# POPULATION ECOLOGY OF THE MALLARD

## II. Breeding Habitat Conditions, Size of the Breeding Populations, and Production Indices

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
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## II. Breeding Habitat Conditions, Size of the Breeding Populations, and Production Indices

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# ABSTRACT

This report, the second in a series on a comprehensive analysis of mallard population data, provides information on mallard breeding habitat, the size and distribution of breeding populations, and indices to production. The information in this report is primarily the result of large-scale aerial surveys conducted during May and July, 1955–73. The history of the conflict in resource utilization between agriculturalists and wildlife conservation interests in the primary waterfowl breeding grounds is reviewed. The numbers of ponds present during the breeding season and the midsummer period and the effects of precipitation and temperature on the number of ponds present are analyzed in detail. No significant cycles in precipitation were detected and it appears that precipitation is primarily influenced by substantial seasonal and random components. Annual estimates (1955–73) of the number of mallards in surveyed and unsurveyed breeding areas provided estimates of the size and geographic distribution of breeding mallards in North America. The estimated size of the mallard breeding population in North America has ranged from a high of 14.4 million in 1958 to a low of 7.1 million in 1965. Generally, the mallard breeding population began to decline after the 1958 peak until 1962, and remained below 10 million birds until 1970. The decline and subsequent low level of the mallard population between 1959 and 1969 generally coincided with a period of poor habitat conditions on the major breeding grounds. The density of mallards was highest in the *Prairie-Parkland Area* with an average of nearly 19.2 birds per square mile. The proportion of the continental mallard breeding population in the *Prairie-Parkland Area* ranged from 30% in 1962 to a high of 60% in 1956. The geographic distribution of breeding mallards throughout North America was significantly related to the number of May ponds in the *Prairie-Parkland Area*. Estimates of midsummer habitat conditions and indices to production from the July Production Survey were studied in detail. Several indices relating to production showed marked declines from west to east in the *Prairie-Parkland Area*, these are: (1) density of breeding mallards (per square mile and per May pond), (2) brood density (per square mile and per July pond), (3) average brood size (all species combined), and (4) brood survival from class II to class III. An index to late nesting and renesting efforts was highest during years when midsummer water conditions were good. Production rates of many ducks breeding in North America appear to be regulated by both density-dependent and density-independent factors. Spacing of birds in the *Prairie-Parkland Area* appeared to be a key factor in the density-dependent regulation of the population. The spacing mechanism, in conjunction with habitat conditions, influenced some birds to overfly the primary breeding grounds into less favorable habitats to the north and northwest where the production rate may be suppressed. The production rate of waterfowl in the *Prairie-Parkland Area* seems to be independent of density (after emigration has taken place) because the production index appears to be a linear function of the number of breeding birds in the area. Similarly, the production rate of waterfowl in northern Saskatchewan and northern Manitoba appeared to be independent of density. Production indices in these northern areas appear to be a linear function of the size of the breeding population. Thus, the density and distribution of breeding ducks is probably regulated through a spacing mechanism that is at least partially dependent on measurable environmental factors. The result is a density-dependent process operating to ultimately effect the production and production rate of breeding ducks on a continent-wide basis. Continental production, and therefore the size of the fall population, is probably partially regulated by the number of birds that are distributed north and northwest into environments less favorable for successful reproduction. Thus, spacing of the birds in the *Prairie-Parkland Area* and the movement of a fraction of the birds out of the prime breeding areas may be key factors in the density-dependent regulation of the total mallard population.

# INTRODUCTION

The mallard (*Anas platyrhynchos*) has been the subject of extensive research and management programs in North America. Input from numerous data-collection programs is required to adequately monitor a wildlife population that is found throughout most of North America. Many of the data-collection programs are extensive and have been in operation for several decades, and much of the data have been only partially analyzed. This report is the second in a comprehensive study of the population ecology of the mallard and is designed to evaluate data collected as a result of research and management programs during 1955–73. The first report (Anderson and Henny 1972) discusses the history of waterfowl management in North America, delineates 16 breeding ground reference areas, and describes the band recovery patterns from them. The breeding range of the mallard in North America is divided into reference areas (italicized in reports of this series) because of regional difficulties in migration and harvest patterns.

A comprehensive bibliography of the published literature on the mallard is presented in a third report (Anderson et al. 1974). The mallard harvest in the United States is the subject of the fourth report (Martin and Carney, in preparation), which summarizes data obtained from the Bureau's two mail surveys: 20 years of the Waterfowl Harvest Survey (questionnaire), and 11 years of the Parts-Collection Survey (wing). The United States and Canada are divided into 113 harvest areas and the total mallard harvest, age and sex ratios in the harvest, duck stamp sales, etc., are summarized for each harvest area.

A study of this magnitude must utilize a building-block approach. The first and third reports, together with this report, provide a solid base for future reports in the series which will supply information on the distribution and derivation of the mallard harvest (e.g., what is the source of mallards harvested in Minnesota?), band recovery rates, harvest rates, production rates, and survival rates.

The quality of the habitat in the mallard breeding range, the numbers of breeding mallards present, and indices to production are the topics considered in the present report. The aerial surveys conducted in May (to estimate habitat conditions and the number of breeding birds) and in July (to estimate variables related to midsummer habitat conditions and waterfowl production) are the primary data-collecting programs used to obtain information on the numerical status of the population and the quantity of breeding habitat. The procedures for conducting the May and July surveys for the years 1955–71 are described in detail in two summary papers (Henny et al. 1972; Pospahala et al. in preparation). For this report the stratum boundaries used in the two summary reports were transformed to mallard reference areas described in the first report of the series (Anderson and Henny 1972) and are used here because mallards produced within each reference area have fairly uniform migration and recovery patterns. In later reports we will attempt to estimate various population parameters for mallards banded within each of the reference areas.

Climatic conditions have a considerable effect on the quality and quantity of waterfowl breeding habitat which in turn influence waterfowl production and the distribution of birds on the breeding grounds. The effects of man's activities on waterfowl habitat, primarily through drainage, are also reviewed. The numbers of ponds are discussed in terms of climatic factors such as precipitation and temperature. Furthermore, annual numbers of May and July ponds in the *Prairie-Parkland Area* (southern portions of Alberta, Saskatchewan, and Manitoba) are discussed with respect to climatic conditions. Finally, relationships between breeding population density and indices to production are examined.

## Objectives

Specifically, the objectives of the present report are to: (1) describe trends and annual changes in the condition of breeding habitat for mallards in North America, 1955–73; (2) discuss the breeding habitat of mallards in relation to climatological variables; (3) present annual estimates of the mallard breeding population and its distribution throughout the breeding range; (4) describe relationships between numbers of breeding mallards, habitat, and indices to productivity; and (5) establish weighting factors for use in future reports for the various portions of the mallard breeding range.

## ACKNOWLEDGMENTS

Large studies are generally the result of efforts by many individuals, and this report is no exception. We are indebted to the numerous individuals who have collected data over the years. Those who have participated in the cooperative air and ground surveys in Alaska, Canada, and the north-central United States since 1955 are listed in Appendix A. The information presented in this report would not have been available without the development of aerial survey techniques by early pioneers in the field. Falling into this category are the following Bureau personnel: Walter F. Crissey, Everett B. Chamberlain, Charles D. Evans, Fred A. Glover, Rossalius C. Hanson, G. Hortin Jensen, John J. Lynch, J. Donald Smith, and Robert H. Smith. Current flyway biologists have been helpful in many respects, one of which is their willingness to make these data available in the most useful form. Special thanks for their help are due Arthur R. Brazda, Rossalius C. Hanson, G. Hortin Jensen, K. Duane Norman, Gerald Pospichal, Morton M. Smith, and James F. Voelzer.

