc., in which breeding birds would be more difficult to see.

The acreage encompassed by the 5 management areas – about 121 square miles – represented approximately 0.3 percent of the acreage encompassed by the 3 regions. The average breeding population index for the 5 areas combined (1,940 ducks) represented 4 percent of the total breeding population index for the 3 regions. Crex Meadows, representing only 0.7 percent of the Northwest region, had an average index equal to 6 percent of the average index for that region. The largest contribution by a management area in the SE/Central region was Horicon Marsh Wildlife Area, with 2 percent of the regional index, but only 0.1 percent of the area.

Annual breeding population indexes from the management areas usually did not follow the same trends as the annual breeding population indexes from their regions. Indexes for 3 areas in the SE/Central region increased between 1965 and 1966 while the regional index declined during the same years. Crex Meadows indexes increased in 1968 and 1969 while indexes for the Northwest region showed no change. Habitat conditions on the management areas may have influenced the size of breeding populations more so than annual regional breeding densities.

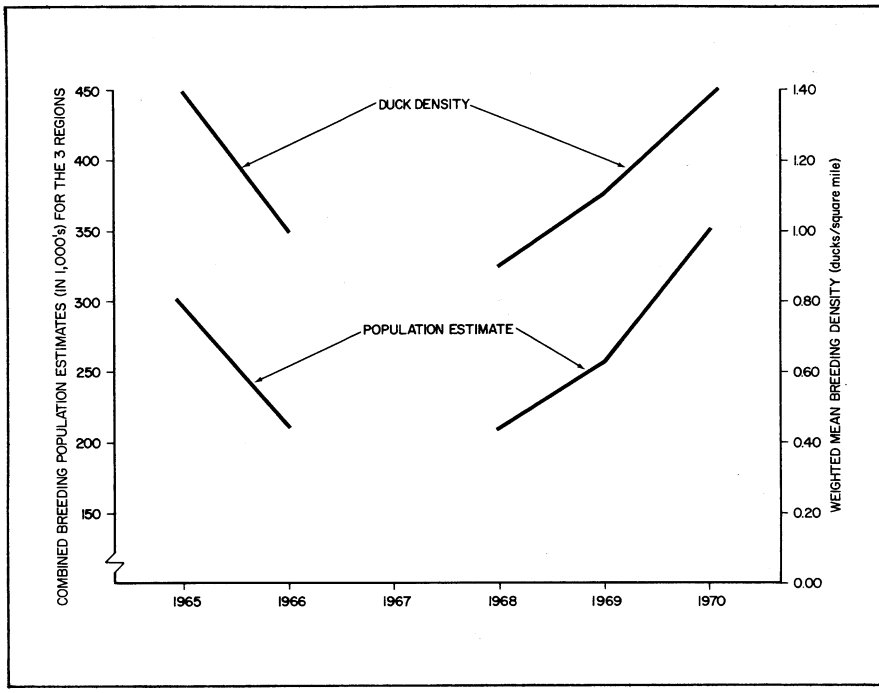


FIGURE 3

Comparison of trends in breeding duck densities and breeding population estimates, for the 3 regions combined 196501970.

TABLE 5. *Average Regional Breeding Population Estimates by Species, 1965-1970*

Species	Breeding Ducks (in Thousands) SE/Central	Northwest	Low Density	Total	Percent of Ducks Present	Seen
Dabblers						
Mallard	63.3	22.0	39.0	124.4	47	50
Blue-winged teal	58.5	17.0	13.5	89.0	34	30
Wood duck	3.9	2.2	3.1	9.2	3	3
Black duck	1.4	1.2	4.5	7.1	3	2
Shoveler	4.7	0.0	0.3	5.0	2	2
Green-winged teal	1.7	0.4	0.8	3.0	1	1
Pintail	1.0	0.3	0.0	1.3	T	1
Gadwall	0.0	0.3	0.0	0.3	T	T
Subtotal	134.5	43.4	61.2	239.3	90	89
Divers						
Ring-necked duck	1.9	2.0	2.6	6.5	2	2
Hooded merganser	0.0	0.5	0.9	1.4	T	T
Redhead	1.3	0.0	0.0	1.3	T	1
Red-breasted and common mergansers	0.0	0.2	0.5	0.8	T	T
Ruddy duck	0.3	0.2	0.0	0.4	T	T
Subtotal	3.5	2.9	4.0	10.4	3	3
Unidentified ducks	10.3	2.6	3.4	16.3	6	7
TOTAL	148.3	48.9	68.6	266.0	99	99

Southwest Wisconsin

Upper Mississippi NWR

Breeding population estimates for the Upper Mississippi NWR averaged about 4,400 ducks during 1966-1970 (Table 7). Wood ducks and mallards were the two most abundant species. Between 100 and 300 blue-winged teal and hooded mergansers were found on the Refuge each year along with 25 to 50 black ducks and green-winged teal. Population trends for the Refuge were similar to those found in the 3 major regions (Table 7). The Refuge population declined from 1966 to 1967 as was also suspected for the 3 regions. No estimate of annual sampling error is available for Refuge population estimates.

TABLE 6. *Annual Breeding Population Indexes and Average Breeding Duck Densities for 5 DNR Waterfowl Management Areas, 1965-1969*

Management Area	Square Miles in Area	Avg. No. Ducks Per Square Mile	Breeding Population Indexes*				
			1965	1966	1968	1969	Avg.
Mead	40.4	11	345	370	410	590	430
Crex Meadows	39.4	16	780	420	540	700	610
Horicon Marsh	17.0	34	520	460	–	760	580
Sandhill	14.8	10	40+	145	210	210	150
Eldorado Marsh	9.1	19	130	170	170	210	170

*Computed from duck densities observed along ¼-mile transects flown across areas at ½-mile intervals along section and ½-section lines.

TABLE 7. *Annual Breeding Population Estimates for the Upper Mississippi NWR, the Driftless Area and the 3 Regions, 1966-1970*

Region and Species	Breeding Population Estimates (in Thousands)					
	1966	1967	1968	1969	1970	Avg.
Southwest Wis.						
Upper Miss. NWR						
Wood duck	3.0	2.3	1.9	2.9	2.6	2.5
Mallard	1.2	1.3	1.3	1.4	2.1	1.5
Blue-winged teal	0.2	0.3	0.2	0.2	0.2	0.2
Hooded merganser	0.3	0.1	0.1	0.1	0.1	0.1
Subtotal	4.7	4.0	3.6	4.7	5.1	4.4
Driftless Area	5.0	5.0	5.0	5.0	5.0	5.0
Total	9.7	9.0	8.6	9.7	10.1	9.4
3 Regions	212.0	—	208.9	255.8	351.0	266.0
STATEWIDE	221.7	—	217.5	265.5	361.1	275.4

Driftless Area

Based on 1949-1950 densities, a breeding population index of about 1,000 ducks was assigned to the Driftless Area, exclusive of the Upper Mississippi NWR. Expansion of this index by .200 – the overall air:ground ratio for all species and regions during 1966-1970 – yielded an estimated annual population of 5,000 breeding ducks in the Driftless Area.

The combined estimate for the Upper Mississippi NWR and the Driftless Area averaged 9,400 ducks during 1966-1970 (Table 7). These estimates, together with the total population estimates from the 3 major regions, produced a statewide breeding population estimate of 275,400 ducks (Table 7). This estimate ranged from 217,500 ducks in 1968 to 361,100 in 1970.

BREEDING PHENOLOGY

Counts of lone males plus flocks of 2-5 males (expressed as a percent of total indicated pairs seen on the aerial surveys, i.e., a "lone drake" index) was used as an indication of the progress of the annual breeding cycle. The annual data were sufficient to obtain lone drake indexes for only mallards and blue-winged teal.

Lone drake indexes for mallards on transects lying south of 45 degrees Latitude (Figs. 1 and 2) averaged 72 percent (range of 67-74 percent) of the total indicated breeding pairs of that species. North of 45 degrees, the lone drake index was higher, averaging 88 percent (range of 84-96 percent). A high lone drake index suggests that mallard laying and incubation were well underway at the time of survey.

Of the total number of mallard breeding pairs, lone drakes comprised the smallest proportions in 1965 (84 percent north of 45 degrees) and 1970 (67 percent south of 45 degrees). This suggests that the mallard breeding cycle was least advanced in those 2 years. But even in the "low" years, at least two-thirds or more of the hens must have been laying or incubating.

Lone drake indexes were much lower for blue-winged teal than for mallards. For transects south of 45 degrees, lone drake indexes averaged only 26 percent of the total breeding pairs, and for transects north of 45 degrees, they comprised 51 percent. Aerial surveys were apparently made during the prelaying or laying periods for blue-winged teal since many drakes were still accompanied by hens. Lone drake indexes north of 45 degrees had the broadest range, 33-73 percent, for individual years. Considerable variation between years suggests that surveys north of 45 degrees were made at different stages of the blue-winged teal breeding cycle each year. The 1965 and 1968 surveys apparently were flown at the earliest stages since lone drake indexes were lowest in those years. South of 45 degrees, lone drake indexes were less variable, with annual values ranging between 20 and 33 percent.

PRECIPITATION

Monthly weather summaries prepared for Wisconsin by the U. S. Department of Commerce, Environmental Data Service, were used to determine regional precipitation during the survey years. The average regional precipitation during August through the end of the aerial survey the following May was assumed to be the moisture which had the greatest influence on wetland habitat conditions each year. For all regions surveyed, August-May precipitation averaged 20.6 inches (14.6-27.2 inches in various years). Least amounts fell during 1969-1970 and the most, in 1965-66 (Fig. 4). Rain and snow during August-November contributed 50-62 percent of the annual August-May totals. December-March snowfall represented 17-31 percent of the totals, and April-May moisture (primarily rain), 8-29 percent. In the average 10-month period, 55 percent of the precipitation came during August-November, 27 percent during December-March and 18 percent during April-May.

Greatest August-May precipitation in both the SE/Central and Northwest regions was recorded in 1965-66 (Fig. 4). The wettest 10-month period in the Low Density region came during August-May, 1964-65. All regions received the least August-May precipitation in 1969-1970.

WETLAND NUMBERS AND USE

Density

Overall mean density of wetlands having surface water during 1965-1970, weighted for differences in regional area, averaged 12.5 per square mile (Table 8). The unweighted 1966-1970 average of the mean annual regional densities, with 95 percent confidence limits, was 11.8 ± 1.2 wetlands per square mile. Although the August-May, 1964-65 precipitation was only equal to the average 1964-1970 August-May precipitation (Fig. 4), highest mean wetland density for the 3 regions combined was recorded in 1965 (Table 8). Driest conditions were encountered in 1970 when the 1969-1970 August-May precipitation was 6 inches below average (Fig. 4). The Low Density region had the greatest average wetland density, but accounted for the highest annual regional density in only 2 years (Table 8). Highest regional density recorded during 1965-1970 was 16.6 wetlands per square mile in the Northwest region in 1965.

Differences in the 1966-1970 yearly and/or regional wetland densities were tested by an analysis of variance, two-way classification (Snedecor and Cochran, 1967). The 1965 data were excluded because of the differences in sampling scheme in that year. A conventional analysis of variance was used instead of the Friedman Test (used for differences in breeding duck density) since wetlands per transect approximated a normal distribution (D. R. Thompson, pers. comm., 1972). Individual mean annual regional densities served as replicates. Means were compared since it was shown previously that the overall sample seemed to comprise a reasonable variance-weighted sample of duck density (D. R. Thompson,

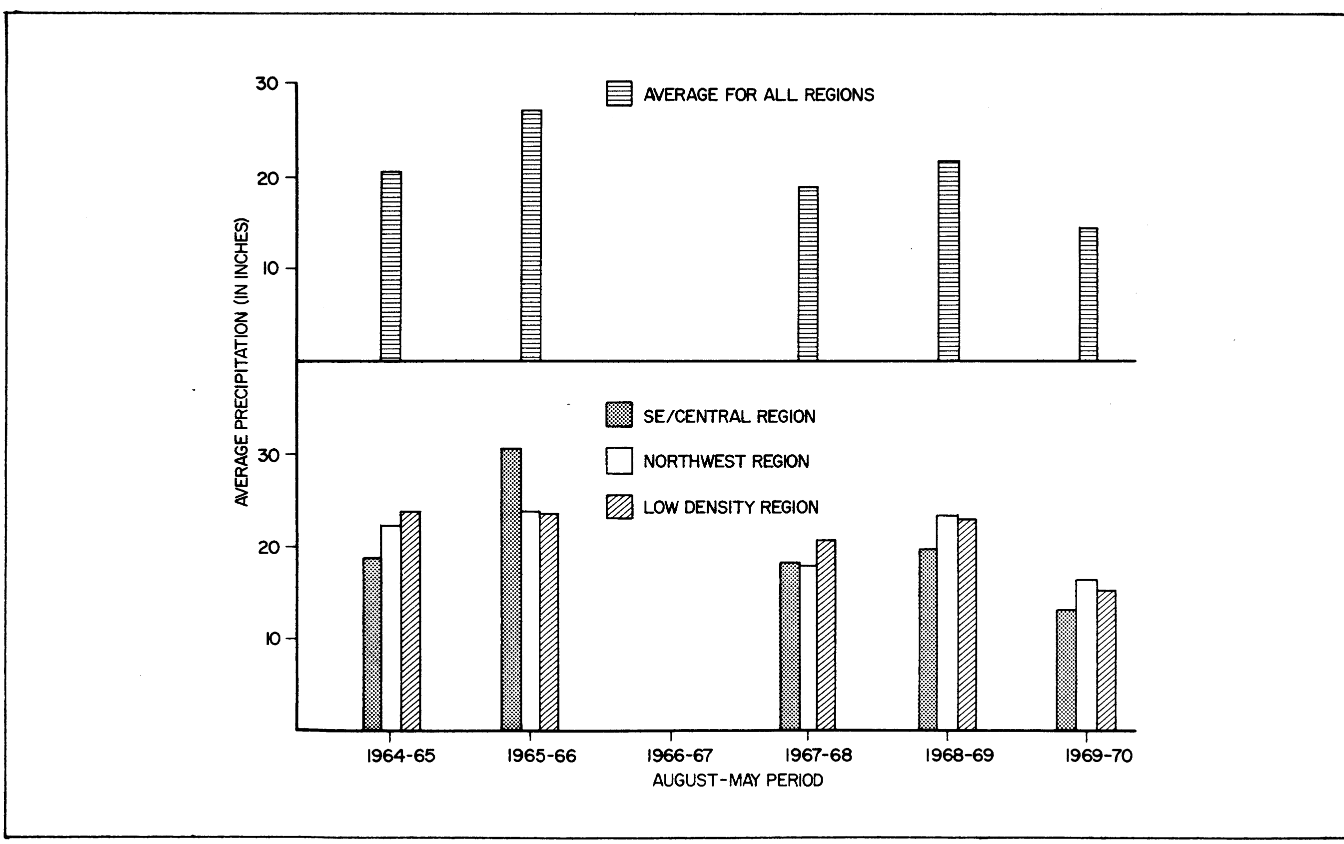


FIGURE 4
Average August-May precipitation for each region and for all regions combined, 1964-1970 (from monthly reports put out by the U.S. Dep. of Commerce Environmental Data Service).

pers. comm., 1972). This allowed us to combine regional allocations on an equivalent basis. F-ratios for effects of regions (F=0.84; 2 and 6 d.f.) and also years (F=1.84; 3 and 6 d.f.) were well below those needed for the desired significance level of P=0.05 (Appendix D). Differences between individual years were also found to be below the P=0.05 level of significance. Largest F-ratio was obtained between 1966 and 1970, but it was not significant (F=3.75; 1 and 4 d.f.). By assuming that the 1965-1970 surveys approximated a properly weighted stratified random sample, and using the number of wetlands recorded on individual transects, confidence intervals were calculated for annual weighted mean wetland densities in Table 8. The degree of overlap of these intervals, together with results of the analysis of variance, indicates little change in overall wetland density in the 3 regions between 1965 and 1970. Densities between individual regions showed greater variability. Inspection of confidence intervals from Table 8, and also the confidence interval calculated for the unweighted average wetland density (11.8 ± 1.2), suggests that differences in overall annual wetland abundance of ± 20 percent should easily be detected, but not changes of ± 10 percent. Based on wetland density during the 1965-1970 surveys, a change of ± 20 percent must occur infrequently in Wisconsin.

Decline in the average weighted mean wetland densities between 1965-66 (13.9 per square mile) and 1968-1970 (11.6 per square mile) is at least partially representative of differences in observers during the 2 periods. On the aerial surveys the observer, within only a few seconds, had to: (1) decide whether a wetland fell within the 1/8-mile strip, (2) subjectively classify its "type" and (3) scan the area for breeding waterfowl. Such a procedure is quite susceptible to biases that would vary with observers. Since different observers were used in 1965-66 and 1968-1970, these biases probably affected the recorded density.

Possible observer bias is especially important when considering annual differences in abundance of the various types of wetlands. Temporary (Types I-II, VI) or semi-permanent (Type III) ponds and marshes were the most abundant wetlands, averaging about 47 percent of the total annual wetland densities shown in Table 8. Permanent areas (Types IV-V) averaged 17 percent of the annual densities; streams, 21 percent; ditches, 11 percent and Types VII-VIII (wooded or shrub swamps and bogs), 4 percent.

Regionally, combined lake, pond and marsh densities were highest in the Northwest and Low Density regions (Table 8). Greatest average density of Type IV and V wetlands was in the Northwest region (Table 8). Type I and II wetlands were more abundant in the SE/Central and Low Density regions. Stream density was highest in the Low Density region, while the SE/Central region was the most heavily ditched. There were more than twice as many ditches per square mile in the SE/Central region as in the Low Density region and more than 20 times as many as found in the Northwest region (Table 8).