Many individuals provided assistance in making estimates of mallard breeding populations in areas that were either unsurveyed, or were surveyed by methods not directly comparable with the standard survey procedures employed by the Bureau. John Chattin (Bureau of Sport Fisheries and Wildlife) provided estimates for most of the Pacific Flyway. Arthur S. Hawkins (Bureau of Sport Fisheries and Wildlife) was instrumental in determining States' estimates in the Mississippi Flyway States. Darrell G. Dennis (Canadian Wildlife Service) and Harry G. Lumsden (Ontario Department of Lands and Forests) aided in the development of mallard breeding population estimates for Ontario and Western Quebec. Individuals who were instrumental in developing individual State estimates were: Karl E. Bednarik (Ohio), Richard A. Bishop (Iowa), Stephen Browne (New York), Howard Funk and Richard M. Hopper (Colorado), Robert L. Jessen (Minnesota), Frank M. Kozlik (California), James R. March (Wisconsin), Edward J. Mikula (Michigan), Harvey A. Roberts (Pennsylvania), George J. Schildman (Nebraska), and George F. Wrakestraw (Wyoming). The authors, however, assume responsibility for the final figures in this report.

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David C. Bowden developed the estimation procedure for the data collected on the May Breeding Population Survey as part of a Bureau contract. He also aided in the preparation of a number of other phases of the analysis of the population data.

Judith P. Bladen aided in nearly all aspects of the analysis, control, and report preparation. Her contribution to this project was indeed substantial. Marcella M. Edwards, Marcia E. Henson, and Rebecca C. Perry aided in numerous aspects of the research and report preparation. Colleen E. Bystrak, Samuel E. Fowler, and Mary T. Fogwell also aided in specific areas. Several others helped in smaller, but important, ways throughout the course of the investigation.

The basic data from which this report was derived are voluminous and computer processing and analysis were required. William M. Cygan was responsible for the computer programming of the basic data in this report. Important administrative services were provided by Thomas S. Baskett, Duncan MacDonald, Henry M. Reeves, John P. Rogers and Robert I. Smith.

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# METHODS

## Sources of Data

### Size of the Breeding Population, Habitat Conditions, and Production Statistics

The data analyzed in this report were collected primarily during the May Breeding Ground Survey and the July Production Survey in Alaska, Canada, and the north-central United States. These surveys have recently been described and are summarized for 1955-73 by Pospahala et al. (in preparation) and Henny et al. (1972) and details will not be repeated here. Information on the conduct of the ground: air comparison studies may be found in Martinson and Kaczynski (1967) and Pospahala et al. (in preparation).

The survey information was initially collected and summarized on the basis of survey strata. These data have been resummarized by reference areas for this report. Resummarization was done on the basis of area (e.g., if 40% of the stratum 19 was in Reference Area 04, then 40% of the estimated mallard breeding population in stratum 19 was allocated to Reference Area 04). This procedure was used because ground:air comparison data are collected on the basis of survey crew areas. In many cases, reference areas include more than one habitat type and crew area.

Data in this report differ somewhat from those in Henny et al. (1972) and Pospahala et al. (in preparation), because reference area boundaries are somewhat different. Although the figures used in this report are considered best for an analysis of mallard population ecology, the "official" set of population and production survey figures is in Henny et al. (1972) and Pospahala et al. (in preparation).

Basic information collected during the May Breeding Ground Survey and the July Production Survey is summarized in detail in Appendix B which includes nearly all of the information discussed in this report. Annual population estimates and weighting factors are summarized in Appendix C. Repeated reference to these appendixes will not be made.

### Precipitation and Temperature Data

Precipitation and temperature data are from *Monthly Record; Meterological Observations in Canada*, published by the Department of Transport, Toronto, Canada. Monthly data for precipitation (1937-70) and temperature (1940-70) were summarized by river basin for the southern portions of Alberta, Saskatchewan, and Manitoba. These data represent the average climatic conditions in each Province for a particular month. Although the data were summarized by river basins, they conform closely to Reference Areas 03 through 06, the *Prairie-Parkland Area*. The analyses were made on data summarized on a Provincial level or a series of data computed as a weighted average of the three Provinces. The weighted average was based on the approximate size of the three areas (weights: Alberta, 0.296; Saskatchewan, 0.525; Manitoba, 0.179). Emphasis was placed on data representing the southern portions of these three Provinces, since this area generally contains the most important mallard breeding areas on the continent. In addition, estimates of pond numbers are available for this area since 1955.

In view of the importance of May and July pond numbers, the weather data were summarized into two annual periods: (1) June 1 through May 31, and (2) August 1 through July 31. Sets of data based on these annual periods were calculated for each of three Provinces and for a weighted means of the three Provinces.

The number and distribution of the weather stations have varied considerably over the 33-year period studied, but for purposes of this study, the stations recording data were assumed to represent the particular Province. The following table lists the number of weather stations active at the beginning and end of the 33-year period.

| | 1937 | 1970 |
|---|---|---|
| Alberta | | |
| North Saskatchewan River Basin | 23 | 59 |
| Red Deer River Basin | 22 | 37 |
| South Saskatchewan River Basin | 27 | 57 |
| | 72 | 153 |
| Saskatchewan | | |
| Assiniboine River Basin | 34 | 83 |
| North Saskatchewan River Basin | 17 | 24 |
| Saskatchewan Forks | 7 | 20 |
| South Saskatchewan River Basin | 25 | 40 |
| | 83 | 167 |
| Manitoba | | |
| Assiniboine River Basin | 19 | 36 |
| Red River Basin | 11 | 48 |
| | 30 | 84 |
| Total | 185 | 404 |

The techniques used to analyze the climatic data and information on pond numbers were mostly power spectral analysis, generalized time series decomposition and adjustment, spectral modeling, multiple regression, partial correlation, moment statistics, and some nonparametric methods. These methods are described in detail in various sources. Grenander and Rosenblatt (1957), Blackman and Tukey (1958), Bringham et al. (1967), Jenkins and Watts (1968), and Dixon (1970) cover the subjects of autocovariance functions and power spectral analysis. Shiskin and Eisenpress (1957) and Shiskin (1957) discuss the methods of time series analysis and decomposition. Spectral models are developed in publications by Kalman (1963), Astrom et al. (1965), and Astrom and Bohlin (1966). A discussion of multiple regression and partial correlation analyses may be found in Draper and Smith (1967) or Wonnacott and Wonnacott (1970). Moment statistics and nonparametric methods are covered in many standard texts such as Davies (1954), Ostle (1963), Duncan (1965), and Snedecor (1967).

## Reconstruction of the May and July Survey Data Files Data Files

The data relating to the May Breeding Population Survey and the July Production Survey were completely reconstructed for this study. Information from the original flight forms was taken as a starting point. Master data files were assembled and thoroughly checked and rechecked. Summaries of the data were frequently sent to flyway biologists for critical review and checking. Several survey boundaries were changed, areas of various strata were recalculated, and data from partial segments were eliminated.

In some cases the corrected files have resulted in estimates of various parameters that are significantly different from earlier estimates. Publications by Henny et al. (1972) and Pospahala et al. (in preparation) present additional information concerning the reconstruction of the master data files and discuss difference between the new estimates and those published previously.

## Definitions

*Autocorrelation Coefficient*—A measure of the linear relationship between successive terms in a series (e.g., the correlation of $X_{(t)}$ with $X_{(t-l)}$). Autocorrelation coefficients are denoted by $r_a$ in this report.

*Autocovariance Function* — The covariance between $X_{(t)}$ and $X_{(t+r)}$ as a function of the lag r.

*Brood Index*—The number of class II and III broods (all species) seen from the air during the July Production Survey. The brood index is expanded by the sampling fraction but not adjusted for visibility.

*Cyclic Component (of a time series)*—Periodic, but uneven patterns of varying amplitude and irregular duration. Cyclic components are identified by autocovariance analysis, spectral estimates, or decomposition techniques.

*Durbin-Watson Statistics (DW)*—A test statistic employed to detect serial correlation in the vector of residuals resulting from a regression analysis. This statistic is particularly important if the dependent variable and/or the independent variables represent a time series (see Wonnacott and Wonnacott 1970). This statistic is represented by the abbreviation *DW* in the text.

*Late Nesting Index*—The number of pairs and single drakes seen during the July Production Survey and expanded for sampling proportion. Flocked birds (three or more birds of mixed sexes) and groups of two or more drakes are not counted. The late nesting index is used as a measure of renesting effort and of breeding season chronology and is not corrected for visibility.

*Pond Types*—Ponds are classified as to size and permanency. Only Types III, IV, and V (after Shaw and Fredine 1956) and stock dams are recorded on the aerial surveys.

*Power Spectrum*—Fourier transform of the autocovariance function. The power spectral "density" is the value of a function whose integral over any frequency interval represents the contribution to the variance from that frequency interval (Blackman and Tukey 1958). The spectral densities computed in this report are "hammed" and are therefore "refined" spectral densities. Precise mathematical description of the procedure is found in Dixon (1970).

*Prairie-Parkland Area*—The southern portions of Alberta, Saskatchewan, and Manitoba. Reference Areas 03, 04, 05, and 06 comprise this area.

*Random Component (of a time series)*—The residual component of a time series after the trend, seasonal, and cyclic components have been removed. It is the component that is unrelated to any known observable variable.

*Seasonal Component (of a time series)*—Intrayear fluctuations following a fairly regular pattern (e.g., consistent wet summers and drier fall, winter, and spring periods).

*Serial Correlation Coefficient*—A measure of dependence between successive values in a vector of numeric data. This is similar to the autocorrelation coefficient; however, it is not restricted to the relationship of a variable to itself nor to time series data.

*Statistical Significance Level*—In general, tests of hypotheses in this report are based on the 95% level of significance. Confidence intervals are based on the 90% level of significance. Significance at the 95% level is indicated by a single asterisk, while significance at the 99% level is denoted by two asterisks.

*t*—(1) an integer subscript used to denote time; e.g., $MP_t$ and $MP_{t-1}$ represent the number of ponds estimated in year *t* and *t*-1, respectively. (2) computed value of a test statistic following the *t* distribution. Such *t* values are always presented as a decimal and should therefore avoid confusion with the time index, above.

*Trend (in a time series)*—A significant linear, directional pattern as a function of time.

*Time Series*—A function of time, $X(t)$, which exhibits random and/or fluctuating properties.

# RESULTS AND DISCUSSION

## Quality of Waterfowl Habitat with Relationship to Man

Wetland utilization in North America provides a classic case of conflict in resource management. The disadvantages of marshes and ponds for the individual farmer encourage their drainage and conversion to cropland. At the same time, these wetlands provide vital habitat for migratory waterfowl, a principal wildlife resource associated with these wetlands. The dramatic effect of agricultural drainage upon waterfowl nesting habitat is illustrated in Fig. 1. The descussion below documents conflicting views on use that agricultural interests and wildlife biologists have maintained throughout the development of agricultural technology. For other recent discussions of the wetland situation, see the excellent review papers by Sanderson and Bellrose (1969) and Kiel et al. (1972).

Shaw and Fredine (1956:3) define "wetlands" as:

> lowlands covered with shallow and sometimes temporary or intermittent waters. They are referred to by such names as marshes, swamps, bogs, wet meadows, potholes, sloughs, and river-overflow lands. Shallow lakes and ponds, usually with emergent vegetation as a conspicuous feature are included in the definition, but permanent waters of streams, reservoirs, and deep lakes are not included. Neither are water areas that are so temporary as to have little or no effect on the development of moist-soil vegetation.

Schrader's (1955) classification of prairie wetlands ranges from class I (the most ephemeral type of field depression that holds water for a few days or weeks in spring) to class V (deep

FIG. 1.—Example of intensive drainage and land-clearing in western Minnesota. (Photo by Grady Mann, Bureau of Sport Fisheries and Wildlife.)

marshes that retain some water even in time of drought).

Much of the legislation and literature concerning wetlands in the United States avoids the distinction between breeding, migration, and wintering habitat. Although this report focuses on breeding habitat, related information on migration and wintering habitat has been included to present a more complete and cohesive account of habitat loss.

## Wetlands in the United States

The Soil Conservation Service estimated that, at the time of settlement, there were 127 million acres of natural wetlands in the United States and that by 1953 only 82 million acres remained (Shaw and Fredine 1956). Harmon (1968) recently indicated a further decrease in the total acreage in the United States to 75 million acres, 8.5% less than in the 1952-53 inventory. At approximately the same time these findings were reported, a U.S. Department of Agriculture report (1965) stated, "Excess water is a problem on much cropland in the humid part of the country. Nationally, about 112 million acres need further artificial drainage for maximum agricultural use." Approximately half of this acreage lies in the corn belt and the lower Mississippi Valley and provides good wildlife habitat.

During the last century, many things have occurred to reduce the total wetland acreage. Shaw and Fredine (1956:5) summarized the public attitude toward wetlands during the middle of the 19th century when they stated, "wetlands were actually considered as a menace and hindrance to land development." The Swamp Land Act (1849) granted Louisiana all swamp and overflow lands then unfit for cultivation to help control floods in the Mississippi River Valley. In 1850 and 1860, the act was made applicable to the other States. The original purpose of the grants was to enable the States to reclaim their wetlands by the construction of levees and drains. As of June 30, 1954, a total of about 65 million acres of wetlands had been patented to the 15 States affected (Shaw and Fredine 1956). Shaw and Fredine concluded that the Swamp Land Act paved the way for transferring nearly 65 million acres of wetlands in 15 States from Federal to State administration for the purpose of expediting their drainage.

Comparable wetland surveys spanning the period 1850 to 1973 are difficult to find; however, Shaw and Fredine (1956) presented survey data for seven States that they thought were fairly comparable. Their table is reproduced herein (Table 1) and indicates that the period 1907 to 1922 reflected the greatest annual rate of wetlands loss in the seven States. Drainage together with more intensive agricultural practices have had a dramatic impact on the wetland acreage in the United States. Furthermore, these two factors are continuing to play an important role today.

## Waterfowl Breeding Grounds in the United States

Comparable long-term information specific to wetland drainage on the waterfowl breeding grounds in the United States does not exist. However, the U.S. Department of Agriculture (1963) reported that drainage benefited approximately 6.2 million acres in Minnesota, North Dakota, and South Dakota from 1936 to 1963. Biologists of the Bureau of Sport Fisheries and

TABLE 1. *Change in wetland acreage since 1850–1953 (from Shaw and Fredine 1956:7)*

| State | Swampland patented to States since 1850 | USDA inventory of 1906 | USDA inventory of 1922 | FWS inventory (1952–53) |
|---|---|---|---|---|
| | Acres | Acres | Acres | Acres |
| Arkansas | 7,686,575 | 5,912,300 | 4,220,000 | 3,748,800 |
| California | 2,192,875 | 3,420,000 | 1,179,000 | 457,200 |
| Florida | 20,325,013 | 19,800,000 | 16,846,000 | 15,266,400 |
| Illinois | 1,460,164 | 925,000 | 600,000 | 176,700 |
| Indiana | 1,259,231 | 625,000 | 778,000 | 267,100 |
| Iowa | 1,196,392 | 930,000 | 368,000 | 117,000 |
| Missouri | 3,432,481 | 2,439,000 | 1,085,000 | 322,000 |
| Total | 37,552,731 | 34,051,900 | 25,076,000 | 20,355,200 |
| Percent reduction since 1850 | --------- | 9.3 | 33.2 | 45.7 |

Wildlife investigated the significance of these figures as an indication of actual wetland losses and concluded that approximately 25% of the reported drainage significantly reduced waterfowl habitat (Committee on Land Use 1970). On that basis, the loss of productive wetlands was about 1½ million acres. On the other hand, data compiled by the Soil Conservation Service indicated that approximately 206,000 potholes totaling 247,000 acres were drained in the Dakotas and Minnesota from 1946 to 1965. Although this 20-year period is not the same as the 28-year survey interpreted by the Bureau of Sport Fisheries and Wildlife, a 5-to-1 difference in the acreage lost (55,000 acres per year vs. 12,000 acres per year) indicates a fundamentally different approach to the problem. The Bureau's interpretation of habitat loss apparently included acreage influenced by the drainage in addition to the portion actually drained.