TABLE 8. *Annual Regional Wetland Densities by Wetland Type, Weighted Mean Density, Standard Error of Means and 95 Percent Confidence Limits, 1965-1970*

Region and Wetland Type	No. Wetlands Seen per Square Mile 1965	1966	1968	1969	1970	Avg.
SE/Central						
I–II, VI	4.7	2.7	4.1	5.8	2.5	4.0
III	1.4	1.7	0.7	1.1	1.3	1.2
IV–V	2.0	1.6	1.5	1.4	2.0	1.7
VII–VIII	0.5	0.3	0.2	0.1	0.1	0.2
All Lakes, Ponds & Marshes	8.6	6.3	6.5	8.4	5.9	7.1
Streams	2.2	2.4	2.3	2.2	2.2	2.3
Ditches	2.1	2.2	2.4	2.6	1.8	2.2
All Wetlands	12.9	11.0	11.3	13.3	9.9	11.8
Northwest						
I–II, VI	4.2	3.0	2.3	3.0	2.2	3.0
III	6.6	4.1	1.5	2.0	2.1	3.3
IV–V	3.6	4.8	3.4	3.6	3.6	3.8
VII–VIII	0.6	1.0	0.1	0.1	0.1	0.4
All Lakes, Ponds & Marshes	15.0	12.9	7.3	8.7	8.0	10.5
Streams	1.6	2.3	1.9	1.6	1.8	1.8
Ditches	0.1	0.2	0.2	0.1	0.1	0.1
All Wetlands	16.6	15.4	9.4	10.6	10.0	12.4
Low Density						
I–II, VI	3.4	3.0	4.2	4.5	4.7	3.9
III	4.1	2.9	1.5	1.3	1.3	2.2
IV–V	1.9	2.7	2.1	1.6	1.8	2.0
VII–VIII	0.8	1.2	0.6	0.1	0.2	0.6
All Lakes, Ponds & Marshes	10.2	9.8	8.4	7.5	8.0	8.7
Streams	3.2	4.2	3.2	2.8	3.3	3.3
Ditches	0.7	1.0	0.8	0.9	1.0	0.9
All Wetlands	14.0	15.1	12.6	11.3	12.2	13.0
Weighted Mean Density	14.0	13.8	11.8	11.8	11.2	12.5
95% C. L.	12.4-15.6	12.0-15.6	9.9-13.7	10.5-13.1	9.3-13.1	–
95% C. L. as % of Mean	11	13	16	11	17	–

TABLE 9. *Percent Occupancy of Wetland Types, 1965-1970*

Year	Percent of Wetlands on Which Ducks Were Seen: Lakes, Ponds and Marshes: Type I	Type II & VI	Type III	Type IV	Type V	Type VII-VIII	Streams	Ditches	All Wetlands
1965	5.0	1.4	3.3	8.2	10.8	0.3	2.0	4.4	3.6
1966	1.0	1.4	2.0	8.9	8.4	0.0	2.0	2.0	3.0
1968	2.3	1.4	5.2	10.9	8.9	0.0	1.9	3.3	3.7
1969	2.0	3.4	7.4	10.3	6.6	4.2	4.6	2.0	4.4
1970	0.0	0.5	4.7	13.8	8.9	4.3	5.5	2.0	4.4
Avg.	2.1	1.6	4.5	10.4	8.7	1.8	3.2	2.7	3.8

TABLE 10. *Average Percent Occupancy of Wetland Types by Region, 1965-1970*

Region	Percent of Wetlands on which Ducks were Seen: Lakes, Ponds and Marshes: Type I	Type II & VI	Type III	Type IV	Type V	Type VII-VIII	Streams	Ditches	All Wetlands
SE/Central	2.8	3.2	8.5	15.2	13.1	2.2	5.5	2.6	5.7
Northwest	3.1	0.6	4.0	10.6	14.0	0.0	3.3	0.0	5.4
Low Density	0.7	0.2	1.9	4.3	5.0	0.0	1.3	0.9	1.5

Occupancy

Observed breeding duck use of wetlands lying within the 1/8-mile strip on the right side of the aircraft was taken as an index to annual occupancy rates. The average occupancy rate for all types of wetlands during 1965-1970, based solely on breeding ducks seen by the aerial crew, was 3.8 percent (Table 9). Highest occupancy was recorded in 1969 and 1970. Occupancy rates in 1966 were the lowest in the 5 years. Average regional occupancy rates were highest in the SE/Central and lowest in the Low Density region (Table 10).

Observed occupancy in each region was greatest on Type IV and V wetlands, averaging between 6.6 and 13.8 percent annually (Table 9). Average occupancy was highest for Type IV wetlands. Type III wetlands received intermediate use and the lowest occupancy was observed on the temporary wetlands (Types I, II, VI, VII and VIII). Occupancy on streams and ditches was slightly higher than that on temporary wetlands (Table 9). Average occupancy rates for streams were higher than those for ditches.

Observed occupancy of all wetlands combined was quite similar between the SE/Central and Northwest regions, but occupancy in the Low Density region was considerably lower (Table 10). Occupancy of all wetlands, except Types I and V, was highest in the SE/Central region (Table 10). Heaviest use of Type I and V areas came in the Northwest region. The most heavily used wetlands were Type IV wetlands in the SE/Central region (15.2 percent average annual occupancy). The greatest annual occupancy for a wetland type was 35.7 percent for Type V areas in the Northwest in 1965.

Breeding ducks were seen on more individual wetlands (227) in 1965, when 5 additional transects were censused, than in any other year (Table 11). When only 55 transects were covered, the highest number of occupied areas was 193 in 1969. (This includes areas on either side of the aircraft as does the 1965 figure.) For all regions, Type IV and V wetlands accounted for 25-54 percent of the occupied areas annually (Table 11). The 2 types averaged 42 percent of the total. Average occupancy of the remaining wetlands for all 3 regions combined was as follows: Types I-III and VI-VIII (31 percent), streams and ditches (26 percent). Greatest use was made of the temporary (Types I, II, VI-VIII) and semi-permanent (Type III) areas in 1969 when they accounted for 47 percent of the total occupied wetlands. Greatest use of ditches and streams was made in 1970 when they comprised 33 percent of all wetlands occupied during that year. Wetland Types VII and VIII received very little observed use by breeding ducks, and averaged less than 1 percent of the total occupied areas.

Breeding ducks utilized Type IV and V wetlands most heavily in the Northwest region (Table 11). These 2 types also accounted for an average of one-half (Low Density) to one-third (SE/Central) of the occupied wetlands in the other regions. Temporary (Types I, II, VI-VIII)

TABLE 11. *Percent of the Total Wetlands by "Type" on which Breeding Ducks were seen During Aerial Counts, 1965-1970**

Year and Region	Total No. Occupied Areas	Percent Total Occupied Areas: Types I-II, VI-VIII	Type III	Types IV-V	Streams and Ditches
1965					
SE/Central	140	28	19	29	23
Northwest	42	17	36	40	7
Low Density	45	7	20	51	22
All Regions	227	21	22	36	20
1966					
SE/Central	86	15	10	46	28
Northwest	27	4	0	85	11
Low Density	39	8	18	49	26
All Regions	152	11	10	54	25
1968					
SE/Central	102	17	13	41	29
Northwest	22	9	23	59	9
Low Density	21	24	19	43	14
All Regions	145	17	15	45	24
1969					
SE/Central	144	31	23	18	28
Northwest	30	13	23	53	10
Low Density	19	5	0	37	58
All Regions	193	26	21	25	28
1970					
SE/Central	112	2	13	46	38
Northwest	36	6	14	56	25
Low Density	37	5	11	59	24
All Regions	185	3	13	50	33
5-Year Average					
SE/Central	117	19	16	36	29
Northwest	31	10	19	59	12
Low Density	32	10	14	48	29
All Regions	180	15	16	42	26

*Includes all wetlands on either side of the plane on which breeding ducks were seen.

and semi-permanent (Type III) wetlands were utilized the most in the SE/Central region. Use of these types was similar in the other regions. Streams and ditches were of greatest importance in the SE/Central and Low Density regions (Table 11).

Chi-square tests (Snedecor and Cochran, 1967) were used to determine whether wetlands of a particular type(s) were occupied by breeding ducks more frequently than expected based on the abundance of these wetlands. The effects of wetland size on occupancy were not considered because data on wetland acreage were not gathered in the survey. The number of Type IV and V areas being used by breeding ducks (all species combined) was significantly greater ($P \leq 0.05$) than expected on the basis of the abundance of these 2 types in all regions, and occupancy of Type I and II wetlands was significantly less ($P \leq 0.05$). Mallards, when considered separately, occupied Types IV-V in all regions more frequently ($P \leq 0.05$) than expected and Types I and II, less frequently. Blue-winged teal occupied Type IV and V wetlands in all regions more frequently than expected and temporary types, less frequently in the SE/Central and Low Density regions ($P \leq 0.05$).

Type III wetlands in the SE/Central region were used more than expected ($P \leq 0.05$) by all ducks combined and individually by both mallards and blue-winged teal. In the Northwest region, use of Type III wetlands by all ducks combined and by mallards was lower than expected ($P \leq 0.05$). Type III wetlands were not used significantly more than expected by blue-winged teal in the Northwest region, nor by all ducks combined or mallards in the Low Density region ($P \leq 0.05$).

In the SE/Central region, streams and ditches were occupied by breeding ducks (all species) less than expected based on the abundance of these areas. In the other 2 regions, occupancy of streams and ditches was no different than expected for all ducks ($P \leq 0.05$).

HABITAT TRENDS

SE/Central Region

Regional lake, pond and marsh density (all types) declined 27 percent between 1965 and 1966 (Table 8). Water was less abundant even though August-March precipitation in 1965-1966 was the heaviest recorded for that region during the entire study period. Moisture in April and May, 1966, however, was the lowest amount measured during these 2 months from 1965 to 1970. The lack of spring rainfall could have accounted for the reduction in temporary wetlands (Types I, II, VI-VIII) – the types which decreased the most (Table 8). Density of lakes, ponds and marshes in 1968 was similar to that in 1966. Precipitation in 1967-68 was below average except during April and May which were wetter in 1968 than in any other April-May period from 1965-1970. The wet spring undoubtedly was responsible for the abundance of temporary wetlands in 1968 (Table 8). With density of lakes, ponds and marshes in 1969 29 percent above that recorded in 1968, temporary wetlands (Types I, II, VI-VIII) reached their highest level of abundance since 1965. The August-May precipitation in 1968-69 was about one inch greater than in 1967-68 and was average for the 1964-1970 period (Fig. 4). The spring of 1970 was the driest of the 5 survey years, with less than 6 lakes, ponds or marshes per square mile. Density of Type I and II wetlands in 1970 was less than half that recorded in 1969. August-May, 1969-1970 was also the driest 10-month period for the region, with precipitation almost 7 inches below the 6-year average (Fig. 4).

Fluctuations in the region's temporary and semi-permanent wetlands were principally responsible for annual changes in density. Density of Types I-II fluctuated an average of 48 percent from year to year, and density of Type III's, 40 percent. Density of Type IV and V wetlands changed annually only an average of 15 percent. Stream and ditch abundance changed little from year to year (Table 8); stream densities showed an average difference of 8 percent, and ditch density, 13 percent. The amount of runoff occurring at the time of survey probably was a major factor affecting the number of streams and ditches with surface water.

Northwest Region

Density of lakes, ponds and marshes dropped from 15.0 per square mile in 1965 to 12.9 per square mile in 1966 – a decline of 14 percent. There were fewer areas with surface water in 1966 even though the August-March precipitation in 1965-66 was greater than that in 1964-65. However, April-May precipitation in the region was also the lowest recorded in those 2 months during 1965-1970. Regional lake, pond and marsh density continued its downward trend in 1968 (Table 8), dropping 43 percent below the density observed in 1966 and over 50 percent below that in 1965. Wetland Types I-III showed the largest declines. The scarcity of wetlands in 1968 may be a response to dry conditions in 1967-68. In terms of total

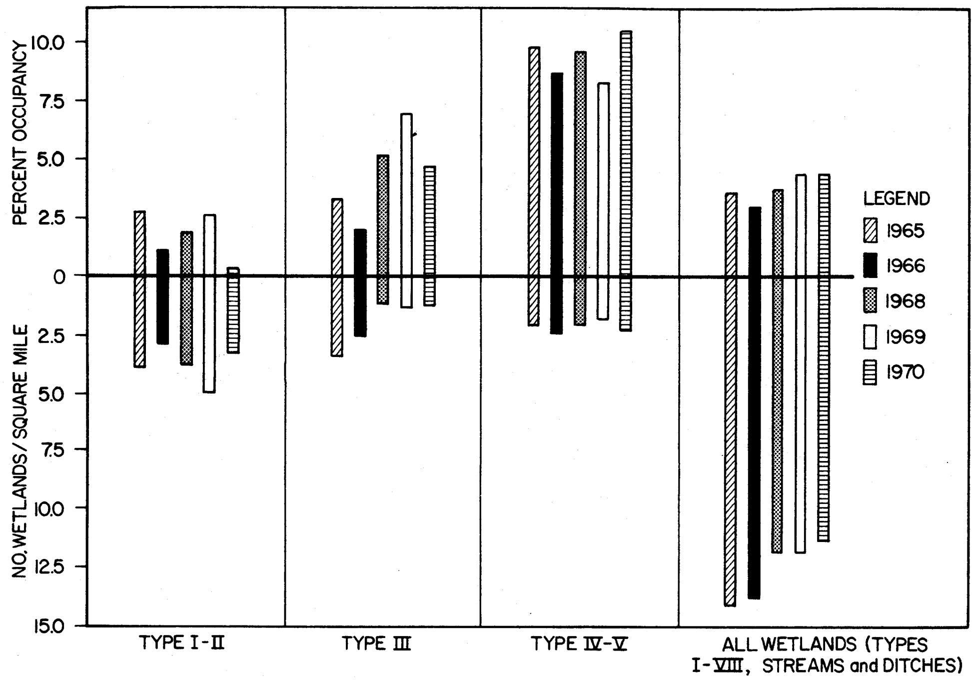


FIGURE 5
Relationship between percent occupancy and wetland density by wetland Types, 1965-1970.

August-May precipitation, that period in 1967-68 was the second driest recorded in the region during 1964-1970 (Fig. 4). Wet years in 1964-65 and 1965-66, followed 2 years later by an unusually dry August-May, may have exaggerated the apparent 1968 reduction in water areas. Wetland densities in 1968 were probably more representative of average conditions. In 1969, after the 1968-69 August-May precipitation approached the 1965-66 level, lake, pond and marsh density rose by 19 percent over 1968. Water might have been even more abundant in 1969 if the April-May rainfall had not been below average. Wetland density declined only slightly in spring, 1970, even though the 1969-1970 August-March precipitation was the second lowest recorded and April-May moisture was about average.

Fluctuations in lake, marsh and pond abundance in the Northwest region was also mainly the result of changes in density of Types I-III. These temporary and semi-permanent wetlands fluctuated annually – on the average, 31 percent. Density of Types IV-V changed 17 percent from year to year and streams, 22 percent. Ditches had little effect on the annual availability of water in the Northwest region since there were only 0.1-0.2 per square mile (Table 8).

Low Density Region

Total wetland density for the region increased slightly in 1966 (Table 8), but the number of lakes, ponds and marshes recorded per square mile declined from that recorded in 1965. Although the August-May precipitation in 1965-66 equalled that in 1964-65, the portion falling in April and May, 1966, was the least amount recorded in the 5 survey years. Lake, pond and marsh density dropped further in 1968 – a decline of 14 percent over 1966 – and 1969 – a decline of 11 percent over 1968. The 1968 density did not change as drastically as might be expected on the basis of the 1967-68 August-March precipitation which was over 10 inches less than that recorded in 1965-66. Rainfall in April and May, 1968, however, was above average. August-March precipitation in 1968-69 was about 3 inches more than in the previous year, but April-May precipitation in 1969 was over 1 inch less than precipitation during the same months in 1968. The density of lakes, ponds and marshes increased about 10 percent between 1969 and 1970 even though precipitation during August-May, 1969-1970, was the least amount recorded in the region (Fig. 4 and Table 8). This was the only region where wetland density increased rather than decreased after those extremely dry 10 months (August, 1969-March, 1970).

In contrast to the 2 other regions, temporary and semi-permanent wetlands in the Low Density region showed the least amount of year to year change in density – an average of 5 percent annually. Wetland Types VI-VIII exhibited the largest average annual change in density (71 percent), followed by Types IV-V which fluctuated on the average of 25 percent annually. Stream and ditch density fluctuated an average of 21 percent annually.

RELATIONSHIPS

Crissey (1969), Geis et al. (1969), Stoudt (1971) and Smith (1971) all suggest that on Canadian prairies, a direct relationship exists between pond numbers in May and breeding populations and between pond numbers in July and annual production. Given the number of breeding pairs, the number of ponds in May and in July and an index to brood production, it was possible to predict the number of mallard young reared annually (Geis et al., 1969). The possibility of a similar relationship existing in Wisconsin was examined using the 1965-1970 survey results. Figure 5 summarizes overall occupancy rates and densities for all wetlands and Types I-V. Standard linear correlation analyses (Snedecor and Cochran, 1967) were also used to test the significance of these and other relationships:*

1. *Breeding duck density and wetland density.* Weighted mean breeding duck densities for 1965-1970 were not significantly correlated with weighted mean wetland densities for 1965-1970. Also, no significant relationships were found between these 2 variables in any region. Annual mean densities of wetland Types I through V for the 3 regions combined had no significant relationship to annual weighted mean breeding duck densities when compared by individual types or in combinations of types. Significant correlations were also not obtained between densities of these specific wetland types in any region and the corresponding breeding duck densities in that region.

2. *Breeding duck density and wetland occupancy.* Annual occupancy of all wetland types combined was not significantly correlated with the annual, weighted mean breeding duck density. In the SE/Central region, however, annual percent occupancy of all wetlands, 1965-1970, was positively correlated with the annual breeding duck density for that region at P=0.05 (Fig. 6). Other regions failed to show similar relationships between wetland occupancy and breeding duck density.

Annual occupancy rates (in the 3 regions combined) for individual wetland types or for Types I-II, Types IV-V and Streams-Ditches combined were not significantly correlated with annual, weighted mean breeding duck densities. At the regional level, occupancy of individual or combined wetland types was significantly correlated only for occupancy of Types IV-V and breeding duck density in the Northwest region at P=0.10 (Fig. 7).

3. *Wetland density and wetland occupancy.* Weighted mean annual density of all wetlands for 1965-1970 was not significantly correlated with the annual observed occupancy rate in the 3 regions combined for all wetlands. Also, no significant relationships were found between annual regional occupancy and the corresponding annual wetland density of that region.

Comparisons between occupancy rates in the 3 regions combined and densities of specific wetland types, either separately or in combination(s), yielded only one significant correlation at $P \leq 0.10$: occupancy of Types I-III was negatively correlated ($P \leq 0.05$) with the density of wetland Types IV-V (Fig. 8). When this same relationship was tested in each region separately, the correlation was significant only in the Northwest region (Fig. 9).

4. *Wetland density and annual precipitation.* Average annual August-May precipitation in the 3 regions combined was not correlated with the annual

*Correlation coefficients were considered indicative of a mutual relationship if $P \leq 0.10$.

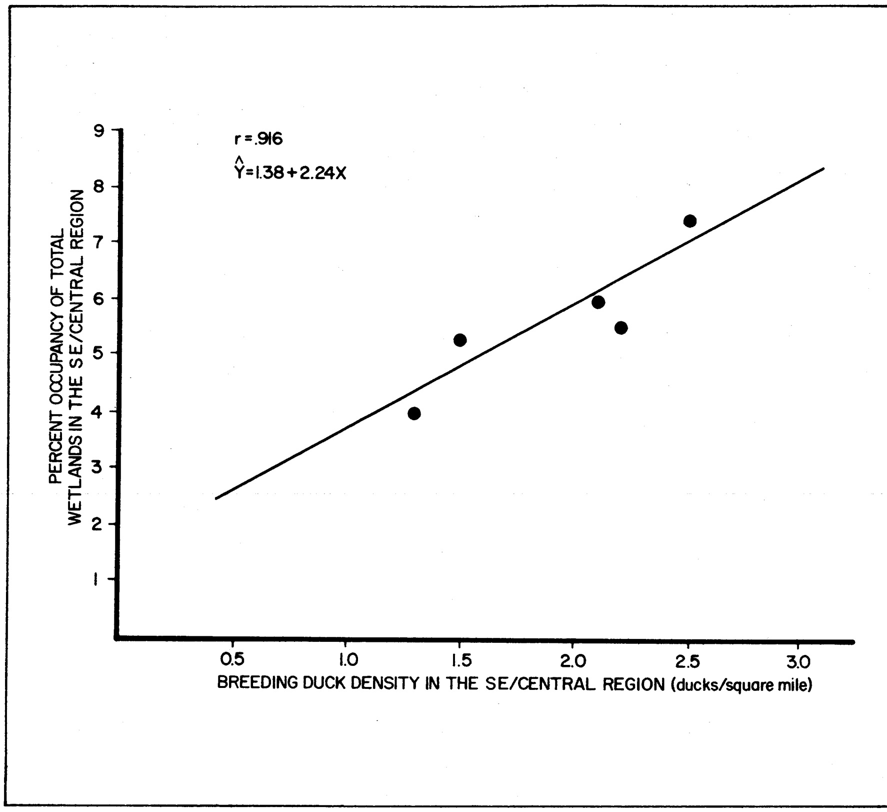


FIGURE 6
Relationship between percent occupancy of total wetlands and breeding duck density in the SE/Central Region, 1965-1970

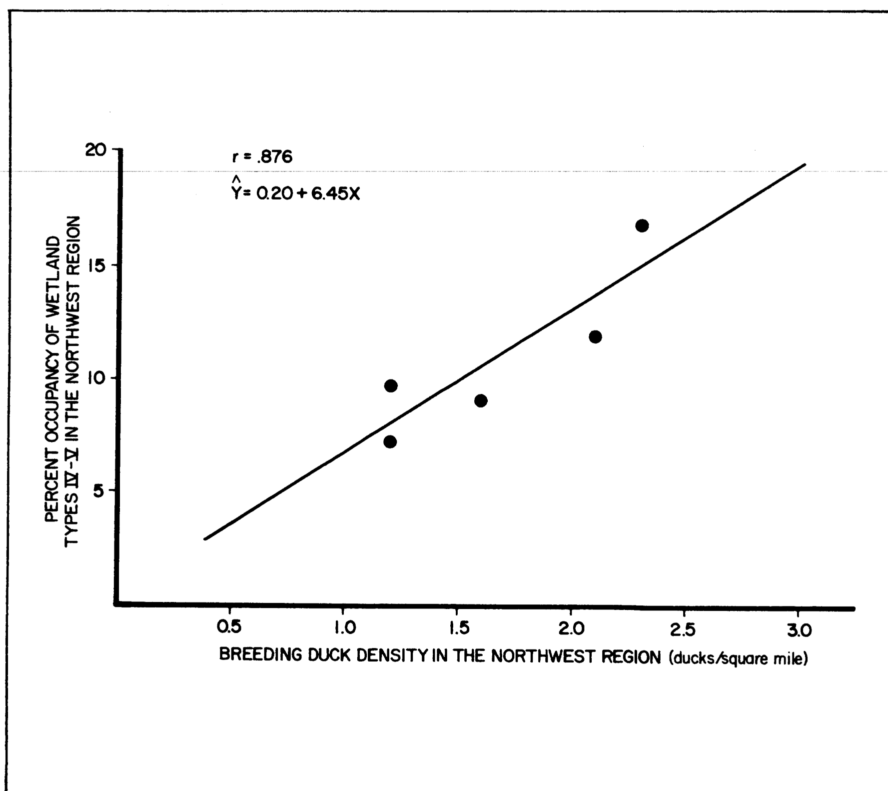


FIGURE 7
Relationship between percent occupancy of wetland Types IV–V and breeding duck density in the Northwest region, 1965-1970.

weighted mean wetland density. No significant relationships were found between annual regional August-May precipitation and the corresponding annual wetland density in that region.

August-May precipitation was split into 6 periods of 2 or more months (August-October; October-November; October-March; December-March; December-May; and April-May). Each period was tested for its relationship to wetland density in the following spring. Density of total wetlands, of lakes, ponds and marshes and of wetland Types I-III were used in the comparisons. No significant correlations were found when results for the 3 regions combined were tested. When these same comparisons were made for each region, no significant relationships were found at P–0.05. Annual October-March precipitation in the Low Density region, however, was correlated with annual total wetland density in the Low Density region at P–0.10 (Fig. 10).

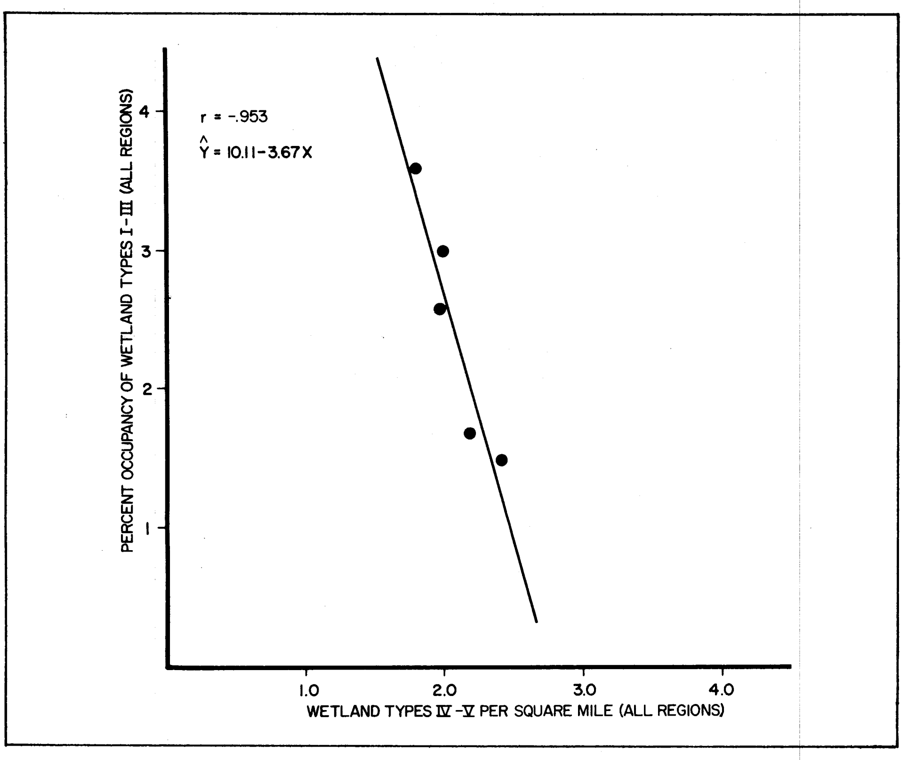


FIGURE 8
Relationship between percent occupancy of wetland Types I-III and density of wetland Types IV-V, for the 3 regions combined, 1965-1970.

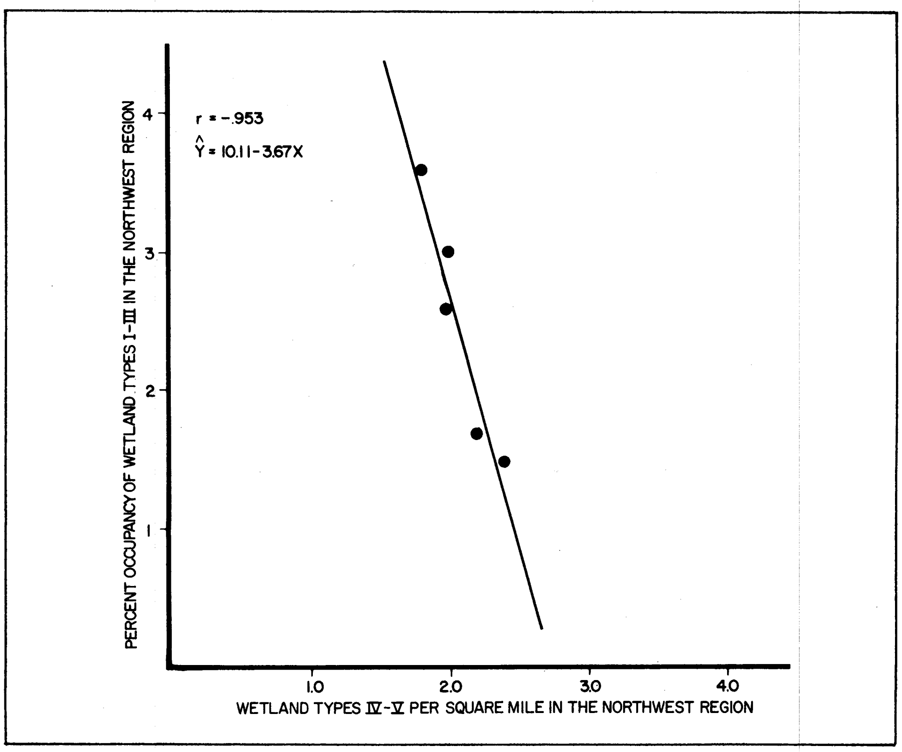


FIGURE 9
Relationship between percent occupancy of wetland Types I-III and density of wetland Types IV-V in the Northwest region, 1965-1970.

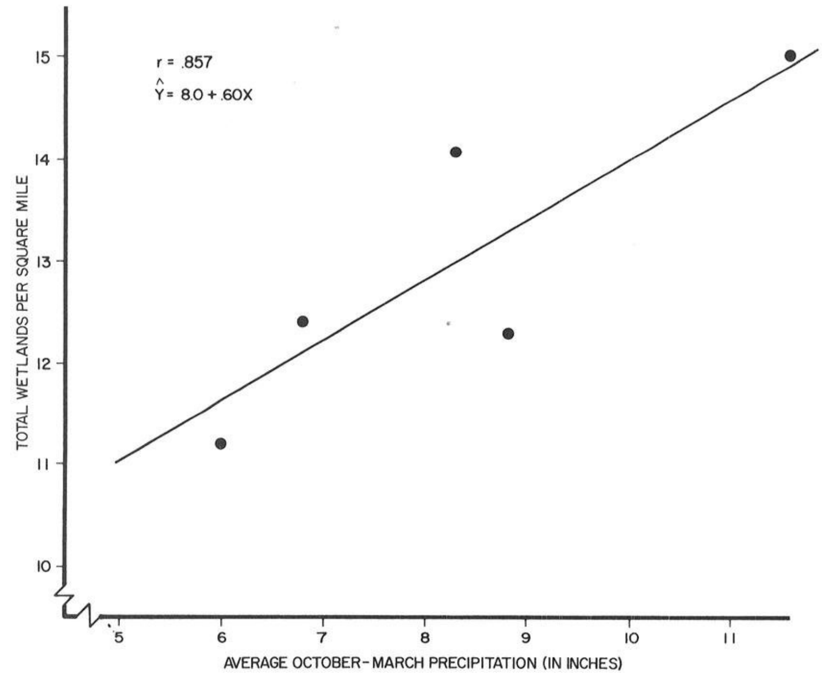
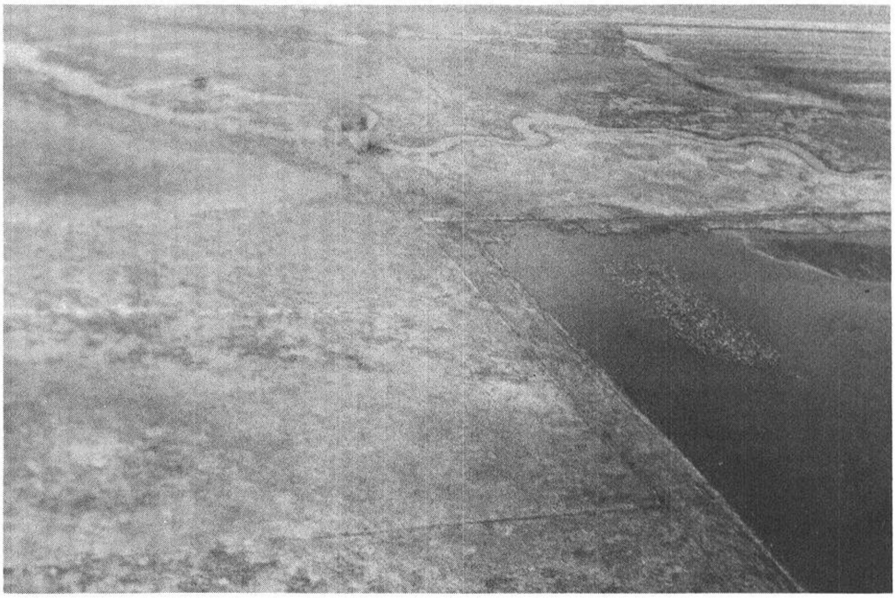
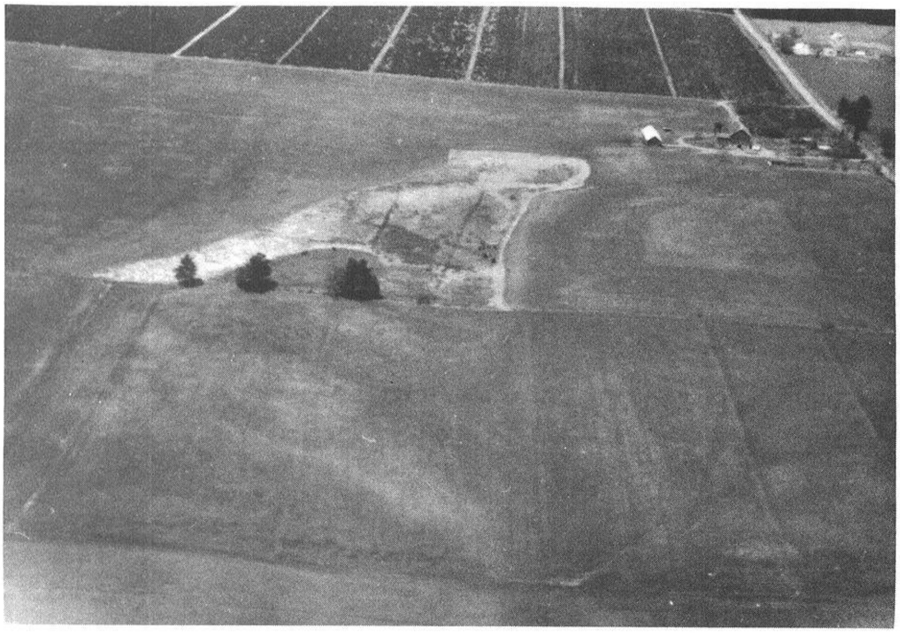


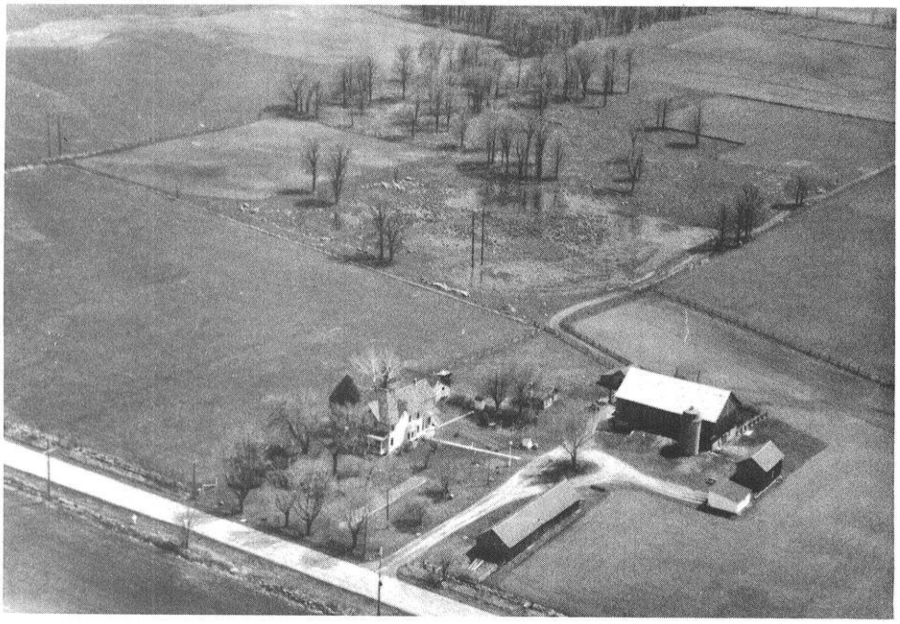
FIGURE 10
Relationship between wetland density and average October-March precipitation in the Low Density region, 1965-1970.