More reliable indications on the extent of recent drainage come from studies made by the Bureau of Sport Fisheries and Wildlife during the last two decades when more accurate base-level information was available. Cooperation of the Soil Conservation Service and the Agricultural Stabilization and Conservation Service (ASCS) made more drainage records available, and field appraisals, in terms of wetland categories, have aided interpretation. The wetland situation on the breeding grounds in the United States in the early 1960's was aptly summarized by Jahn (1961):

> To date, losses of potholes have exceeded preservation efforts. The magnitude of subtractions are indicated by the following examples. Historically, the prairie pothole area in the U.S. covered 115,000 square miles. Man, largely through drainage, has practically removed all potholes in slightly more than one-half of the area (an estimated 56,000 square miles remained in the early 1950's). Within the remaining portion, federally assisted drainage—not counting locally financed projects—claimed 256,700 acres of prairie duck habitat between 1951 and 1955 (Reuss, 1958:3). During the same period, a total of 3,462 acres of all types of habitat was acquired for waterfowl in the three prairie pothole states by the U.S. Fish and Wildlife Service. In other words, the federal Agricultural Conservation Program removed a little more than 74 times as many acres of wetlands as were acquired by the Federal Government for waterfowl purposes. Farm drainage is continuing. In North Dakota, South Dakota, and Minnesota, drainage increased sharply in 1958 over the average of the three precedign years (Seaton 1959:-391). An estimated 10,000 potholes were drained in this single year. Under existing governmentaly guidelines, Morgan (1960:8) estimates that eventually 90 percent of the wet areas of the region will be lost through federally subsidized drainage.

There has been a progressive loss of waterfowl habitat in the northern prairie region from a combination of causes, including agricultural drainage, land leveling and filling, soil washing and siltation, wind erosion, road building and urban occupancy, and pollution. Of these causes, agricultural drainage is undoubtedly the most important. Haddock and DeBates (1969) indicated a further decrease in prime waterfowl habitat in Minnesota (down 14%), North Dakota (down 5%), and South Dakota (down 1%) between 1964 and 1968. Examples of wetland drainage in the latter two States are illustrated in Figs. 2 and 3.

## Wetland Preservation Programs in the United States

The State and Federal governments have not stood by watching the waterfowl habitat deteriorate. The National Wildlife Refuge system had its beginning in 1903; by 1963 it consisted of 289 national wildlife refuges and about 28.6 million acres. Of these, 220 refuges covering about 2.6 million acres were managed primarily for waterfowl (Salyer and Gillett 1964). As of June 30, 1972, there were 342 refuges encompassing slightly over 29 million acres.

In 1937, the Congress enacted the Federal Aid to Wildlife Restoration Act (Pittman-Robertson Act), which provided financial help and enabled many States to finance important wildlife restoration work for the first time. Under this act, the 11% Federal excise tax on manufacturers' price of sporting arms and ammunition is apportioned to State fish and game departments. During the first 15 years of the program (1939-53), 38 States acquired and improved habitat for waterfowl. By 1961, 1,360 separate waterfowl areas, totaling about 4.6 billion acres of land and water, were under State control. About 2.4 million acres were owned and about 2.2 million acers were under longterm lease, easement, or agreement. About 44% (approximately 2 million acres) provided some waterfowl habitat.

Sanderson and Bellrose (1969) provided a brief summary of the wetlands owned by local and State governments, and also by private organizations including the Nature Conservancy, National Audubon Society, duck clubs, and Ducks Unlimited. The Minnesota Conservation Department initiated a state-wide acquisition program for wetlands in 1951, and through 1972, has purchased more than 767 management areas (186,000 acres of wetland and upland habitat). South Dakota's wetland acquisition program has been based primarily on Pittman-Robertson matching funds and on $9 of each nonresident hunting license. The bulk of this money has been used for wetland purchases. North Dakota's wetland acquisition program has been very limited because of lack of funds. In addition to natural areas, some wetlands have been created. These include stock ponds, dugouts, and reservoirs. Most of these have been constructed outside the main waterfowl production area, but in some areas (e.g., Montana and the western portion of the Dakotas) stock dams

FIG. 2.—Aerial view of a large scale drainage complex in South Dakota. Most potholes are drained by small ditches that feed into the large canal in the center of the photo. (Photo courtesy of Bureau of Sport Fisheries and Wildlife.)

FIG. 3.—Pothole drainage in North Dakota. Three potholes are drained into the large water area at the top of the photo. (Photo courtesy of Bureau of Sport Fisheries and Wildlife.)

may contribute significantly to waterfowl production. A recent estimate of the number of acres of habitat controlled by private waterfowl hunting clubs is shown in Table 2.

More significant Federal legislation was passed during the late 1950's. The Waterfowl Production Area Program was initiated by the passage of P. L. 85–585 on August 1, 1958, with the increase in the price of the duck stamp from $2 to $3. This law provided that all money obtained from the sale of duck stamps, except costs reimbursable to the Postal Service for the printing, sale, and accounting of stamps, must be spent for the acquisition of habitat for migratory waterfowl, primarily in the prairie States. Further impetus to the program was provided by the passage of P.L. 87–383 on October 4, 1961, which authorized an advance appropriation of $105 million over a 7-year period for an accelerated acquisition program of habitat preservation.

Annual appropriations plus duck stamp receipts are combined to make up the Migratory Bird Conservation Fund from which land purchases are made. Since all of the loan fund monies were not made available at the end of the first 7 years of the program (only $37.5 million of the $105 million authorized), P.L. 90–205 was passed on December 15, 1967, which extended the loan fund authorization through Fiscal Year 1976. Repayment of the interest-free loan will be made with three-fourths of the annual duck stamp receipts. For the accelerated program the Bureau established an acquisition goal of 2.5 million acres. Of this total, 750,000 acres were to be acquired for the National Wildlife Refuge Program and 1,750,000 acquired as small waterfowl production areas.

The primary goal of the Waterfowl Production Area Program is to preserve the best waterfowl production habitat in the prairie States. The goals established were 600,000 acres in fee purchase in scattered wetland tracts throughout the prairie at the rate of four to five per township with all remaining wetlands eligible for an easement which prohibited the landowner from burning, draining, filling, or leveling all wetland basins found within the lands described in the easement.

Accomplishments to date are reflected in Table 3. The need for the State Governor's approval on fee purchase and the limitation of funds available in recent years are two factors that have effected the success of the program. The actual number of potholes protected by fee purchase and easement is unknown; however, as the program continues, it has to have a positive effect in preventing the drainage of wetlands that were sure to have been lost without the Bureau's wetland program.

Two very significant laws relating to drainage were passed by Congress in 1962. The first, popularly known as the Reuss Amendment to the Agricultural Appropriations Act, was re-enacted annually and applied nation-wide. It prohibited the use of Agricultural Conservation Program funds for the drainage of wetland Types III, IV and V. The second law, P.L. 87–732, applied to government assisted drainage in Minnesota, North Dakota, and South Dakota. In the best waterfowl producing counties of these States, a wetlands enhancement biologist was requested to determine whether wildlife would be materially harmed by the proposed drainage before an individual could receive either technical or

TABLE 2. *Minimum number of private waterfowl hunting clubs and acreages (wetland + upland) in the four flyways of the United States, with Alaska and Hawaii excluded, 1962–66 (from Anonymous 1967)*

| Flyway | No. states reporting club data | Number reported | |
|---|---|---|---|
| | | Clubs | Acres |
| Atlantic | 13 | 205 | 97,644 |
| Mississippi | 12(2) [1] | 3,941(1,036) | 1,032,900(+?) |
| Central | 6 | 153(28) | 300,013(+?) |
| Pacific | 6 | 1,250(10) | 445,000(+?) |
| U.S. total | 37(2) | 5,199(1,074) | 1,875,557(+?) |

[1] Additional states or number of clubs with acreages unknown.

TABLE 3. *A summary of the waterfowl production area program, 1962–73*

| Year | Refuges fee acres | Waterfowl production areas (acres) | | | Total acres |
|---|---|---|---|---|---|
| | | Fee | Easement | Total | |
| 1962–73 [1] | 381,293 | 333,070 | 931,000 | 1,264,070 | 1,648,363 |
| Goal | 750,000 | 600,000 | 1,150,000 | 1,750,000 | 2,500,000 |
| Percent complete | 51.3 | 55.5 | 81.0 | 72.2 | 65.9 |

[1] 1973 accomplishments estimated. States in the program include Montana, North Dakota, South Dakota, Minnesota, and Nebraska.

financial drainage assistance. The biologist was required to report his findings within 90 days to the county Soil Conservation Service and ASCS offices. In the event the area had value for waterfowl, the Bureau or State agency could, within a year, offer to acquire the wetland as a waterfowl resource. If the landowner was not willing to sell the land or give an easement (agreeing never to drain, fill, or burn his wetland), the Department of Agriculture could provide drainage assistance 5 years after the offer was made. Owners could receive drainage assistance immediately on wetlands having little or no value to waterfowl, or on which the Bureau did not choose to make an offer.