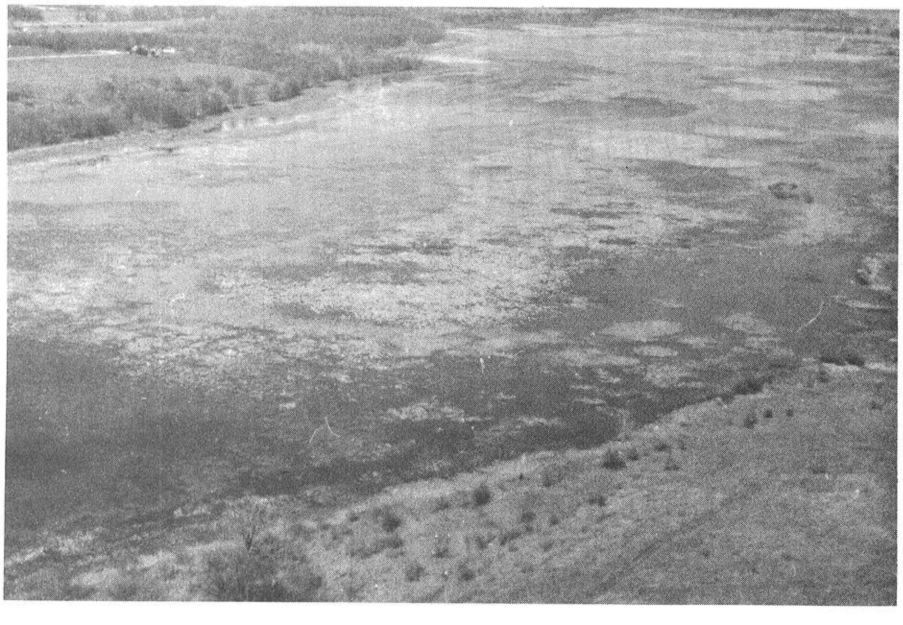
Seasonally flooded depressions in croplands or pastures (Type I wetlands) were the most abundant water areas in the SE/Central region during wet springs. The small meandering stream in the background is typical of similar streams which are attractive to blue-winged teal pairs and which also represent a major part of the region's permanent brood habitat. (Dodge County)



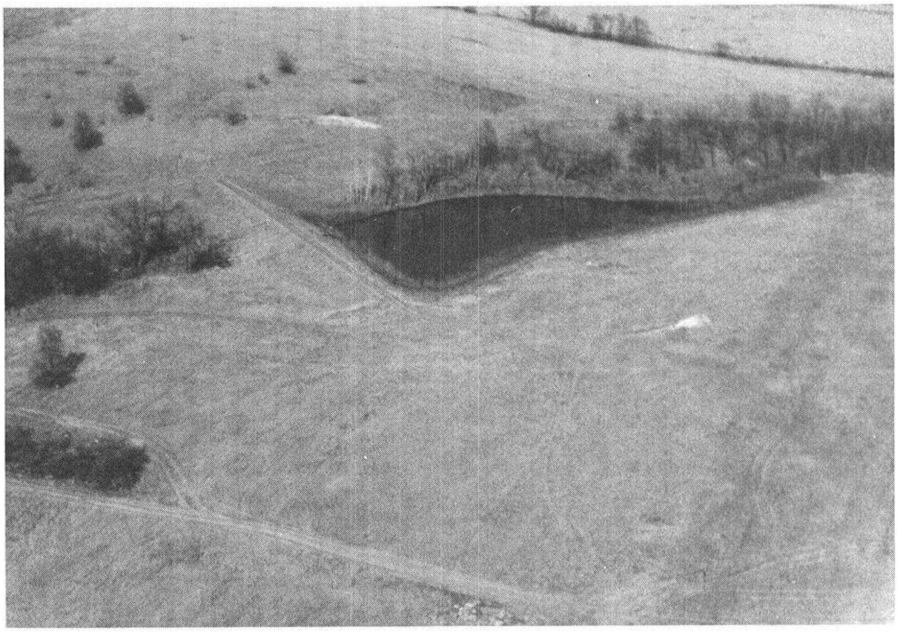
Type II wetlands (seasonally flooded sedge meadows, often with a partial brush overstory) were the most abundant wetlands in the SE/Central and Low Density regions in most years. Often overgrazed, these areas are dry by July 1 under normal precipitation conditions. (Waupaca County)



Cattail- and bulrush-rimmed marshes (also the deeper flooded alder bottoms and willow/dogwood areas) expected to go dry by July 15 were classified as Type III wetlands. (Oconto County)

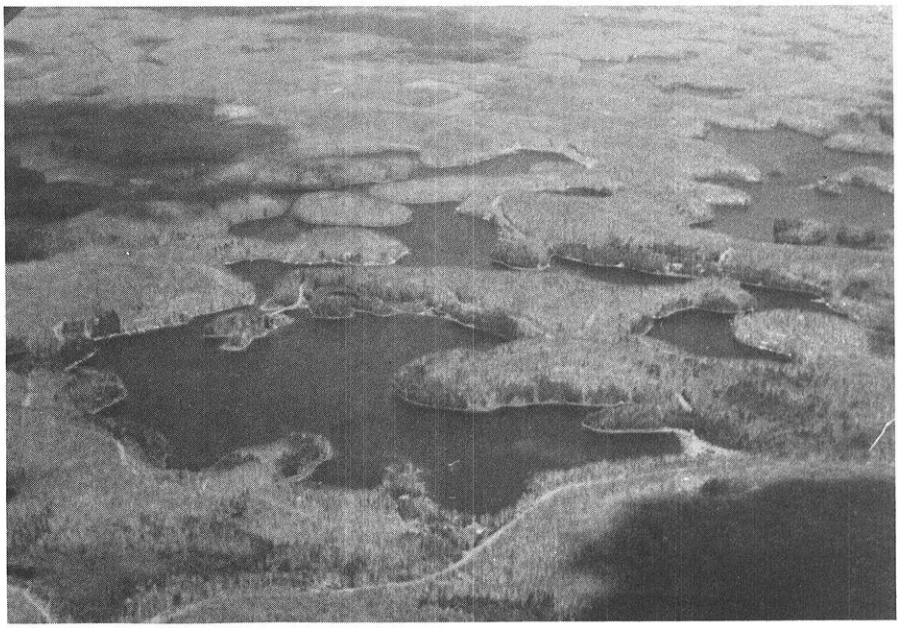


Permanent wetlands with clumps of emergent vegetation scattered throughout their basins were classed as Type IV areas. These wetlands, together with Type V lakes, etc., received the highest observed duck use in all regions. (Columbia County)

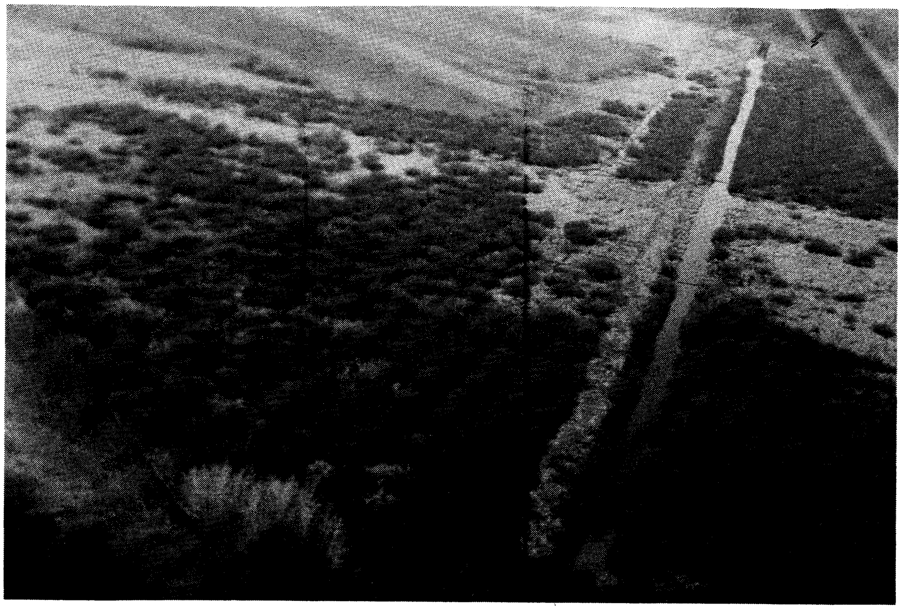


Lakes, man-made ponds (in photo), some beaver flowages and all other permanent wetlands with emergent vegetation restricted to their shorelines were included as Type V areas. These wetlands represented the most abundant types of permanent waterfowl habitat found in Wisconsin. (Columbia County)

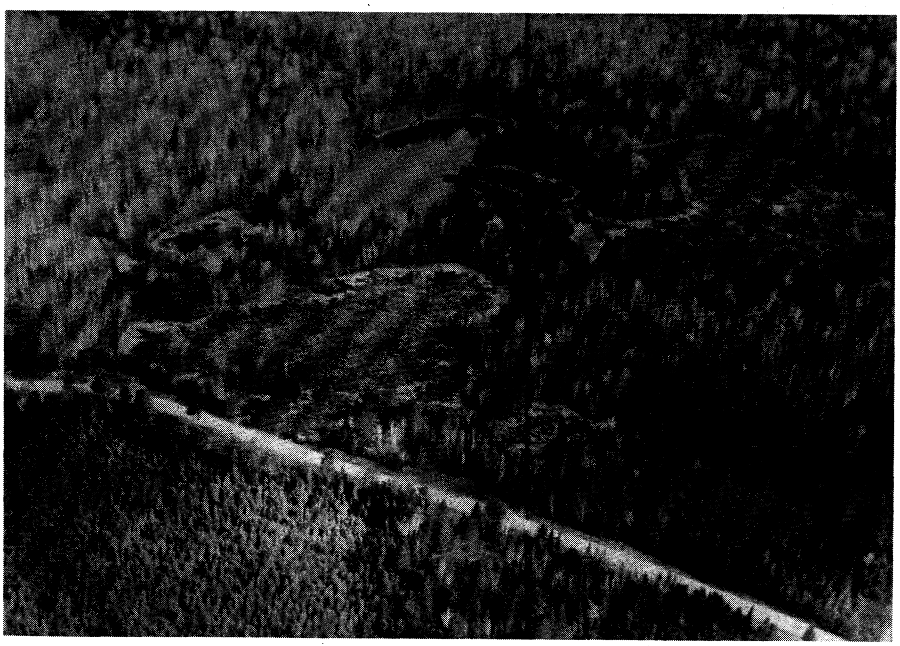
Wisconsin's only true pothole country is found in portions of St. Croix, Polk, Barron and Dunn counties of the Northwest region. Highest densities of wetland Types III-V were found in that region. Wetland Types II-V are all present in the photo. (St. Croix County)



The lake country of northern Wisconsin, while relatively low in overall duck density, carries an important segment of the breeding population because of an abundance of permanent habitat. (Vilas County)



A typical Type VI wetland in southern Wisconsin. Many of these areas were formerly Type II's that were converted to Type VI's by uncontrolled brush encroachment. Flooded wetlands of this type were called either Type II "brush" or Type III "brush" on the basis of expected permanency. The ditch shown would be used by pairs in spring and may be the only brood habitat left in July. (Dodge County)



Bog lakes (photo center) and Type VIII wetlands (foreground) were found primarily in north central and northeastern Wisconsin and were used by mallards and black ducks. (County unknown)

Beaver ponds and flowages represented a key segment of northern and central Wisconsin waterfowl habitat. Dam is at the top center of the photo. Wood ducks and hooded mergansers were found on streams flowing through similar sedge meadows and bogs. (Sawyer County)

DISCUSSION AND CONCLUSIONS

BREEDING GROUND IMPORTANCE

Western U.S./Canadian Populations

Statewide breeding population estimates (for the 3 major regions and southwest Wisconsin) ranged between 217,500 and 361,100 ducks from 1965-1970. Over the same period, indexes from the western U.S. and Canada for 10 game duck species, including all those breeding in Wisconsin except wood ducks, black ducks and hooded mergansers, were between 31 and 47 million birds (Pospahala and Anderson, 1972). Considering that the Wisconsin estimates also include population estimates for these 3 species, numbers of ducks breeding in Wisconsin appear to have little impact on annual U.S.-Canadian duck numbers. With the possible exceptions of wood ducks and black ducks, it appears that less than 1 percent of the North American duck population currently breeds in Wisconsin.

The 2 most abundant breeding ducks in Wisconsin, based on aerial surveys, are the mallard and the blue-winged teal. The 1965-1970 western U.S. and Canadian indexes averaged about 8.7 million and 5.0 million ducks, respectively, for mallards and blue-winged teal (Pospahala and Anderson, 1972). During this same period, an average of about 125,900 mallards, or less than 2 percent of the average U.S.-Canadian index, were estimated present in Wisconsin's 3 major regions and the Upper Mississippi NWR. Average population estimates for blue-winged teal in Wisconsin were equivalent to about 2 percent of the U.S.-Canadian average.

Information on the size of the various breeding populations contributing ducks primarily to the Mississippi Flyway was not available. However, breeding ground derivations of mallards killed in the Mississippi Flyway presented in Geis (1971), when applied to the average mallard harvest in the states other than Wisconsin (calculated from Martinson, Voelzer and Hudgins, 1968; Martinson et al., 1969; Carney, 1967; Croft and Carney, 1969), suggest that in 1966-68, 3-4 percent of the mallards killed outside Wisconsin but within the Flyway came from Wisconsin populations. When the kill within Wisconsin is included, mallards from the state represented about 10 percent of the Flyway kill.

Based on the 1965-1970 breeding estimates for Wisconsin and considering populations in eastern Canada, Michigan, New York, Pennsylvania and Ohio, a single 400,000-bird addition to continental mallard indexes represents a very conservative adjustment and one which greatly minimizes the importance of mallards in these regions.

We recommend that, in the future, annual population data from Wisconsin be included as a separate entry in the continental mallard population estimate made by the Bureau of Sport Fisheries and Wildlife. In the absence of annual population figures from the state, a separate, average value of between 100,000 and 150,000 mallards should be assigned to Wisconsin each year. The population data presented here will also be valuable in any studies which use band recoveries weighted for differences in breeding population size. Wisconsin mallard estimates have already been used in this manner by Geis (1971). His report also discusses some ramifications of underestimating populations in "fringe areas" such as Wisconsin.

The status of the Wisconsin wood duck population and its importance to continental populations is still not clear. From 1965 to 1970, the average annual population of wood ducks breeding in the state's 3 major regions and in the Upper Mississippi NWR was estimated at 11,700 birds. However, other data suggest the species was almost certainly underestimated in the 1965-1970 aerial surveys. Preseason banding information, when combined with annual harvest data from Bureau of Sport Fisheries and Wildlife surveys, suggests that the average preseason adult population in Wisconsin consists of over 50,000 wood ducks (March, unpubl.). Kimball (1971) estimated the continental adult wood duck population at between 1.0 and 1.7 million birds during 1965-1970. If Wisconsin actually does have a breeding population of 50,000 or more wood ducks as seems probable, this could represent 4-5 percent of the continental population, and rank the state as one of the five or six most important North American breeding grounds for that species.

United States Populations

Wisconsin duck populations may be of greater importance when considering only breeding grounds within the United States (excluding Alaska). The 1970 Waterfowl Status Report (Chamberlain et al., 1971) listed the following breeding population indexes for 9 of the best duck production states in the three western Flyways of the U.S.: North Dakota, 1,040,400 ducks; South Dakota, 667,900; Montana, 455,900; Wyoming, 389,300; Minnesota, 350,000; Washington, 228,600; California, 134,600; Nebraska, 121,600; and Colorado, 114,800. Not all of these indexes are directly comparable with the 1970 Wisconsin breeding population estimate of 361,100 ducks. Indexes from the two Dakotas, Montana, California and possibly several other states were not adjusted for birds missed by the aerial crews. Recognizing that these indexes are minimal in most instances, Wisconsin apparently ranks somewhere in the lower one-third of this group of states. If these 9 states are representative of the best United States breeding grounds, Wisconsin, currently should also be classed as an important production area.

Average mallard breeding population estimates given by Geis (1971) for the same 9 states listed above ranged from 423,000 ducks in North Dakota to 57,000 in Nebraska. In addition, Oregon, Idaho and Michigan had 50,000 or more breeding mallards. The average annual breeding population estimate of 125,900 mallards (for the state's three major regions and the Upper Mississippi NWR) ranks Wisconsin seventh or eighth in importance among these 14 states. Minnesota currently is the most important breeding ground in the Mississippi Flyway. Because of the size of its breeding population and variety of species, Wisconsin must rank second. On the basis of population figures in Martinson et al. (1969), and Chamberlain et al. (1971), Wisconsin had more breeding mallards than Minnesota in 1969 and 1970. Results of the Bureau of Sport Fisheries and Wildlife's 1967-69 breeding bird survey (Robbins and Van Velzen, 1969) also suggest that Minnesota has fewer mallards than Wisconsin (A. Geis, pers. comm., 1969).

It was difficult to compare blue-winged teal indexes from various other United States breeding grounds. Data from Chamberlain et al. (1971) were used to obtain average indexes for 6 states: Washington, Colorado, Montana, North Dakota, Nebraska and Minnesota. Blue-winged teal indexes for these states ranged from 164,000 ducks in Minnesota to 9,100 in Colorado. However, only the Minnesota and Colorado data were known to be adjusted for ducks present but not seen by the aerial crews. The average annual breeding population estimate of 89,200 ducks (for the state's 3 major regions and the Upper Mississippi NWR) ranks Wisconsin well within the indexes listed. Although the state's blue-winged teal population would be less important if indexes from several of these other areas were adjusted for missed birds, it does appear that Wisconsin might at least be included among the 10 most important breeding areas for blue-winged teal in the United States.

Breeding populations for states in the Mississippi and Atlantic Flyways, except for Minnesota, were purposely excluded from the discussion above because survey data were not available for consideration. Undoubtedly, some of the larger states or those with better habitat have good breeding populations of certain species. However, the western states included in our discussion are considered to be the best breeding grounds in the United States, excluding Alaska.

Production Potential

Jahn and Hunt (1964) used 50 percent as the "best" estimate for the number of females successfully producing broods in Wisconsin. No new data have been obtained that would change this estimate. During 1965-1970, the average size of Class III broods for all species of ducks in Wisconsin (after brood classification of Gollop and Marshall, 1954) was about 6 young (March, unpubl.).

If 50 percent of the adult females produced broods (at 6 young per brood) during 1965-1970, Wisconsin had an annual potential production of 310,000-525,000 ducklings to flying stage (using breeding population estimates from Table 3). Annual potential mallard production in the same period was 150,000-250,000 Class III young, averaging 186,500 young per year. Wisconsin's preseason immature mallard population, calculated from harvest rates (i.e., band recovery rates adjusted for nonreporting) and annual Bureau of Sport Fisheries and Wildlife data on age ratios and retrieved kill, averaged about 380,700 ducks during 1965-1970 (March, unpubl.). Direct comparison of these figures suggests that, in an average year, locally produced mallards could account for about one-half of the state's preseason population of immature mallards. Annual potential blue-winged teal production in 1965-1970 was 100,000-160,000 Class III young. However, preseason population estimates of blue-winged teal in Wisconsin were not available, so a comparison of Wisconsin-produced young with those from other areas cannot be made.

Geis (1971), in his analysis of 1966-68 weighted, first-hunting season mallard band recoveries, using an average breeding population of 150,000 mallards for Wisconsin, indicated that as much as 70 percent of Wisconsin's mallard harvest could be derived from birds reared in the state. Recalculation of Geis's data, using a breeding population of about 104,000 mallards for Wisconsin (average population for 1966 and 1968), credits about 64 percent of the harvest to locally-reared ducks (March, unpubl.). These figures suggest that for mallards, at least, local birds represent *the* major input to Wisconsin hunters.

POPULATION TRENDS

U. S.-Canadian Trends

Wisconsin population estimates followed the same upward trends as U.S.-Canadian game duck indexes from Pospahala and Anderson (1972) during 1968-1970 (Fig. 11). Populations in the state declined, however, in 1966 (and presumably showed no change or declined in 1967), while U.S.-Canadian indexes increased and showed little or no change in 1967. Wisconsin populations were less in 1968 than in 1966. The U.S.-Canadian index was also less in 1968 than in 1966 or 1967.

U.S.-Canadian and also Wisconsin mallard populations increased during 1968-1970 (Fig. 12). Mallard populations in the state declined in 1966 and were low in 1968, while U.S.-Canadian indexes increased annually in 1966 and 1967, but declined in 1968 (Pospahala and Anderson, 1972).

Blue-winged teal indexes for the western U.S. and Canada (Pospahala and Anderson, 1972) increased annually during 1968-1970 (Fig. 13). Wisconsin populations showed a similar trend between 1969 and 1970, but not between 1968 and 1969. Although more blue-winged teal were seen on the aerial transects in Wisconsin between 1968 and 1969, the breeding population estimates did not show this trend. U.S.-Canadian blue-winged teal indexes increased in 1966, declined slightly in 1967, then showed a large decrease in 1968. In 1966, Wisconsin populations also declined, but by 1968, numbers of blue-winged teal were again high in the state(Fig. 13).

Wisconsin Trends

Population Numbers

The minimum 1949-1950 breeding duck population in Wisconsin (based on aerial surveys) averaged 133,500 birds (Jahn and Hunt, 1964) or 132,500 fewer ducks than the average breeding population estimate in the 3 regions combined for 1965-1970. However, based on data from Shaw and Crissey (1955), state populations may have been as high as 280,500 ducks in 1949-1950 (Jahn and Hunt, 1964) or essentially the same numbers as found in 1965-1970.

Population estimates derived from the 1949-1950 aerial surveys were not directly comparable to those obtained in 1965-1970 for two reasons: (1) the 1949-1950 aerial surveys were based on nonrandom sampling schemes and (2) no air:ground comparison data were gathered in 1949 and 1950. Adjustments for birds present but not seen during the 1949-1950 surveys were made from information gathered by the Bureau of Sport Fisheries and Wildlife in the aspen parklands of Canada. Twenty-five percent of the blue-winged teal and 66 percent of all other ducks were assumed to have been seen from the air (Jahn and Hunt, 1964). Air:ground data from 1966-1970 indicate that only about 17 percent of the blue-winged teal, 23 percent of the mallards and 22 percent of all other ducks present were seen by the aerial crews. Assuming conditions were similar in the earlier years and adjusting the 1949-1950 data by average air:ground ratios (about .200) from 1966-1970, populations in the late 1940's and early 1950's – 250,000-320,000 ducks – were similar to current ones.

The most comparable data available for 1949-1950 and 1965-1970 populations were the actual breeding duck densities observed for the areas sampled. Observed density in 1949-1950 averaged 1.2 ducks per square mile (Jahn and Hunt, 1964). The average weighted mean breeding duck density for 1965-1970 was also 1.2 ducks per square mile. Based on the ducks actually seen during the aerial surveys, Wisconsin's current breeding population is not markedly different numerically from populations present in 1949-1950.

Since habitat losses and degradations have occurred since 1950, the apparent absence of change in breeding populations must be related to one or more of the following factors:

1. Current population estimates

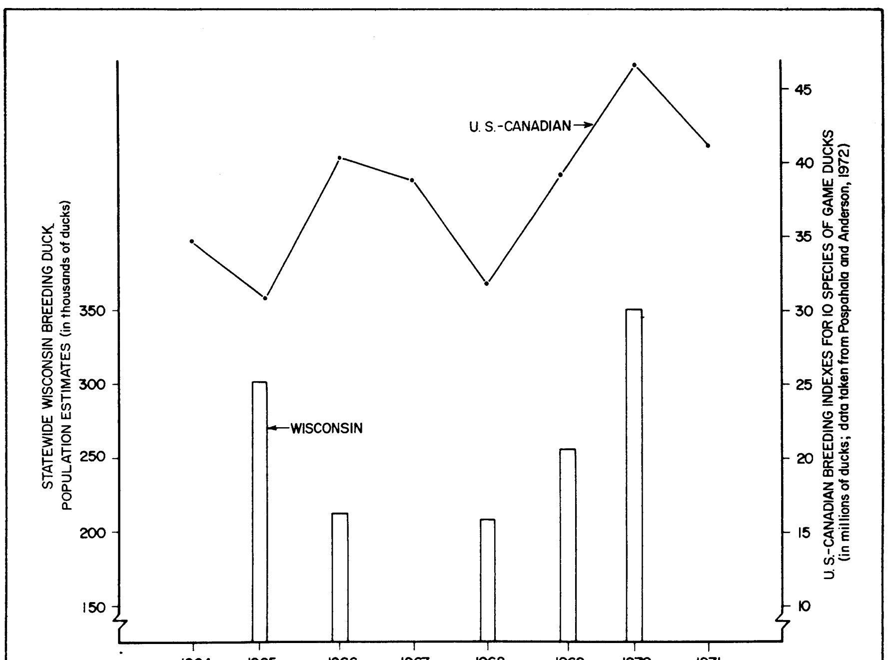


FIGURE 11
Wisconsin breeding population estimates, 1965-1970, in relation to breeding indexes for 10 species of game ducks from the western United States and Canada.

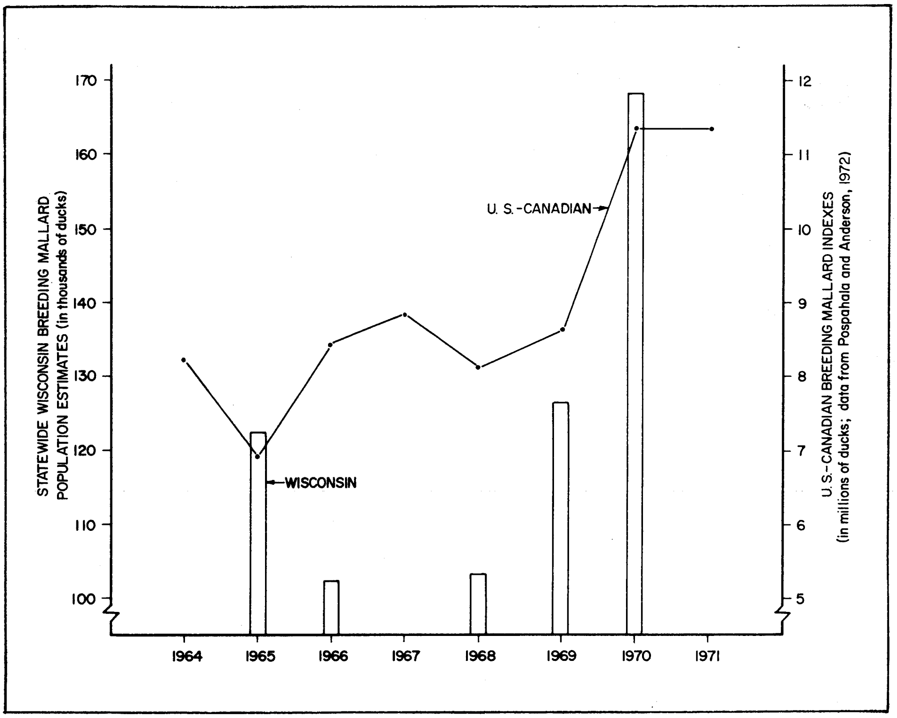


FIGURE 12
Wisconsin breeding mallard population estimates, 1965-1970, in relation to breeding mallard indexes from the western United States and Canada.

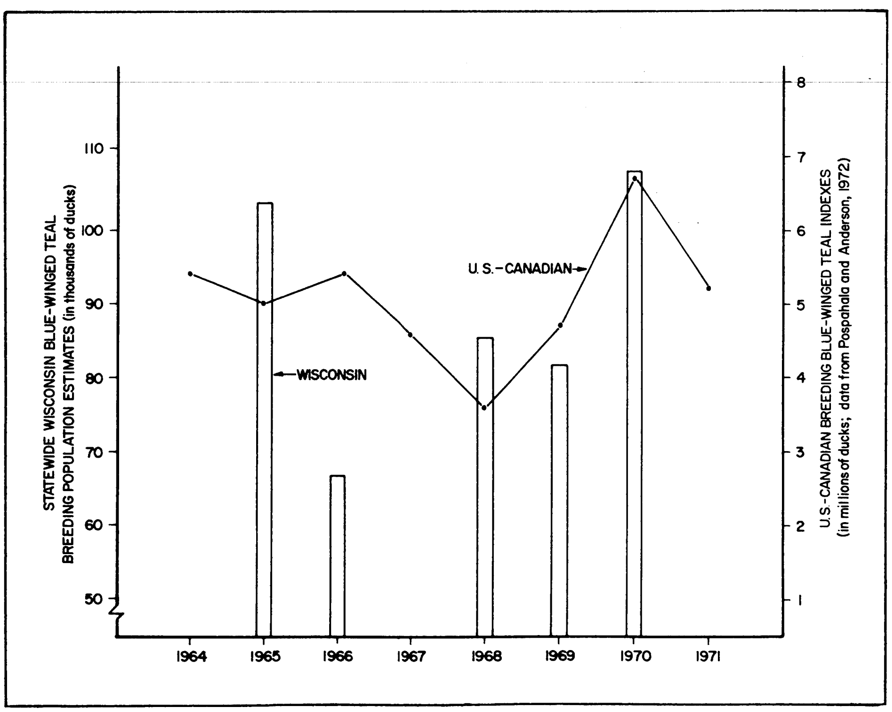


FIGURE 13
Wisconsin breeding population estimates for blue-winged teal, 1965-1970, in relation to breeding blue-winged teal indexes from the western United States and Canada.

may be too high. We believe that sampling design and census procedures used in 1965-1970 did give a valid estimate of the abundance of breeding ducks in Wisconsin (excluding wood ducks). Calculated error for the basic sample – ducks seen per square mile – has been within the acceptable limits. Ground censuses to measure the proportion of ducks present but not seen from the air indicate that breeding populations are considerably greater than the 1 or 2 ducks per square mile obtained from aerial counts. Between 1 and 14 pairs per square mile were found during ground searches. Use of air:ground ratios to expand breeding population indexes has been accepted as standard procedure on the annual surveys of the Canadian breeding grounds (Martinson and Kaczynski, 1967). The lower air:ground ratios obtained in Wisconsin, especially for mallards, reflect the poorer visibility in the cover types utilized by breeding ducks in the state. Wisconsin has an abundance of woody habitat and many flooded grass and sedge meadows at the time of spring surveys. Adjusted population estimates have the disadvantage that there is no practical measure of annual variability which permits the calculation of confidence limits.

2. Flowage development on state management areas and on some private areas since 1950 may have offset wetland losses and their associated effects of reducing production, etc. Approximately 26,000 acres (20 major projects) have been flooded since 1950 on state wildlife management areas (King, 1971). It is doubtful, however, that higher breeding densities on these state areas and the creation of additional flowages on private lands could have completely replaced the production lost from drained natural wetlands. Kabat (1972) estimated that wetland losses in southeastern Wisconsin approximated 2 percent annually during 1941-1960, and about 1-2 percent annually since 1961. Since 1878, about 746,000 acres of wetlands (about 61 percent) have been lost in 14 southeast Wisconsin counties (Kabat, 1972). Even if habitat losses in other regions were less dramatic, it is difficult to conceive that habitat restoration, at its present level, could have kept abreast of drainage in compensating for lost production.
3. The method of sampling used in 1949-1950 may have greatly underestimated breeding population density. The 1949-1950 cross-country aerial transects were designed to cover portions of each major physiographic region in Wisconsin, but were not es-

tablished on a random sampling basis (Jahn and Hunt, 1964). No measure of sampling error was available and the surveys may not have been representative of all breeding densities in the state. Observed density did not exceed 1.7 ducks per square mile in any physiographic region. Since observed breeding density in the current surveys exceeded 2 ducks per square mile in the SE/Central region in 3 of 5 years and in the Northwest region in 2 of 5 years, it is probable that the 1949-1950 transects did not adequately sample the areas of higher breeding density and that the 1949-1950 estimates were indeed low.

4. Habitat may not be a limiting factor and breeding populations may, therefore, be stable within certain levels. Observed wetland occupancy in 1965-1970 was 3.8 percent for all wetlands combined (Table 9). Jahn and Hunt (1964) reported that occupancy of all wetlands in 1948-1950, obtained on cross-country road censuses, was 7-18 percent, depending on the section of the state. The 1948-1950 and 1965-1970 occupancy levels are not directly comparable since the early figures partially represent results of ground searches. In any case, occupancy rates obtained by air during 1965-1970 are low and occupancy observed during ground censuses (made as part of the air:ground comparisons) indicates that the actual level of occupancy is also relatively low, particularly in the north. This suggests Wisconsin may have more habitat available to breeding pairs in some regions than there are pairs to utilize these wetlands. However, such an assumption is misleading for several reasons. First of all, available wetlands not used by ducks may not necessarily be of high quality (i.e., be attractive to ducks). Secondly, good brood areas are probably scarce in some parts of the state, especially those with intensive agriculture. Thirdly, the subjective classification of wetland permanency in May could overestimate the amount of water present to the extent that some wetlands classified as permanent might not be available to broods by July. Jahn and Hunt (1964) and Gates (1965) discussed limitations on brood habitat in Wisconsin, and both studies suggested that duckling survival may be poorer in southeastern Wisconsin because of a shortage of permanent wetlands.
5. Restrictive hunting regulations may have reduced the proportion lost to hunting and, therefore, may have maintained populations in spite of habitat losses. The role of restrictive hunting regulations in diminishing losses of local populations to shooting will be considered in a separate report and will not be discussed further.

Species Composition

Mallards and Blue-winged Teal. Population estimates from the 1965-1970 surveys indicated that mallards comprised slightly less than one-half of the breeding duck population and blue-winged teal, about one-third. This varied by region, with proportionately more blue-winged teal present in the SE/Central and Northwest regions than in the Low Density region. Species composition observed by air (Table 5), because of differences in visibility, tended to minimize the proportion of blue-winged teal in all regions.

It is virtually impossible to directly compare the current species composition with that derived by Jahn and Hunt (1964) during 1948-1956. They found that 46 percent of the population consisted of blue-winged teal and only 30 percent were mallards. These percentages are practically the reverse of our recent data, but were based on automobile counts and other ground censuses of selected wetlands. Jahn and Hunt (1964) obtained their data, on the average, later in the breeding season than we did. While they made a correction for early-nesting mallards that might have been missed on the surveys, this correction may not have been adequate.

We attempted to explain the significance of these differences in species composition for the 2 surveys by comparison of blue-winged teal and mallard ratios by regions, in light of: (1) the techniques used to obtain these ratios and (2) changes in habitat and land use since 1948-1956.

In the Low Density region, the 1965-1970 blue-winged teal:mallard ratios from all aerial counts (0.3) and ground censuses (0.4) were in general agreement that more mallards were present than blue-winged teal. The 1948-1956 ground censuses showed 0.7 blue-winged teal:mallard, a higher value than currently obtained.

These data suggest that a decline in blue-winged teal populations has occurred in the region since 1956. This is plausible since blue-winged teal are less adaptable in their selection of nest sites than mallards (Jahn and Hunt, 1964 and Stoudt, 1971). Habitat succession, in the absence of fire and intensive agriculture, has probably produced a long-term reduction of grassy nesting habitat preferred by blue-winged teal. We know that growth of woody vegetation in formerly open habitat (once created by logging and farming) has occured in Wisconsin especially in the forested areas of the northern and central counties (Jahn and Hunt, 1964).