In December 1972, as an economy measure, the U.S. Department of Agriculture terminated the Rural Environmental Assistance Program, which began in the mid-thirties as the Agricultural Conservation Program. Cost-sharing incentives for drainage thereby ceased.

## Waterfowl Breeding Grounds in Canada

The *Prairie-Parkland Area* in Canada, as defined by waterfowl biologists, is also a major agricultural region. The agriculturalist looks at the region as the source of 98 out of every 100 bushels of wheat produced in Canada (Lodge 1969), while the waterfowl biologist views the area as the source of five out of every eight ducks shot by hunters in North America. The conflict of interest is readily apparent.

Prairie Canada now comprises one of the world's most important agricultural regions. Ranches were first established in the prairies, at least in Alberta, on completion of the Canadian Pacific Railroad in 1885 (Keith 1961). Rangeland subsequently yielded to grain farms when large numbers of homesteaders arrived between 1909 and 1916 (Wyatt et al. 1937). The conversion of prairie sodlands to farmlands, once started, progressed with startling speed. In 1901 a mere 5 million acres were farmed in Prairie Canada, but 10 years later, this acreage had increased to 23 million; by 1936 a total of about 61 million prairie acres was under cultivation (Dickson 1943). Additional historical information and current data relating specifically to southwestern Manitoba are given by Kiel et al. (1972).

During an aerial appraisal in the middle 1950's, 72% of the prairie lands (101 million acres) was in agricultural use (Lynch et al. 1963). Gollop (1965) indicated that there may be as many as 9.4 to 10.0 million depressions capable of holding water in mid-May. These totals do not necessarily represent "ponds" per se but rather are surface water basins or depressions capable of holding water. Later in this report we show approximately 7.1 million May ponds in the southern portions of Alberta, Saskatchewan, and Manitoba in 1955. Nearly all of these basins have no source of water other than ground water and direct precipitation or rain and snow-melt waters that trickle in from the surrounding terrain.

In Canada both draining and filling of duck breeding habitat, although still in early stages of development, are growing in importance (Hawkins and Jahn 1960; Moulding, 1960). Gollop (1965) stated that during the mid-1950's when the Prairie Provinces experienced record high water levels, the clamor for drainage was great. However, most of the areas drained during that period were not normally covered with water. In certain Provinces, governmental assistance was provided for draining and clearing land for crop production (Hopkins 1952; Gollop 1965). Gollop (1965:251) indicated ". . . to date it appears that pothole destruction by man has had no significant effect on waterfowl production in Canada but we have no measure of this aspect of agricultural progress." Burwell and Sugden (1964) noted that drainage began in the late 1800's, reached its first peak in the 1920's, declined during the drought of the 1930's, resumed in the 1940's and is continuing. Annual water conditions in the *Prairie-Parkland Area* fluctuate substantially. For this reason, the number of May ponds counted during the Bureau's annual May Breeding Ground Survey does not provide definitive information on habitat loss resulting from man's activities.

Studies designed to assess the influence of drainage on wetland acreages in Canada are nearly nonexistent; however, Kiel et al. (1972) have recently summarized information collected in the Minnedosa district of southern Manitoba. They used a two-phase approach to their study: (1) a 50.4 square mile area that was studied by the aid of aerial photographs, and (2) an intensive study area which contained 120 potholes. Aerial photographs indicated that the percentage of cultivated and cleared land increased steadily from 48% of the area in 1928-30 to 68.9% in 1964. Correspondingly, wetlands, woodlots, and bushlands declined. From the intensive study area, they reported that more potholes were altered by land clearing practices in the last 4 years (1960-64) of the study than in the previous 12 years. In regard to the question, "How far has pothole drainage gone in the Minnedosa district?", they reported that 16% of the 120 intensively studied potholes were partially or completely drained between 1949 and 1964, and that for essentially the same time period (1948-64), aerial photographs indicated a decline of 15% in wetland acreage in the 50.4 square miles of transect area. Their 16-year study indicated that the pace of drainage was accelerating.

Recently, Goodman and Pryor (n.d.) presented the results of a study of waterfowl habitat in the Black Soil Zone (roughly the northern and western portions of the *Prairie-Parkland Area*) using stereo examination of aerial photographs of randomly selected quarter sections. They estimated an overall net loss of about 12.9% of the wetland acres and 4.5% of the ponds since pristine times. An estimated 23% of the quarter sections had wetlands which had been adversely affected by man, 18% had been improved or developed by man, 61% still had wetlands unchanged by man, and 29% had no wetlands. Pond loss occurred primarily before 1950, and pond improvements and developments occurred primarily since 1950.

According to Jahn (1961:98), two agencies working in Canada have provided duck breeding habitat:

> Since the Prairie Farm Rehabilitation Act was passed in 1935, the Canadian government has constructed over 56,000 small water areas, primarily to provide water for farm purposes. Secondarily, a small proportion of these areas accommodate breeding ducks. Ducks Unlimited has made some of the most important contributions to the preservation and development of lands for waterfowl. Between initiation of the work in 1938 and 1 March, 1960, development has been carried out on 519 projects comprising 788,000 acres of water and having 4,457 miles of shoreline (W. B. Leitch, personal communication 1960). Ducks Unlimited owns no land. All projects are established by securing flood easements from landowners.

Ducks Unlimited has greatly expanded its program since 1961 and by the end of 1972, 1,036 projects were completed. The projects have led to the improvement of 1.2 million acres of waterfowl habitat and 9,541 miles of shoreline. Another 500,000 acres are now under easement or lease. In Canada in 1971, Ducks Unlimited expended $2.6 million; this amount is equivalent to 14% of the total monies spent by Ducks Unlimited since it began in 1938 (W. B. Leitch, personal communication 1973).

In April 1966, Canada declared a policy and program for the preservation of duck breeding habitat. This policy was a response to evidence that many valuable wetlands were already lost and others were threatened. It is unfortunate that more quantitative data on drainage in Canada are not available. Canada's wetland preservation program had only very limited success in offsetting the incentive to drain by offering a monetary return for not draining. Land clearing, a forerunner to drainage, is proceeding rapidly. But most serious of all is the prospect that the expanding human population will, in the decades ahead, create a tremendous demand for agricultural lands, especially land suitable for high wheat production. The uncertain future of the Canadian and United States prairies is considered to be the major threat to the waterfowl resource in the future. For additional information on waterfowl habitat in Canada, see Sanderson and Bellrose (1969) and Kiel et al. (1972).

## Annual Water Conditions in the Mallard Breeding Range

A general discussion of the habitat types within the 16 reference areas and photographs of representative locations were provided in the first report in this series (Anderson and Henny 1972). A map showing location of reference areas is presented in Fig. 4. The quantity of water in the reference areas and the annual fluctuations in numbers of water areas important