In the SE/Central and Northwest regions, the 1965-1970 aerial surveys produced a blue-winged teal:mallard ratio of 0.7 and a ground census (from air:ground comparisons) ratio of 2.5 blue-winged teal:mallard. The ratio from 1949-1950 air counts was 0.4 blue-winged teal:mallard and the ground censuses gave a ratio of 1.5. These ratios suggest that an increase in abundance of blue-winged teal or a decrease in abundance of mallards occurred between the mid-1950's and the late 1960's in these regions. Also, the ground censuses in both surveys (1948-1956 and 1965-1970) show that blue-winged teal make up a larger fraction of the breeding population than mallards. This is supported by studies of Labisky (1957) and Gates (1965), both of whom indicated 1.3 blue-winged teal:mallard were present on study areas in southeastern Wisconsin. What is inconsistent and disconcerting about this is that breeding population estimates (adjusted for unseen birds) for 1965-1970 show mallards to be more abundant than blue-winged teal in both the Northwest and SE/Central regions.

It would seem logical to expect a higher proportion of breeding mallards in recent years since mallard daily bag limits have been reduced and should have lowered annual mortality rates while teal regulations have been liberalized. Four-bird daily bag limits on mallards and blue-winged teal were in effect during 1948-1958; daily bags were reduced to 3 birds in 1959 and 1960, and were only 1-2 mallards but 2-6 blue-winged teal from 1961-1969. Also, special teal seasons of 9 days took place in some states in the Mississippi Flyway during each of the years from 1965-1967 and 1969-1970. Wisconsin did not participate in these special seasons, but instead selected a 2-bird blue-winged teal bonus bag in 1969-1970. Geis et al. (1969) reported that restrictive hunting regulations in the late 1950's and in the 1960's reduced harvest and mortality rates for mallards. A separate report is planned that will investigate the harvest and mortality rate relationships for Wisconsin mallards.

We have not been able to answer the basic question raised by the SE/Central and Northwest regional surveys—how we could find more blue-winged teal on ground censuses and yet obtain a breeding population estimate higher than mallards. To bear watching in future investigations are two points: (1) The selection of air routes with higher bird densities for ground segments should not bias the results toward "productive" habitats that may be attractive to blue-winged teal. The more versatile mallard is found in all types and could be undercounted with this procedure. (2) An attempt to look at species composition should take into account the fact that regional bird visibilities differ because of cover differences.

Other Species. Average population estimates from the 3 regions for ducks identified to species suggest several additional changes in species abundance since 1948-1956.

Original data used by Jahn and Hunt (1964), when broken down by region, indicated that shoveler, green-winged teal and pintail together represented less than 3 percent of the breeding population statewide and also in what is considered by our study as the SE/Central region. For 1965-1970, these 3 species combined averaged 4 percent of the total identified ducks in the 3 regions and over 5 percent of those in the SE/Central region. Shovelers and green-winged teal showed the greatest increases for the 3 species. The proportion of green-winged teal in northern Wisconsin also increased between 1956 and 1965-1970. Ring-necked ducks declined since the 1950's in all regions and the proportion of black ducks dropped in the north. The ring-necked duck formerly represented 4-19 percent of the breeding ducks in the 3 regions (highest in the Low Density); the species accounted for only 1-4 percent of the identified segment in 1965-1970. Black ducks, which totalled 25 percent of the ducks in north central and northeast Wisconsin during 1948-1956, represented only about 9 percent of the 1965-1970 population estimates from the north (identified segment). Since the early 1950's, Wisconsin black ducks apparently have followed the same downward trend reported by Martinson, Geis and Smith (1968) for eastern North American populations of this species.

For the other less abundant species, the annual variation in population estimates necessitates that caution be used when discussing changes in abundance. Differences between 1948-1956 and 1965-1970 of only a few percent should probably not be considered as evidence of significant population changes.

RELIABILITY OF POPULATION DATA

Breeding Duck Density

The "best" indicator of changes in annual abundance of breeding ducks was the number of birds actually observed per square mile on the transects. The numbers of ducks seen on individual transects did not conform to a recognizable frequency distribution and were highly variable. The number of ducks seen per transect ranged from 0-58 in the SE/Central region, 0-22 in the Northwest region and 0-18 in the Low Density region. A conventional analysis of variance used to test for effect of "regions" on the mean number of ducks seen per square mile from 1965-1970 was significant at $P \leq 0.01$ (2 and 9 d.f.), with the difference occurring largely between the Low Density region and the other 2 regions. The Friedman Ranks Test was used to test for effect of "years" on mean duck density (D.R. Thompson, pers. comm., 1972). The Friedman Test indicated that the overall annual weighted mean breeding density for all 3 regions differed significantly between 1966 and 1968, 1968 and 1970 and 1969 and 1970 (Appendix B).

Within regions significant differences in breeding density were found between some years. However, densities were never significantly different at $P \leq 0.05$ in more than one region for a given combination of years. In the SE/Central region, the 1966 density was lower than that in 1970 (at $P \leq 0.05$), and in 1968, fewer birds were seen per square mile than in 1969 (significant at $P \leq 0.10$). Since the weighted breeding density for all 3 regions did not change significantly in either of these sets of years (Appendix B), increases in the SE/Central region apparently were not sufficiently large to affect weighted mean densities. Breeding density in the Northwest was significantly greater ($P \leq 0.05$) in 1970 than in 1968, and this change, together with nonsignificant changes ($P \leq 0.10$) in the other regions was sufficient to affect the weighted mean densities between 1968 and 1970. A significant decline ($P \leq 0.05$) in observed density in the Low Density region between 1966 and 1968, plus a nonsignificant decrease in the Northwest region were able to offset an increased density in the SE/Central region and significantly lower the weighted density for all 3 regions. An unusual situation occurred between 1969 and 1970. Nonsignificant ($P \leq 0.10$) increases in the Low Density and Northwest regions were sufficient to significantly increase the weighted mean density even though the breeding density in SE/Central region dropped slightly. Although the SE/Central region usually had the highest breeding densities, had the largest total population and represented about one-third of the area in the 3 regions surveyed, changes in duck numbers in that region did not always produce corresponding changes in the weighted duck density. This suggests that population changes in the other 2 regions during certain years were able to offset increases or decreases in the SE/Central region. The Low Density region, second only to the SE/Central region in total breeding population, was important because its large area compensated for lower duck densities. The Northwest region, because its breeding densities equalled those of the SE/Central region, also accounted for an important segment of the state's population.

The 1966-1970 weighted mean duck density (1.1 per square mile) had a calculated confidence interval of ± 18 percent (P=0.05). The 1965 statewide mean, though based on a slightly different sample allocation, had a confidence interval of ± 22 percent (P=0.05). One of the initial survey objectives was to develop a sampling scheme which would detect differences in breeding density of at least ± 20 percent. The 1965-1970 surveys seem to have accomplished this goal. Despite considerable variation in the number of ducks seen per square mile on individual transects, annual changes in weighted mean density of 20 percent apparently could be determined, although conventional statistical tests for these differences were not applicable.

Additional transects and refinement of regional boundaries would be required to improve future precision, e.g. to ± 10 percent. This may not be justified in terms of additional cost and improved information. After 5 years of experience with the 3-region system of sampling, we believe that the major source of variability (other than actual regional differences in duck abundance) was in survey mechanics.

Breeding Population Estimates

Expansion of breeding duck densities to breeding population estimates by regions was based on air:ground ratios for which there was no reliable estimate of sampling error. At best, air:ground ratios were quite variable (Table 3) and based on a limited amount of data. Potential variability in the air:ground ratios was estimated using the 1970 air:ground segment data for mallards in the SE/Central region (Appendix E). Mallard ratios were selected since they appeared more consistent than ratios for blue-winged teal and other ducks. The mean 1970 mallard air:ground ratio from the 4 segments in the SE/Central region was .24. The overall ratio obtained by combining all mallard data from the 4 segments also was .24. However, the ratios obtained on the individual segments ranged between .18 and .30 (Appendix E).

Assuming that this 1970 mallard ratio is representative of air:ground ratios for other years, regions and groups of ducks, the small amount of data and the level of variability associated with these ratios weakens any conclusions concerning supposed changes in duck abundance based on breeding population estimates. Certainly changes of less than 20 percent would be of questionable validity. The only reasonable conclusions that can be drawn from population changes observed are to consider 1965 and 1970 as years when population levels were high and 1966 and 1968 as years when population levels were low.

Additional air:ground segments should improve the reliability of future air:ground ratios and reduce potential error in breeding population estimates.

Aerial Counts

Our surveys were not designed to test for sources of variability inherent in aerial surveys of breeding waterfowl. Diem and Lu (1960) or Martinson and Kaczynski (1967) have examined such factors in considerable detail for aerial surveys of Canadian breeding grounds. Biases which had the most significant influence on the number of ducks seen from the air during Canadian surveys were changes in observers, species composition and duck densities (Martinson and Kaczynski, 1967).

The major sources of variation in the Wisconsin surveys in order of importance were thought to be: (1) duck density, (2) differences between observers, (3) differences between pilots in their ability to assist in observing breeding ducks, (4) differences in habitat types sampled, (5) species composition, (6) changes in amount of surface water and (7) weather conditions. Other less important factors which may have influenced survey results in Wisconsin were the time of day that aerial flights were made, flight direction, altitude and progress of the spring migration.

HABITAT/BREEDING POPULATION RELATIONSHIPS

Occupancy and Wetland Type

Occupancy rates obtained in this study were only indexes to the actual occupancy. Only those wetlands on which ducks were observed by the aerial crew were used to measure annual occupancy. Ground searches of air:ground segments found ducks on some wetlands classed as "unoccupied" from the air. This was especially common where visibility was poor because of areas of flooded vegetation. Occupancy recorded during the aerial surveys probably overemphasized the importance of permanent wetlands since temporary ponds, etc., were more likely to have areas of flooded grasses, sedges, or shrubs. Unfortunately, wetland type and occupancy were not recorded by ground crews on the air:

ground segments for comparison with results from aerial surveys.

Over half the wetlands classed by air as "occupied" were Types III, IV and V. These 3 types were especially important in the Northwest and Low Density regions. Observed use of Type IV and V wetlands was significantly greater than the abundance of these types would predict. Use of Type III wetlands was also higher than expected in the SE/Central region. In the Northwest, fewer Type III areas were occupied than expected on the basis of their abundance. This may be because the Northwest region had a high density of Type IV-V wetlands (3 or more per square mile). There apparently was no special selection for Type III areas in the Low Density region since use was equivalent to abundance of these wetlands.

Mallards and blue-winged teal were found more frequently than expected on the permanent wetlands (Types IV-V) in all regions, although use of Type III areas by these 2 species in the SE/Central region was also greater than expected. Temporary wetlands (Types I-II) were not occupied at a level corresponding to their abundance. This would be expected considering the high observed use of wetland Types IV and V, plus the additional use of Type III wetlands.

While our study could not identify the key factor(s) that determines wetland occupancy in Wisconsin, the patterns of observed use suggest at least 3 possible explanations: (1) the number of breeding ducks is too low for all types of habitat to be used, (2) many Wisconsin wetlands are unattractive to breeding ducks, or (3) use of temporary areas was underestimated by our surveys.

Lee et al. (1964) found that the most breeding duck use in western Minnesota was also on Type IV and V wetlands. Their studies indicated that the poorer use of the temporary and semi-permanent wetlands was because breeding populations were low (i.e., not enough pairs were present to encourage use of the more temporary areas). The situation in Wisconsin and Minnesota is apparently somewhat different from that in northeastern South Dakota where Type I wetlands received the heaviest use (Drewien and Springer, 1969), or on the Redvers, Saskatchewan study area of Stoudt (1971) where use of Type I areas was lowest at peak population levels. Breeding pair densities during the Minnesota, South Dakota and Saskatchewan studies were much greater than normally found in Wisconsin.

If annual production in Wisconsin did not offset losses to hunting and other mortality, a long-term decline in breeding populations would occur unless these deficits were compensated for by ducks pioneering from other areas. Jessen (1970) suggested that such a relationship applies to mallard breeding populations in Minnesota. From limited banding information, shooting losses and total mortality for immature mallards in Wisconsin were 50 percent and 70 percent, respectively in the first year (Jahn and Hunt, 1964). This was less than the 55-65 percent shooting loss and 75-85 percent total mortality suffered by Minnesota immature mallards (Jessen, 1970). At this stage, before an analysis of mallard mortality is completed, we can still only tentatively suggest overharvest as a major factor limiting Wisconsin breeding duck populations.

Although total occupancy of wetlands by breeding ducks was still quite low during the 1950's (12-18 percent), about 60 percent of the "best" permanent wetlands were used annually (Jahn and Hunt, 1964). Use of these better areas was comparable to that reported for wetlands on Canadian breeding grounds (Stoudt, 1971 and Smith, 1971). Jahn and Hunt (1964) suggested that the low overall occupancy indicated that many Wisconsin wetlands were unattractive to breeding ducks. The low observed occupancy and apparent selection for permanent wetlands during 1965-1970 also seem to support their conclusion. However, the possible effect of insufficient breeding pairs cannot be excluded.

The relatively high observed use of permanent wetlands may also mean that use of temporary wetlands was underestimated by our surveys. This may have occurred since ducks were more difficult to see on some temporary wetlands; ducks also may have used the temporary areas at a greater level prior to the period during which aerial surveys were made. Recent studies at the Northern Prairies Wildlife Research Center in North Dakota have suggested that temporary and semi-permanent wetlands are important as feeding areas for ducks during the early stages of the reproductive cycle (G. A. Swanson, pers. comm., 1971). The annual aerial surveys in Wisconsin covered various stages of this cycle, from pre-laying into incubation, depending on species. At the time surveys were made, mallard drakes had already begun to form groups on permanent wetlands, indicating that most mallards were well into laying and/or incubation. As a result, use of Types I and II wetlands by mallards may have already declined by the time that surveys were flown. The North Dakota studies indicate that use of permanent areas does increase as the breeding cycle progresses.

Population Size and Wetland Density

Lowest densities of Type III, IV and V wetlands were found in the SE/Central region, yet this region had the highest average breeding duck density. Twelve of the 55 transects flown from 1966-1970 averaged 2 or more breeding ducks seen per square mile. Eleven of these transects were in the SE/Central region, located primarily in Green Lake, Fond du Lac, Winnebago, Waupaca, Outagamie, Calumet, Manitowoc, Dodge, Columbia, Dane, Jefferson, Washington and Kenosha counties (Fig. 14). Two of these 11 transects had the highest observed duck density (6-8 ducks per square mile) of any of the 55 transects.

The annual observed occupancy rates for all wetlands combined was positively correlated with breeding density in the SE/Central region, but not in the other 2 regions. Also, temporary and semi-permanent wetlands received their greatest observed occupancy in the SE/Central region which had less than 2 Type IV or V wetlands per square mile. Apparently the relationships between breeding ducks and wetlands in the SE/Central region is unique from those in the Northwest and Low Density regions.

In general, the highest breeding densities and occupancy rates for the SE/Central region were recorded in years of greatest wetland density. Each year that wetland density declined, the breeding duck density also dropped. Occupancy rates followed a similar pattern, decreasing in years when wetland density declined, except in 1970 (a dry year) when wetland occupancy showed almost no change from that found in 1969. Annual fluctuations in wetland density within the region were primarily the result of differences in the abundance of temporary wetlands. During the years when wetland Types I and II in the region were most abundant, occupancy of these 2 types of wetlands and density of breeding ducks was highest.

Two possible hypotheses can be drawn from these relationships: (1) In years when temporary water is more abundant, pairs disperse out into wetland Types I and II with greater frequency than in drier years. And, because in these wet years, there are more wetlands per lineal mile, a larger number of ducks are counted along a given transect. (2) Habitat in the SE/Central region is utilized in relation to its abundance because the region is more fertile than the other regions or because of some unknown factor. If fewer temporary wetlands are available, ducks are more likely to be on the permanent or semi-permanent areas, and because there are fewer total water areas per square mile, the breeding density appears to decline. This relationship assumes that not all ducks on a given wetland are seen by aerial crews, an assumption which is valid. The important parameter then, if it could be adequately determined, would be the total ducks per wetland. If the observed density were related to the abundance of temporary wetlands, the ducks per pond should be less for permanent areas in wet years and higher in dry years. Unfortunately, no reliable estimate of ducks per pond was obtained for these studies. An extension of this hypothesis that duck abundance is directly related to habitat abundance is that more water in SE/Central Wisconsin attracts more ducks (i.e., more pioneering is induced in wet years). A major part of all resident and migrant waterfowl must pass through the SE/Central region each spring. In wet years, ducks that bred in other regions of Wisconsin the previous year(s), plus others that would normally pass through the state to breed elsewhere, are "shortstopped" by the good habitat conditions and remain to nest. This might explain why observed occupancy also increased in some years of higher wetland and breeding duck densities.

The annual breeding densities actually observed in the SE/Central region probably represent a combination of both hypotheses.

TRENDS IN WETLAND HABITAT

Differences from the 1950's

The most recent statewide wetland inventory in Wisconsin was finished in

1955 (Mann, 1955). Wetland densities obtained during the 1965-1970 aerial surveys were compared with this earlier inventory to measure potential losses to drainage, etc. The 1955 inventory included all wetlands, even those with only sub-surface water. Since our aerial data enumerated only areas with surface water, comparisons between 1955 and 1965-1970 were restricted to comparisons of wetland Types III-V. Since acreages of individual wetlands were not estimated during the 1965-1970 aerial counts, only numbers of wetland Types III-V per square mile were compared.

Results from the 1955 inventory were converted to a weighted average density of wetland Types III-V. This density was based on abundance of these wetlands in various soil types which served as the basic sampling units in the 1955 inventory. Total area of each major soil type within the boundaries of each of the 3 1965-1970 survey regions was estimated from maps in Mann (1955).

Density of Types III-V in that part of the state currently designated as the SE/Central region, averaged 2.6 wetlands per square mile in 1955. The average 1965-1970 density for wetland Types III-V in that region was 2.9. The 1965-1970 density was only 11 percent higher than that for 1955, which is probably not a significant difference considering that in 1965-1970, standard errors for annual wetland densities were as high as 17 percent of the mean (Table 8).

In the Low Density region, the 1955 density of wetland Types III-V (4.4 per square mile) was quite similar to that recorded in 1965-1970 (4.2 per square mile).

The greatest differences in density between 1955 and 1965-1970 were found in the Northwest region. The 1955 inventory indicated about 8.7 wetland Types III-V per square mile were present, but only 7.1 per square mile were recorded on the 1965-1970 flights.