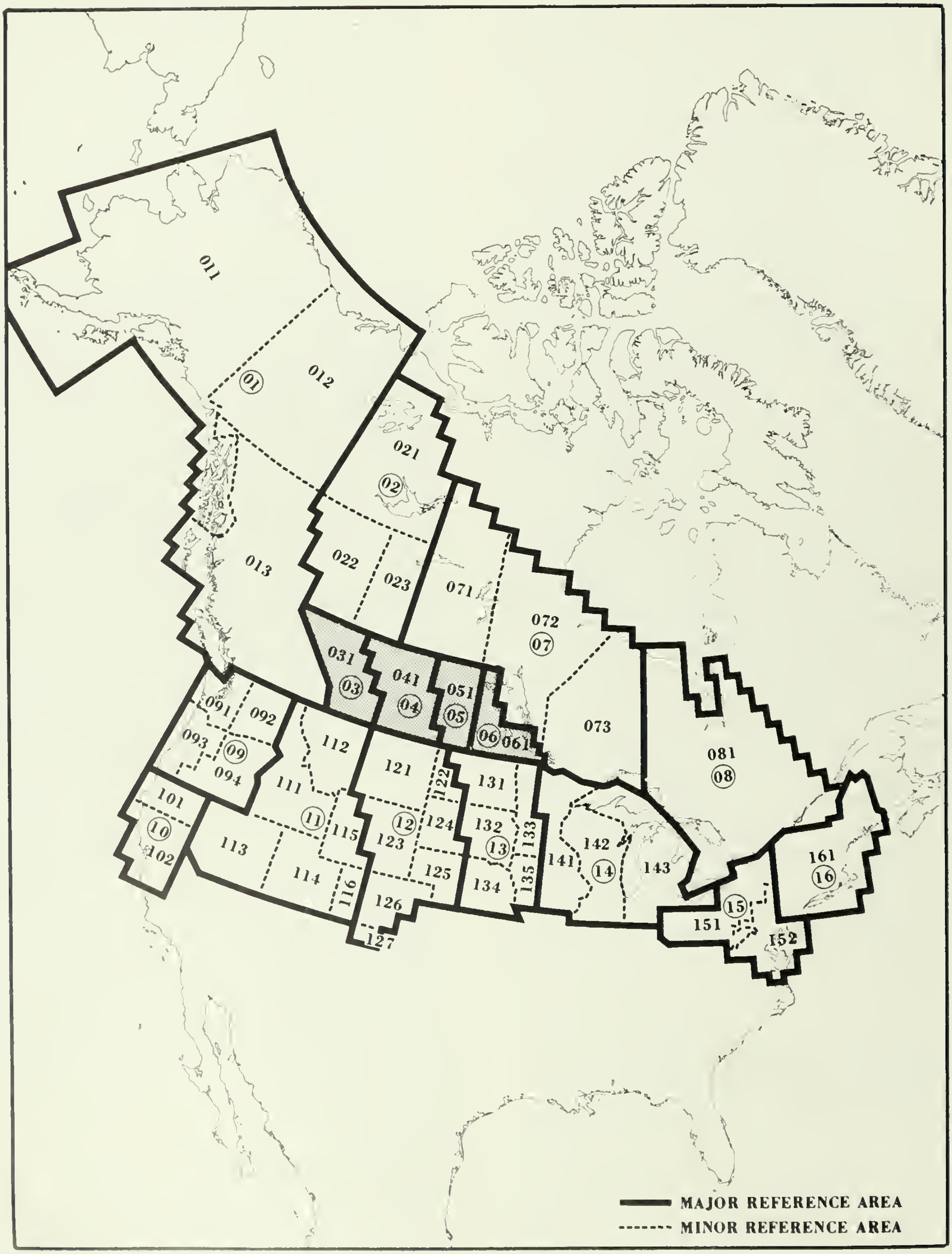


FIG. 4.—Reference areas for breeding mallards in North America. The shaded area represents the southern portions of Alberta, Saskatchewan, and Manitoba that constitute the *Prairie-Parkland Area.*

to waterfowl production are discussed in this report. Numbers of water areas are counted twice a year in the unstable habitats of the mallard breeding range. The unstable areas include the *Prairie-Parkland Area* of Canada and the prairie pothole region of the north-central United States (Fig. 5) (Lynch et al. 1963). Stoudt (1971) reported that the number of water areas on his Redvers study area in southeast Saskatchewan ranged from a low of 10 in July 1961 to a high of 574 in May 1964. Water areas remain relatively stable in the more northern areas and are not counted (Wellein and Lumsden, 1964), but production rates in these areas seem to be low and poorly known (Crissey 1963; Hansen and McKnight 1964; Smith 1970). Dzubin and Gallop (1972) concluded that the center of mallard abundance occurs in the most unstable and climatically unpredictable environments (southern Saskatchewan), while Crissey (1969) estimated that between 1955 and 1964, 57% of the mallards bred in the southern portion of the three Prairie Provinces. Crissey (1963, 1969) and Gollop (1965) documented a direct relationship between pond numbers in the southern portions of the Prairie Provinces and the number of mallards produced. Therefore, the portion of the breeding range where the amount of water available is variable is indeed important to

FIG. 5.—Prairie wetland habitat in North Dakota which represents excellent breeding habitat for mallards and other waterfowl. (Photo courtesy of North Dakota Game and Fish Department.)

mallard production. The basic information concerning the number of water areas recorded on the May and July surveys is reported and discussed below. The aerial identification of wetland types is a difficult procedure and unfortunately may effect the comparability of estimates among areas within a year and among years. However, this problem is not considered to be a serious limiting factor in the conclusions reached in this report.

## Southern Portions of the Prairie Provinces

Estimates of the number of ponds for the *Prairie-Parkland Area* in May and July are shown in Table 4 and Fig. 6. The annual variation among the four reference areas within the unit, together with the percentage ponds remaining in July, is also shown in Table 4. The number of ponds estimated in the 225,330 square miles ranged from a high of 7.1 million (1955) to a low of 1.6 million (1961 and 1968) in May; and ranged from a high of 3.3 million (1955) to a low of 0.6 million (1961) in July. Generally, the number of water areas peaked in the mid-1950's, reached a low in the early 1960's, and reached an intermediate level in the late 1960's and early 1970's.

Henny et al. (1972) noted that the center of the southern Prairie Provinces (Saskatchewan) has the highest annual variation in number of ponds, with a coefficient of variation for the July pond counts being approximately twice that for either Alberta or Manitoba. Similarly, the two reference areas which include southern Saskatchewan show the highest annual variability for both May ponds and July ponds (Table 4). Although there is a considerable geographic variation in pond numbers, the four areas seem to be related to a degree. The following correlation matrices quantify the relationships among the four reference areas in the *Prairie-Parkland Area* for 1955–73.

$$\begin{array}{cc} & \begin{array}{cccc} 03 & 04 & 05 & 06 \end{array} \\ \begin{array}{c} 03 \\ 04 \\ 05 \\ 06 \end{array} & \begin{bmatrix} 1.0 & 0.77^{**} & 0.74^{**} & 0.78^{**} \\ & 1.0 & 0.90^{**} & 0.80^{**} \\ & & 1.0 & 0.86^{**} \\ & & & 1.0 \end{bmatrix} \end{array} \qquad \begin{array}{cc} & \begin{array}{cccc} 03 & 04 & 05 & 06 \end{array} \\ \begin{array}{c} 03 \\ 04 \\ 05 \\ 06 \end{array} & \begin{bmatrix} 1.0 & 0.59^{**} & 0.41^{*} & 0.40^{*} \\ & 1.0 & 0.75^{**} & 0.49^{*} \\ & & 1.0 & 0.69^{**} \\ & & & 1.0 \end{bmatrix} \end{array}$$

May ponds July ponds

TABLE 4. *Summary of the number (in thousands) of May and July ponds in the* Prairie-Parkland Area *of Canada, 1955–73*

| Year | Southwestern Alberta (03) May ponds | Southwestern Alberta (03) July ponds | Southwestern Saskatchewan (04) May ponds | Southwestern Saskatchewan (04) July ponds | Southeastern Saskatchewan (05) May ponds | Southeastern Saskatchewan (05) July ponds | Southwestern Manitoba (06) May ponds | Southwestern Manitoba (06) July ponds | Total May ponds | Total July ponds | Percent remaining in July |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1955 | 867.7 | 425.7 | 2,110.9 | 854.0 | 2,744.6 | 1,396.7 | 1,391.6 | 592.7 | 7,114.8 | 3,269.1 | 45.9 |
| 1956 | 671.7 | 437.3 | 1,442.8 | 618.7 | 1,579.5 | 737.2 | 950.9 | 386.4 | 4,644.9 | 2,179.6 | 46.9 |
| 1957 | 425.0 | 290.9 | 819.6 | 379.6 | 1,310.8 | 456.1 | 611.4 | 231.7 | 3,166.8 | 1,358.3 | 42.9 |
| 1958 | 518.3 | 312.1 | 914.7 | 315.5 | 1,111.7 | 250.5 | 598.7 | 466.9 | 3,143.4 | 1,345.0 | 42.8 |
| 1959 | 359.2 | 228.9 | 466.7 | 286.5 | 464.9 | 315.3 | 571.0 | 364.1 | 1,841.8 | 1,194.8 | 64.9 |
| 5-year mean | 568.4 | 339.0 | 1,146.9 | 490.9 | 1,442.3 | 631.2 | 824.7 | 408.4 | 3,982.3 | 1,869.4 | 48.7 |
| 1960 | 628.9 | 260.2 | 957.9 | 357.9 | 1,438.9 | 416.8 | 531.8 | 342.6 | 3,557.5 | 1,377.5 | 38.7 |
| 1961 | 418.9 | 153.8 | 538.1 | 188.8 | 237.6 | 92.4 | 379.5 | 115.7 | 1,574.1 | 550.7 | 35.0 |
| 1962 | 301.2 | 225.7 | 765.4 | 247.7 | 742.2 | 152.2 | 400.4 | 206.2 | 2,209.2 | 831.8 | 37.7 |
| 1963 | 460 9 | 471.8 | 733.8 | 636.1 | 554.4 | 363.8 | 602.2 | 300.1 | 2,351.3 | 1,771.8 | 75.4 |
| 1964 | 397.5 | 256.1 | 559.0 | 256.3 | 943.7 | 359.2 | 701.3 | 411.5 | 2,601.5 | 1,283.1 | 49.3 |
| 5-year mean | 441.5 | 273.5 | 710.8 | 337.4 | 783.4 | 276.9 | 523.0 | 275.2 | 2,458.7 | 1,163.0 | 47.2 |
| 1965 | 610.1 | 599.0 | 1,091.8 | 783.4 | 919.6 | 431.7 | 732.9 | 350.7 | 3,354.4 | 2,164.8 | 64.5 |
| 1966 | 512.6 | 345.9 | 980.7 | 621.4 | 1,299.2 | 610.0 | 818.1 | 375.4 | 3,540.6 | 1,952.7 | 55.2 |
| 1967 | 541.6 | 425.9 | 1,087.8 | 503.8 | 1,199.3 | 300.0 | 784.5 | 250.2 | 3,613.2 | 1,479.9 | 41.0 |
| 1968 | 318.5 | 221.5 | 545.3 | 266.9 | 399.6 | 171.6 | 319.2 | 143.3 | 1,582.6 | 803.3 | 50.8 |
| 1969 | 412.8 | 235.4 | 1,186.8 | 645.9 | 867.1 | 427.2 | 430.1 | 324.2 | 2,896.8 | 1,632.7 | 56.4 |
| 5-year mean | 479.1 | 365.5 | 978.5 | 564.3 | 923.0 | 388.1 | 617.0 | 288.8 | 2,997.5 | 1,606.7 | 53.6 |
| 1970 | 442.2 | 296.2 | 1,437.9 | 1,088.3 | 1,667.6 | 826.6 | 749.5 | 386.4 | 4,297.2 | 2,597.5 | 60.4 |
| 1971 | 381.7 | 329.4 | 1,145.7 | 725.5 | 1,467.6 | 560.5 | 737.2 | 371.3 | 3,732.2 | 1,986.7 | 53.2 |
| 1972 | 375.1 | 194.2 | 942.3 | 415.4 | 1,264.1 | 413.8 | 726.4 | 260.0 | 3,307.9 | 1,283.4 | 38.8 |
| 1973 | 368.2 | 342.8 | 704.7 | 561.8 | 554.4 | 611.5 | 237.8 | 204.7 | 1,865.1 | 1,720.8 | 92.3 |
| 4-year mean | 391.8 | 290.7 | 1,057.7 | 697.8 | 1,238.4 | 603.1 | 612.7 | 305.6 | 3,300.6 | 1,897.1 | 61.2 |
| 19-year mean | 474.3 | 318.6 | 969.0 | 513.3 | 1,089.3 | 468.1 | 646.0 | 320.2 | 3,178.8 | 1,620.2 | 52.2 |
| Coef. of var. | 29.7 | 35.1 | 41.1 | 47.4 | 53.3 | 63.1 | 40.1 | 35.9 | 40.9 | 40.2 | ----- |
| Average number of ponds per sq. mile | 10.0 | 6.7 | 11.6 | 6.1 | 23.4 | 10.0 | 18.8 | 9.3 | 15.0 | 7.6 | ----- |
| Percent ponds remaining in July 1955–73 (average) | ----- | 67.2 | ----- | 53.0 | ----- | 43.0 | ----- | 49.6 | ----- | 51.0 | 52.2 |

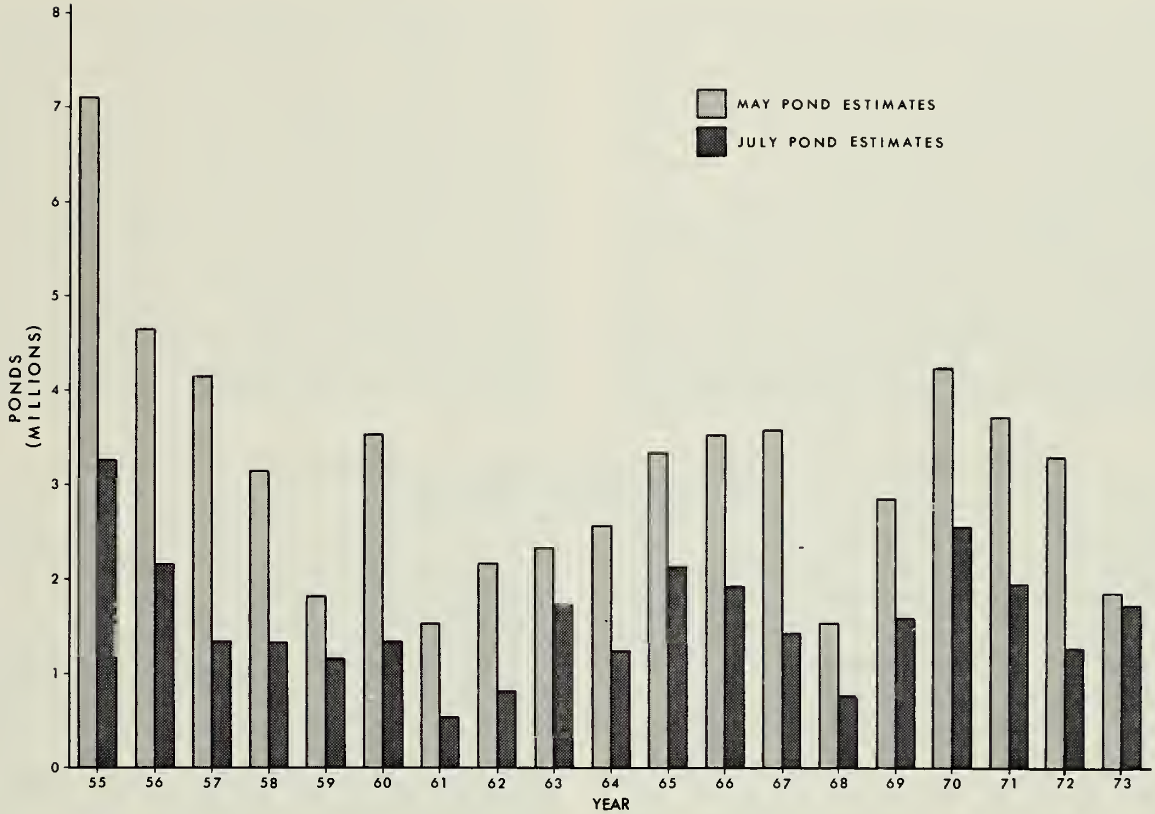


FIG. 6.—Estimated numbers of May and July ponds in the *Prairie-Parkland Area*, 1955–73.

The significant relationships indicate that, for example, if wet conditions prevail in Reference Area 05 in a given year, then there is a tendency for Reference Areas 03, 04, and 06 to be wet also. All of the correlation coefficients in the matrix are significant, which indicates relationships among reference areas that are not adjacent to each other (e.g., Reference Areas 03 and 06). Stronger relationships exist for May ponds than July ponds.