Wetland densities obtained from 2 independent surveys, at least 10 years apart, were surprisingly similar, assuming that a continuing loss of wetlands had occurred during that period. Looking at these comparisons, one might conclude that the density of Wisconsin's better duck habitat (i.e., wetland Types III-V) is now relatively stable.

There are several possible explanations for the absence of change in densities of wetland Types III, IV and V in SE/Central Wisconsin. First, those wetlands which are most permanent and least susceptible to drainage were selected for comparison. Drainage and filling of wetlands other than wetland Types III-V undoubtedly occurred, especially in view of the region's extensive agriculture and urbanization. Secondly, while wetland Types III-V showed little change in numbers, they may have changed considerably in quality as a result of water and air pollution in the region. Thirdly, heaviest drainage of wetland Types III-V may have taken place prior to the 1955 inventory. Kabat (1972) estimated that 54 percent of the wetlands present in the 1870's in 14 southeastern Wisconsin counties were drained by 1958. Drainage decelerated between 1958 and 1968, with only an additional 7 percent of the wetlands being lost during this 10-year period (Kabat, 1972). Density of wetland Types III-V has apparently not changed much in the Low Density region, or at least in the northern section of this region. Little change from density found in 1955 would be expected since most of the wetlands compared are lakes, flowages, beaver ponds and other areas with poor drainage potential. Many of the lowland soils in this region are quite water-logged, and the removal of surface water would be difficult. Again, no changes in quality were measured, and the effect of activities such as shoreland development or removal of aquatic vegetation was not considered. Some losses to drainage, etc., probably occurred in the southern section of the Low Density region, but major losses should have come before 1955.

The apparent decline in density of wetland Types III-V in the Northwest region is difficult to explain. Drainage and filling were not thought to be a major problem in that region of Wisconsin, yet 18 percent fewer permanent and semi-permanent wetlands were recorded in 1965-1970. The difference is probably due to sampling variability which may have been greater in the Northwest region where densities of wetland Types III-V were highest. Also, a weighted average 1955 density of Types III-V was more difficult to obtain for this region than for the other 2 regions. Regional boundaries did not correspond well to soil types. As a result, weighting factors used may have affected the average enough to produce the apparent differences in density.

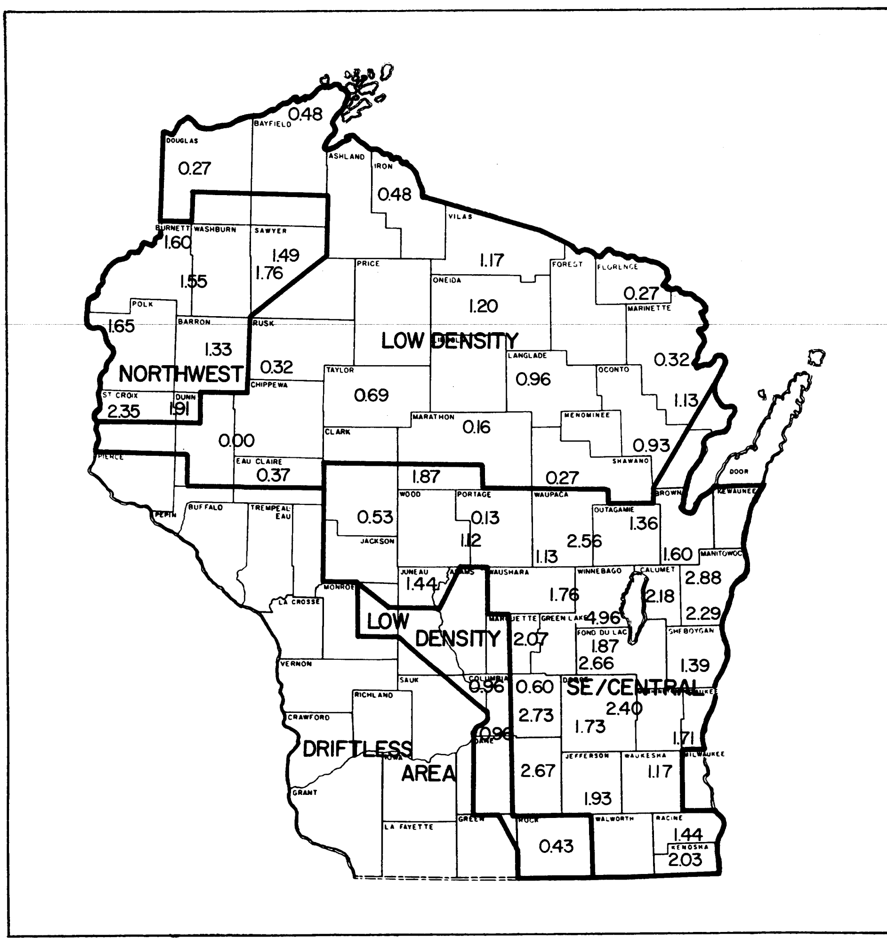


FIGURE 14
Average number of breeding ducks observed per square mile on the 55 transects surveyed during 1966-1970. Density figures are located at the approximate center of each transect.

Addition of New Habitat

The construction of ponds and small flowages to furnish water for recreation (e.g., hunting, fishing, swimming or other water sports) or for agriculture is currently quite popular in Wisconsin. Greatest activity seems to be in the southeast and southwest, but some pond and flowage construction has been noted in all parts of the state. These man-made wetlands may have offset some losses to draining and filling of natural wetlands. Although it was often difficult to identify a water area as natural or "artificial", at least one-third of the Type V areas tallied in the SE/Central region appeared to be man-made. Observed occupancy of man-made ponds in that region was about 10 percent in 1969 and about 13 percent in 1970. This level of use was equal to the average occupancy for "natural" Type V wetlands in the region. No records were kept on the use of various-sized ponds.

Continued interest in wetlands and their benefits to wildlife, etc., may stimulate an increase in man-made wetlands over the next 10 years. Interest in restoring natural wetlands will undoubtedly increase. Such endeavors should help to sustain the amount of habitat in Wisconsin currently available to breeding ducks.

In addition to the construction of flowages and ponds, beaver activities in northern and central Wisconsin seemed to be making an important contribution to the habitat available to breeding ducks. On transects in the northern one-half of the state, the number of beaver flowages went from 22 in 1969 to 34 in 1970, an increase of over 50 percent. Beaver complaints handled by the DNR during 1968-1970 also indicated increased beaver activity. Total complaints of beaver damage numbered 389 in 1968, 482 in 1969 and 584 in 1970 (Barger, 1971). The number of dams removed also increased, from 554 in 1968 to 1,188 in 1970.

Streams with a series of beaver dams seemed especially attractive to ducks. In some of the drier forested country, beaver flowages represented a major part of the available habitat. Ducks were observed on 9 percent of the beaver ponds in 1969 and on 12 percent in 1970. Occupancy equalled that observed for all Type IV and V wetlands in the Northwest region and exceeded occupancy rates for wetland Types IV-V in the Low Density region by as much as 50 percent. Use of beaver ponds by breeding and migrating ducks has also been reported by Knudsen (1962) who found an average of 2.3 ducklings per pond per year on 333 Wisconsin beaver ponds studied. He found migrating and/or breeding ducks on 72 percent of the ponds checked between late April and late October.

VALIDITY OF HABITAT INDEXES

Variability of Wetland Densities

The overall standard error calculated for wetlands per square mile (± 10 percent) was somewhat less than that obtained for breeding ducks per square mile (± 18 percent), although the 2 figures are not directly comparable. On individual transects, the number of wetlands counted per transect ranged from 16-89 in the SE/Central region, 23-95 in the Northwest region and 12-114 in the Low Density region. Despite these quite broad ranges of wetlands per transect, wetland abundance was apparently less variable between transects and between years than duck abundance. The absence of a visibility bias in regard to wetlands may account for most of this difference. In addition, the year-to-year stability of permanent wetland densities also would contribute to reduced variability.

On the basis of wetland densities recorded during 1965-1970, and recognizing the level of variability inherent to our surveys, we concluded that there was very little change in the available habitat between 1965 and 1970. At least there was little significant change in the number of water areas available to breeding pairs each spring. This suggests little similarity between conditions in Wisconsin and those described by Crissey (1969) as relating to the prairie pothole region of Canada and the U.S. Although sufficient habitat is usually available to accommodate Wisconsin breeding populations in April and May, habitat in July and August for brood rearing may be less secure.

The annual wetland density was not consistently related to the amount of precipitation during any individual period of 2 or more months between August and May. Each year, wetland abundance seemed to depend on precipitation, or lack of it, during a different period. Overall August-May precipitation showed considerable variation (more than 12 inches) in the average amount received between the driest and the wettest years. Because of these inconsistencies, it was not possible to predict how much habitat would be available in May on the basis of precipitation during any one part of the preceding 9 months. Lynch (1964) considered the ideal precipitation pattern for prairie-nesting ducks to be heavy and general rains during late summer and fall of the previous year. This, plus spring snow melt, is held in wetlands by a good frost seal. Relationships between precipitation and condition of Type III-V wetlands in Wisconsin might be expected to be different from those on the prairies. Eisenlohr (1969) discussed the great importance of soil conditions (i.e., "basin seal") in controlling basin inflow of prairie potholes. Basin seal may be less important in Wisconsin since streams, lakes and marshes are generally the result of slow ground water movement to points of surface discharge (Cotter and Jahn, 1969). Moisture conditions some distance from the actual wetland could have considerable influence on the amount of surface water because of this flow of ground water. Precipitation directly on a prairie wetland represents its major source of water (Eisenlohr, 1969). Annual precipitation in grassland or prairie regions is also much less than normally falls in Wisconsin (21 inches versus 30 inches–Lynch, 1964; Curtis, 1959). Precipitation on the prairies is also quite variable and unpredictable (Eisenlohr, 1969).

Sources of Variation

Wetland densities were based on the assumptions that all wetlands within the 1/8-mile strip on the right side of the aircraft were recorded and that all wetlands were classified correctly to "type" each year. Potential biases in the number of wetlands recorded and their classification could be traced to 3 major sources of variation:

1. *Differences in observers.* Ability of observers to census and correctly classify all wetlands was affected by differences in judgment between observers and by the ability of individual pilots to maintain proper altitude and flight path and has been previously discussed.

2. *Fluctuations in water levels.* Rain fell during the survey periods in most years. On transects flown immediately after periods of precipitation, temporary wetlands were more abundant than on transects flown prior to the precipitation. These additional areas bias wetland density: (1) since they do not represent wetlands that were initially available to resident pairs arriving from the wintering grounds, and (2) since some of them were undoubtedly misidentified as semipermanent wetlands. Possible incorrect classification may have occurred most frequently when shrub swamps (Type VI) and large wet meadows were present. Because of variations caused by water level fluctuations, the best wetland densities by type were probably obtained in dry years when permanency of most areas was easier to judge.

3. *Deviations in flight routes and direction.* Slight deviations in flight routes between years were unavoidable. As a result, some wetlands were omitted from the 1/8-mile strip and also, new ones included. In addition, weather, flight scheduling and overall survey efficiency made it impractical to fly all transects in the same direction each year. Between 65 and 70 percent of the total transects flown in the SE/Central and Low Density regions were covered in the same direction on each of the 5 surveys. In the Northwest, about 80 percent of the total transects were flown in the same direction. The average density of the permanent wetlands (Types IV-V) and streams calculated from the same transects flown in opposite directions on one or more of the surveys varied with flight direction. Densities of Type IV-V wetlands obtained from west-to-east flights were 12 percent, 12 percent and 26 percent greater for the SE/Central, Northwest and Low Density regions, respectively, than those densities obtained from east-to-west flights. Stream densities obtained on east-to-west flights were 4 percent greater, 14 percent lower and 25 percent greater for the SE/Central, Northwest and Low Density regions, respectively, than stream densities obtained on west-to-east flights. Considering the variability associated with densities of all wetlands, these differences in densities of streams and Type IV-V wetlands may not be important except in the Low Density region.

RECOMMENDATIONS

MONITORING FUTURE POPULATIONS

Alternatives

The five surveys during 1965-1970 established the magnitude of Wisconsin's breeding duck population and provided an estimate of current habitat abundance. Techniques which could be used to obtain future population and habitat information were also tested. Scope and frequency of future monitoring should depend on the importance and priority of obtaining additional population and habitat data in Wisconsin.

The resumption of annual surveys or switching to surveys at designated intervals, e.g., every 5 or 10 years, are the 2 alternatives to monitoring future populations and habitat. Annual surveys produce the most valuable information since they have the advantages of: (1) providing managers with yearly indexes to habitat, species composition and regional breeding duck numbers, plus allowing measurement of long-term trends; (2) giving a base on which to predict annual production potential; (3) permitting the inclusion of current Wisconsin data into the national waterfowl forecast on which annual regulations are based; and (4) allowing a more realistic approach to determining which regulations guidelines would best benefit Wisconsin in a given year on the basis of current population trends.

If surveys are to be made at intervals, instead of annually, they should be activated for 3 consecutive years. Increasing or decreasing populations cannot be detected by a single survey. Even with 2 consecutive surveys, trends are difficult to interpret because of sample variability. Three consecutive surveys every 5 years would be more reliable for predicting trends than 3 consecutive surveys every 10 years. Continental duck populations tend to show fluctuations of highs and lows over roughly a 10-year period, because of droughts on the prairies. Since the 1968-1970 data seem to suggest that there is some relationship between Wisconsin populations and those in the major prairie breeding grounds (although this relationship is still not clearly defined because of the absence of long-term Wisconsin information), surveys every 10 years might census Wisconsin during a continental peak one time and a continental low the next. Or, 2 highs or 2 lows might be encountered. Any changes noted in Wisconsin populations between the 2 sets of surveys might be misleading since they could be influenced by prairie populations. Monitoring populations every 5 years should furnish information in periods of both high and low continental populations, and would probably not cover 2 consecutive periods of one or the other. Reduction in the monitoring effort to 3 surveys every 10 years may be warranted after several more comparisons of Wisconsin and continental duck population trends.

Survey Mechanics

Aerial surveys, using the 1968-1970 sampling scheme, with minor refinements in regional boundaries and transect allocation, would be the most efficient means for monitoring populations. Air counts should be used whether surveys are run annually or at designated intervals. If annual population indexes are to be adjusted for birds missed by air, air:ground comparison data must be collected at the time of the aerial surveys.

Length of transects should remain 30 linear miles. In order to increase the number of ducks observed per route by 50 percent, transects would have to be made 45 miles long. Since transects in the SE/Central and Northwest regions exceed ten ducks per transect in most years, longer transects are probably not needed. It would require transects at least 60 miles long in order to bring the number of ducks seen in the Low Density region to 10 per transect and probably would not be justified in terms of additional information.

Population and habitat surveys should be coordinated by the Bureau of Game Management. One observer should be responsible for an entire annual survey (unless a 3- or 4-place aircraft were available that would permit the use of 2 observers, one responsible for each side of the aircraft). Aerial counts would require 10 or 12 days of aircraft use. Thirty-five to 40 man-days would be needed to complete the necessary air:ground segments.

To further reduce variability within regions, portions of the SE/Central region averaging less than 1.0 breeding duck per square mile should be transferred to the Low Density region. Regional boundaries would have to be redefined slightly to accomplish this. In order that the entire sampling scheme can more closely approximate a stratified random sample, a completely new set of transects should be randomly selected within each region prior to resuming these surveys, using optimum allocation techniques.

To improve the reliability of the air:ground ratios, air:ground comparison coverage should be expanded. At least 10 percent of the actual area counted by air in each region should be included in air:ground segments. Reliability of the ratios would also be greater if these segments were better delineated. To accomplish this, it might be necessary to shift flight paths to follow roads (other than main highways) on the air:ground segments. Also on the air:ground segments, all wetlands within the 1/4-mile strip searched on the ground should be enumerated and classified to type. They should also be tallied as "occupied" or "unoccupied". This information would serve to adjust for errors in wetland classification and observed occupancy made during the aerial surveys. It is also essential to record the number of ducks present on individual wetlands censused from the ground to provide a ducks/pond index for clarifying how changes in wetland type and abundance affect the distribution and density of breeding ducks.

The bias to wetland density resulting from changes in flight direction should be eliminated. All wetlands lying within the 1/8-mile strip on the north side of the aircraft should be enumerated and classified by type on each transect. The north side should be used since it will eliminate sun glare associated with looking south.

All transects should be flown between 7 a.m. and 12 noon, CST. Reduced air turbulence earlier in the day permits more efficient counting. In addition, flying transects at this time of day conforms more closely to techniques used by the Bureau of Sport Fisheries and Wildlife in their surveys of prairie breeding grounds.

The unevenness of the Wisconsin terrain, the extensive forested regions in the north, and an abundance of power lines and cities in the south, make it impossible to fly all transects at prescribed altitudes. Wind direction and velocity also have a major influence on the ground speeds which can be safely maintained. However, except when safety precautions require otherwise, all flights should be made at an altitude of 100-150 feet above the ground and at a ground speed of 75-90 mph.

If more than one pilot or observer are used to complete the surveys, the same crews should census the same transects on each survey in each year.

Appendix F gives a complete set of suggested instructions for future aerial surveys and air:ground comparison coverage.

FUTURE RESEARCH AND MANAGEMENT

The importance of various wetland types to breeding ducks, especially in regard to use at different stages of the reproductive cycle, is not known in Wisconsin. A long-term study of the various characteristics of the different wetlands, e.g., invertebrate food resources, water quality, vegetation and water retention or permanency in relation to duck use should be considered. Such studies could monitor a series of wetlands selected for their representativeness of the different types and could be combined into an extended evaluation of pioneering by breeding pairs, nesting success and brood production in various habitats similar to work done by Stoudt (1971) and Smith (1971). The relationship between numbers of breeding ducks and the eventual brood production should be emphasized. Results could be used to guide future acquisition and development for waterfowl production as well as to clarify population dynamics of local ducks.

Currently, a major portion of Wisconsin ducks are still produced on private wetlands. Despite continuous drainage, the state has a good cross-section of wetland types left in most regions. Although the Type III, IV and V wetlands appeared to be the most important to breeding waterfowl in our surveys, temporary wetlands may also make a significant contribution. Their abundance alone accounts for a considerable amount of water available to breeding ducks in early spring. The importance of these areas in future wetland preservation programs, particularly in any statewide land use plan or other zoning schemes, must not be disregarded.

Acquisition and preservation of permanent wetlands probably has the greatest potential for maintaining waterfowl habitat in Wisconsin. The maintenance of key wetlands with permanent water, plus the development of temporary and semi-permanent wetlands into permanent brood waters could make a major input toward perpetuating Wisconsin duck populations. An accelerated scattered wetlands program for waterfowl that includes all types of wetlands could also benefit many other species of wetland flora and fauna.

Until more is known about the relative importance of temporary wetlands to waterfowl, major acquisition or easement emphasis should be directed toward Type III, IV and V wetlands. Such wetlands provide habitat essential to brood survival. In any county with high breeding duck densities, all wetlands of these 3 types should be protected, particularly small wetlands (less than 1 acre) which may be especially vulnerable to development and particularly those wetlands in the SE/Central region which has the highest duck production and least amount of "surplus" habitat. In addition, lakeshore development in marshy areas should be discouraged.

State and federal management areas in Wisconsin were found generally to have a higher breeding density than the surrounding regions. Department of Natural Resources' wetlands now total about 270,000 acres, with an acquisition goal of about 330,000 acres. If this habitat currently produced at least 1 duckling per 5 acres, over 50,000 young would be reared on state lands annually. In addition to state lands, national wildlife refuges and forests in Wisconsin contain over 300,000 acres of wetlands. Significant numbers of ducks are also produced on these lands each year. For example, the Upper Mississippi NWR reared an estimated 1 duckling per 8 acres of potential habitat during 1966-1970 (W.G. Green, pers. comm., 1971). By comparison, Jahn and Hunt (1964) considered good production on the better quality (unmanaged) wetlands in southern Wisconsin to be about 1 duckling per acre of occupied wetland (i.e., that area used by breeding pairs).

Efforts to increase production on public lands could offset a considerable habitat loss on private lands or substantially increase the importance of public areas to Wisconsin's fall flight. Through development and management, state-owned wetlands can produce the equivalent of the better-quality natural wetlands. This could amount to a 50-percent increase over the current production estimate for the entire state.

Development of state waterfowl management areas should be aimed at pond and small flowage construction. Most developments to date have involved large, single-structure impoundments. These areas, while attractive to ducks migrating through the state in the fall, are often difficult to manage for breeding ducks. On management areas with large flowages, the development of smaller ponds and "satellite" flowages around the margins of the big impoundments should be encouraged. Pockets of open water should be established in large cattail (*Typha* spp.) and sedge (*Carex* spp.) monotypes, to enhance breeding pair use.

Beaver abundance definitely enhances waterfowl use in northern and central Wisconsin. Dams should be encouraged wherever serious conflicts with other interests can be avoided and whenever duck production is of primary concern. Transplanting beaver into remote areas with little surface water attractive to ducks but with abundant streams, could be beneficial. Use of beaver ponds by breeding ducks represents a relatively inexpensive form of management for improved production.

Wood ducks remain a major question mark in the Wisconsin waterfowl picture. At present, indirect population estimates based on harvest and banding are the best measure of the species' abundance. Because of the wood duck's importance to local breeding populations and the state harvest, an effort should be made to obtain a more reliable index to its abundance. An evaluation of statewide wood duck populations should have high priority in any future species-oriented research. Some type of stratified random sample of stream and lake habitat attractive to wood ducks might be used to estimate pair and brood densities at the initial stage of this study.

Wisconsin has the opportunity – unique from many states, especially those to the south and east – to make an impact on its wetland resources through the management of locally-breeding ducks. The annual Wisconsin harvest receives a major input of local ducks from at least 3 species – the mallard, the wood duck and the blue-winged teal. Many of the ducks seen in Wisconsin throughout the spring, summer and fall represent locally-breeding birds. If Wisconsinites are able to sustain or increase current breeding duck populations and the available habitat, they can obtain increased benefits for human recreation of all types far into the future.

APPENDIX A CRITERIA USED IN CLASSIFYING WETLANDS

MARSHES, PONDS, FLOWAGES, LAKES AND SEASONALLY FLOODED DEPRESSIONS

Type I Areas–Seasonally flooded depressions in agricultural fields, or in pastures (if not associated with sedges).

Type II Areas–Seasonally flooded sedge meadows or brush patches (sedge and willow and/or dogwood).

Type III Areas–Water areas expected to dry out by July 15. Usually associated with cattails and occasionally with bulrush. Included alder bottoms in northern Wisconsin, willow/dogwood areas in southern Wisconsin if these areas appeared to be deep, and flooded creek bottoms if cattail and/or alder were present.

Type IV Areas–Cattail- and bulrush-rimmed marshes and potholes that appeared to have permanent water. Contained clumps of emergents dispersed throughout basin.

Type V Areas–Open, fresh water areas, including most lakes, artificial ponds and blasted potholes with permanent surface water and vegetation restricted to shoreline.

Type VI Areas–Shrub swamps which were included with Type II and Type III areas.

Type VII Areas–Wooded swamps which in the north, included flooded black spruce, tamarack, birch, maple, or cedar, and in the south, included flooded maple, tamarack, birch, willow, or oak.

Type VIII Areas–Bogs, consisting of temporarily flooded leatherleaf, laborador tea, cranberry, sphagnum, occasional sedge, black spruce or tamarack.

DITCHES

All drainage ways, including channelized streams, which contain surface water and which may be either seasonally flooded or permanent waters.

STREAMS

All creeks and rivers, including those flowing water areas which were created by runoff but which did not follow a ditch channel.

APPENDIX B

OBSERVED DUCKS PER TRANSECT BY REGION, AND DIFFERENCES BETWEEN AND WITHIN REGIONS BY YEAR AS DETERMINED FROM THE FRIEDMAN RANKS TEST (D.R. THOMPSON, PERS. COMM., 1972)

Region	Observed Ducks per Transect* 1966	1968	1969	1970	Avg.–All Years	Weighting Factor
SE/Central	10.07	11.43	16.57	15.71	13.45	0.3204
Northwest	12.00	9.25	9.25	16.00	11.63	0.1234
Low Density	5.47	2.95	3.05	5.68	4.29	0.5563
Weighted Mean for All Regions	7.75	6.44	8.15	10.17	8.13 (± 1.41 at P=0.05)	1.0001

*The number of ducks observed per transect divided by 7.5 (the number of square miles per transect) equals the number of ducks observed per square mile.

Yearly Comparisons	Differences Between and With Regions* SE/Central	Northwest	Low Density	All Regions (Weighted)
1966 vs. 1968	n.s.	n.s.	P<0.05	P<0.10
1966 vs. 1969	P<0.10	n.s.	P<0.10	n.s.
1966 vs. 1970	P<0.05	n.s.	n.s.	n.s.
1968 vs. 1969	P<0.10	n.s.	n.s.	n.s.
1968 vs. 1970	n.s.	P<0.05	n.s.	P=0.05
1969 vs. 1970	n.s.	n.s.	n.s.	P<0.05
All Years	P<0.05	n.s.	P<0.10	P<0.05

*n.s. = P>0.10

APPENDIX C

BREEDING POPULATION INDEXES FOR EACH REGION, 1965–1970

Region	Breeding Ducks (in Thousands) 1965	1966	1968	1969	1970	Avg.
SE/Central						
Mallard	16.7	9.6	11.1	14.8	15.8	13.6
Blue-winged teal	11.2	7.2	7.4	12.7	9.6	9.6
Others*	9.3	3.0	4.0	5.2	5.5	5.4
Total	37.2	19.8	22.5	32.7	30.9	28.6
Northwest						
Mallard	5.4	5.1	4.4	3.0	6.3	4.8
Blue-winged teal	4.0	2.4	1.9	2.7	2.8	2.8
Others*	2.8	1.5	0.7	1.3	3.0	1.9
Total	12.2	9.0	7.0	7.0	12.1	9.5
Low Density						
Mallard	6.0	10.8	5.1	6.2	14.9	8.6
Blue-winged teal	2.4	2.3	1.8	1.8	2.6	2.2
Others*	4.7	5.4	3.1	2.6	2.0	3.5
Total	13.1	18.5	10.0	10.6	19.5	14.3
All Regions						
Mallard	28.1	25.5	20.6	24.0	37.0	27.0
Blue-winged teal	17.6	11.9	11.1	17.2	15.0	14.6
Others*	16.8	9.9	7.8	9.1	10.5	10.8
Total	62.5	47.3	39.5	50.3	62.5	52.4

*Includes all other identified and unidentified species of breeding ducks seen.

APPENDIX D OVERALL STANDARD ERROR AND ANALYSIS OF VARIANCE FOR EFFECT OF REGIONS AND YEARS ON THE NUMBER OF WETLANDS COUNTED PER TRANSECT (D.R. THOMPSON, PERS. COMM., 1972)

	Unweighted Mean No. of Wetlands per Transect per Year				
Region	1966	1968	1969	1970	All Years
SE/Central	41.3	42.5	49.9	37.2	170.9
Northwest	57.9	35.4	39.8	37.6	170.7
Low Density	56.7	47.2	42.4	45.8	192.1
All Regions	155.9	125.1	132.1	120.6	533.7

	Analysis of Variance			
Source	d.f.	MS	F-ratio	Sign.
Regions (Rows)	2	37.8	0.84	n.s.
Years (Columns)	3	82.3	1.84	n.s.
Error	6	44.7		
Total	11	53.72		

Overall mean with 95% C. L. = 44.4 ± 4.7 wetlands per transect, or 11.8 ± 1.2 wetlands per square mile

APPENDIX E AIR:GROUND RATIOS FOR MALLARDS FROM THE 1970 AIR: GROUND SEGMENTS IN THE SE/CENTRAL REGION

Segment	No. of Breeding Pairs		
No. *	Air Count	Ground Count	Air:Ground Ratio
3	2	11	.18
17	1	5	.20
19	3	10	.30
68	3	11	.27
			$\bar{x}$=.24

*Each segment was 10 miles long and ¼-mile wide.

APPENDIX F PROCEDURES FOR STATEWIDE SURVEY OF BREEDING WATERFOWL*

JUSTIFICATION AND RESPONSIBILITY

During 1965-1970, the distribution, density, species composition and annual levels of Wisconsin's breeding duck population were established through intensive air and ground surveys. Although state breeding densities (generally 5 pairs per square mile or less) are not sufficient to influence continental population levels significantly, locally produced birds are quite important to Wisconsin hunters. In some years, as much as one-half of the Wisconsin harvest of mallards, wood ducks and blue-winged teal is derived from local breeders and their offspring. These 3 species also represent the state's most abundant breeding ducks.

The investment of millions of dollars in wetland preservation and development in Wisconsin necessitates periodic inventories of current levels of waterfowl production and use of state-owned wetlands.

For adequate management of Wisconsin's duck populations, it will be necessary to initiate extensive statewide surveys. The effects of hunting regulation changes, habitat changes and continuing management on breeding waterfowl can be evaluated only from annual information on numbers of each species and habitat conditions. Such information is especially important for the mallard, which is the most abundant breeding duck in Wisconsin (also continentally) and is the No. 1 bird in the state's harvest. Annual bag limits, etc., in the Mississippi Flyway are based primarily on mallard populations. Since local mallards are very important to Wisconsin hunters, breeding surveys are necessary to assist in monitoring the influence of hunting regulations on spring breeding densities.

Initiation of the survey, design of the sampling scheme and preparation of maps showing transect routes and air:ground segments will be the responsibility of the Wildlife Research Section, Bureau of Research. They will also analyze and prepare a summary of the data.

Basic survey design will consist of 3 regions: the SE/Central, the Northwest and the "Low Density". Each region will be assigned a predetermined number of 30-mile long transects. Transects will be censused by air for breeding ducks, coots and geese. Segments from certain of the transects will also be censused by ground crews to obtain air:ground correction factors. Species composition of the ground counts will also be used to adjust the "unknown" category from aerial counts.

PROCEDURES

Aerial Census

Survey Dates

Surveys will run between May 1 and 20. Starting date may be adjusted in years of unusually early or late springs. Surveys should not be initiated if large numbers of migrant ducks, e.g., scaup, canvasback, pintail or wigeon are still present. Transects in the Southern, Southeast and Lake Michigan Districts are to be run between May 1-10, starting with the southernmost routes. Transects in the West Central, Northwest and North Central Districts are to be flown between May 8 and 20.

Survey Times

Unless aircraft scheduling conflicts dictate otherwise, all transects should be censused between 8 a.m. and 12 noon, CDT. No transects should be started before 7 a.m. or after 2 p.m., CDT.

Survey Speed and Altitude

Each transect should be flown at a ground speed of between 75 and 90 miles per hour. Normally, flights should be made at an altitude of 100-150 feet above ground level for best counting and identification. Censuses should not be made when conditions prevent flights at 250 feet or less. In regions of widely separated wetlands or in hilly terrain, especially over forested areas, higher altitudes can be maintained until wetlands are encountered on a transect.

Personnel Assignments

Two people experienced in waterfowl identification and census procedures shall be arranged by the Director, Bureau of Game Management, to act as observers on all flights. The primary observers are responsible for recording all data and its submission for analysis. The same observers should be maintained on consecutive surveys. It would be most desirable if 1 pilot is assigned to fly all transects. The designated pilot should be selected on the basis of past experience with aerial waterfowl censuses. The pilot is responsible for maintaining proper altitude, flight speed and transect course, and may serve as a secondary observer.

Data Collection

All ducks, coots and geese seen by the observer or pilot within a 1/8-mile strip on either side of the aircraft should be counted and, whenever possible, identified to species. Waterfowl should be classified as pairs, lone drakes (or hens) or mixed flocks (if the number of pairs or singles within a group cannot be determined). Ducks which cannot be identified by species should be designated as "unknown" pairs, lone males, etc.

All wetlands having surface water and lying within the 1/8-mile strip on the north half of each transect will be counted and classified to "type" by the observer. Criteria for "type" classification will be furnished by the Wildlife Research Section. All wetlands within the 1/4-mile transect width on which breeding waterfowl (i.e., occupied areas) are observed should also be recorded by "type".

Data Recording

In-flight waterfowl and habitat data plus all other pertinent information re:survey date, transect number, flight direction, weather conditions, starting and ending times and landmarks for locating on-ground segments, will be recorded for individual transects on a portable tape recorder. Breeding waterfowl data from each transect should be transferred to Form 2300-60, Waterfowl Breeding Survey Form (Ground), at the end of each day's flight. When the entire survey is completed, tapes and Forms 2300-60 should be forwarded to Wetland Game Research at Horicon for analysis and summary.

Ground Counts of Air:ground Segments

Within 3 days after aerial census, ground crews will search all wetlands on designated segments of selected aerial transects and record all breeding waterfowl. Only those wetlands, or portions thereof, that lie within the 1/4-mile strip surveyed by air should be included in ground counts. Ground segments are to be delineated on the basis of road boundaries and other landmarks designated by the aerial observer.

The primary purpose of the ground census is to obtain a complete count of all birds present within the air:ground segment. A thorough search of each wetland will be necessary to obtain this goal. In searching each area, personnel should be alert for "wild" flushing birds, and all birds should be marked down or watched out of sight to reduce "roll-up" and duplicate counts.

Ground Crew Assignments

Annually, upon receiving a tentative time schedule and maps from the Wildlife Research Station, showing air:ground segments, district directors shall assign responsibility for ground counts to area game managers with segments in their counties. Three- or four-man crews can efficiently complete most segments in 4 hours or less. Two-man crews can also make these counts, but make them less efficiently and require a longer time period. Not more than 2, and usually only 1, segments will fall in a given area. The area manager or his assistant should conduct the ground counts in most cases. Personnel of the Wildlife Research Section will also be made available upon request. Requests for assistance from Research should be made directly by the area game manager to Wetland Game Research at Horicon. Exact timing of segment ground counts in each area must be coordinated between the aerial observer and the area manager.

Data Collection

Ground crews should collect the following data for each wetland within a segment: (1) number of ducks of each species, classified by pairs, lone males (or hens), or mixed flocks (if pairs, etc., cannot be determined); (2) number of coots or geese; (3) wetland "type" and dominant vegetation; (4) classification of wetlands as "occupied" or "unoccupied"; and (5) approximate acreage of surface water. Waterfowl passing over the transect in flight which are obviously not associated with the transect should not be counted. Ground censuses should not be made under extreme weather conditions, e.g., heavy rain, snow, fog or extreme cold. Data from ground censuses should be forwarded to Wetland Game Research, Horicon, for analysis.

DNR Wildlife Areas

Designated Areas

The following state wildlife areas will be included in statewide breeding surveys when flight time permits: Crex Meadows, Powell, Mead, Sandhill, Meadow Valley, Germania, Grand River, Collins, Eldorado and Horicon. These 10 areas are selected because of their larger flowage acreages and estimated contributions to Wisconsin duck production. Additional projects may be included as required for management evaluation.

Aerial Census

Aerial counts will be made along section and quarter section lines within project boundaries. Flights will normally follow north-south transects on most projects. On certain projects, east-west transects will give a more efficient coverage of the wetland habitat and better delineate flight paths. Up-to-date project maps, showing transect locations, will be furnished the aerial crew by Wetland Game Research.

All other general survey procedures (where applicable) listed under the section on "Aerial Census" should be followed.

Air:ground Segments

A portion(s) of each wildlife area that is accessible by either foot, car or boat, will be

*Wisconsin Department of Natural Resources (1973).

counted by both air and ground crews to provide air:ground comparison information for that project. In most cases, an air:ground segment (or a series of segments) would consist of a 1/4-mile strip paralleling a dike road or flowage boundary. Length of these segments would depend on project size, accessibility, etc. On some areas which lack accessible dikes, etc., it will be necessary to census a designated transect by boat to obtain the data.

Procedures should follow closely those listed under "Ground Counts of Air:Ground Segments" section. Area or project managers will be responsible for completing ground counts on the designated wildlife areas and submitting results to Wetland Game Research. Selection of air:ground segments will be coordinated between the local manager, the aerial observer and Wetland Game Research.

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