Crissey (1969) reported a significant relationship ($r^2 = 0.50$) between the number of ponds in July in the *Prairie-Parkland Area* of Canada and mallard production on a continent-wise basis. Further studies indicated that the percentage of ponds remaining in July was also related to mallard production (Geis et al. 1969). Also, the numbers of May and July ponds are highly correlated ($r = 0.85^{**}$, 17df); the subject is discussed in detail in the next section.

The number of ponds estimated per square mile in May generally increased from west to east in the southern portions of the Prairie Provinces; however, the pattern in July was not as pronounced because a higher percentage of the May ponds dried up in the east (Table 4). Usually about 50% of the ponds dry up between May and July; however, the percentage is variable among years and locations. During 1955–73, approximately two of every three May ponds remained in July in *Southwestern Alberta* (03), while only two of five ponds remained in *Southeastern Saskatchewan* (05). This difference may be related to differences in pond size, pond depth, evapotranspiration rate and precipitation.

## North-Central United States

The area sampled by aerial surveys in Montana, North Dakota, South Dakota, and Minnesota is approximately equal in size to the area surveyed in the southern portion of the Prairie Provinces of Canada; however, fewer ponds are observed in the north-central United States. An average of about 14.1 ponds per square mile in May was estimated for the *Prairie-Parkland Area* during 1959–73 (Table 4). The average for the Dakotas was 4.9 May ponds per square mile suggesting that approximately one third as many ponds per square mile were present (Table 5). The eastern portions of North Dakota and South Dakota have the highest density of ponds and Montana has the lowest density. Only 52.2% of the Canadian ponds counted in May remained in July (Table 4) whereas between 64.1 and 78.6% of the ponds in the north-central United States were still present in July (Table 5). The higher percentage of ponds remaining between May and July in the north-central United States probably results from drainage that has already removed most of the temporary and semipermanent ponds. In addition, many stock ponds which have been developed in Montana and western North and South Dakota tend to be fairly permanent. For additional information on the distribution of water areas within the north-central United States, see the summary papers by Henny et al. (1972) and Pospahala et al. (in preparation).

## Climatological Factors Influencing the Quantity of Water in Southern Canada

As previously discussed, the number of ponds in May and July has varied markedly in the last 19 years. In this section we discuss climatic factors that affect pond numbers in the most important mallard production areas in North America (southern Alberta, southern Saskatchewan, and southern Manitoba). The precipitation and temperature data analyzed in this section generally cover the 1937–70 period whereas the pond data cover the 1955–71 period. The data used and the statistical procedures employed are discussed in the METHODS section of this report. This section attempts to present significant, but simplified, relationships in a complex system affecting the number of May and July ponds. Several factors such as fall freeze-up, spring thaw, evapotranspiration rates, and ground water could not be quantified and analyzed. These factors may be important, but we were unable to study their dynamics in relation to pond numbers.

It would seem likely that the number of ponds in year $t$ would be related to the number of ponds in the previous year, $t$-1. A simple regression of the number of May ponds on the number of May ponds the previous year was not significant ($r_a = 0.38$, df $= 14$) nor was the relationship between the number of July ponds in year $t$ and the number of July ponds in year $t$-1 ($r_a = 0.38$, df $= 14$). Thus it appears that these autoregressive relationships are confounded by other variables such as precipitation.

Annual precipitation, on a June 1-May 31 basis, was significantly related to the number of May ponds ($r = 0.80^{**}$, df $= 14$). This relationship, illustrated in Fig. 7, indicates that approximately 64% of the variation in the number of May ponds is accounted for by the precipitation

TABLE 5. *Summary of the number of May and July ponds (range and average), and the percentage remaining in July Data are from the north-central United States*

| Category | Western Montana (112) | Eastern Montana (121) | Western N. Dakota (122) | Western S. Dakota (124) | Eastern N. Dakota (131) | Eastern S. Dakota (132) | Western Minnesota (133) |
|---|---|---|---|---|---|---|---|
| May ponds [1] | | | | | | | |
| Low | 26.0(1.6) | 90.1(1.6) | 14.7(0.7) | 32.4(1.3) | 70.2(1.4) | 60.6(1.4) | 88.6(2.4) |
| High | 70.7(4.3) | 212.6(3.7) | 146.7(7.3) | 183.0(7.5) | 593.2(12.2) | 394.6(9.0) | 156.6(4.5) |
| Average | 53.3(3.3) [2] | 169.6(3.0) [2] | 74.6(3.7) [4] | 92.7(3.8) [5] | 324.3(6.7) [4] | 217.2(5.0) [5] | 126.7(3.5) [7] |
| July ponds | | | | | | | |
| Low | 21.6(1.3) | 78.2(1.4) | 50.7(2.5) | 53.8(2.2) | 149.3(3.1) | 119.2(2.8) | 47.3(1.3) |
| High | 60.0(3.7) | 197.4(3.4) | 111.0(5.6) | 126.3(5.2) | 433.3(8.9) | 272.5(6.3) | 145.6(4.0) |
| Average | 38.2(2.3) [3] | 129.6(2.3) [3] | 74.4(3.7) [6] | 87.0(3.6) [6] | 267.1(5.5) [6] | 181.3(4.2) [6] | 98.2(2.7) [7] |
| Percent May ponds remaining | 74.2 [3] | 78.6 [3] | 72.3 [6] | 73.8 [6] | 64.1 [6] | 69.1 [6] | 75.9 [7] |

[1] Ponds per square mile in parentheses.
[2] 1965–73 average.
[3] 1966–73 average (except 1971).
[4] 1968–73 average.
[5] 1959–73 average.
[6] 1966–73 average.
[7] 1958–66 average.

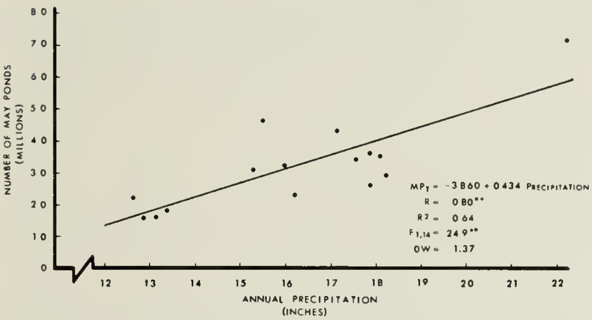


FIG. 7.—The relationship between the number of May Ponds ($MP_t$) and precipitation during the previous 12-month period.

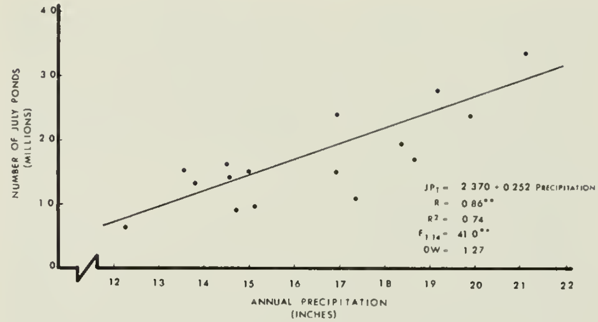


FIG. 8.—The relationship between the number of July Ponds ($JP_t$) and precipitation during the previous 12-month period.

received during the previous 12-month period. Furthermore, annual precipitation, on an August 1-July 31 basis, was highly correlated ($r = 0.86^{**}$, df = 14) with the number of ponds in July (Fig. 8). We conclude that the amount of precipitation received during the 12-month period before the ponds are surveyed is an important variable influencing the number of ponds present in a given year in the *Prairie-Parkland Area*. The relationship between pond numbers and precipitation is slightly stronger for July ponds than for May ponds ($r$ = 0.86 vs. 0.80).

Average annual temperature, summarized on a June 1-May 31 and an August 1-July 31 basis, was not significantly correlated with pond numbers in May or July.

Analyses were conducted to include both precipitation and the number of ponds the previous year to further understand the factors influencing pond numbers in a given year (Fig. 9). The number of May ponds was subjected to a multiple regression analysis with May pond numbers the previous year and precipitation during the previous 12-month period (June 1-May 31). The results of this analysis (Fig. 9a) revealed:

$$MP_{(t)} = -3.429 + 0.344MP_{(t-1)} + 0.333\text{Precip.}$$

(millions & inches)

| | | |
|---|---|---|
| $t$ values | 3.1* | 4.4** |
| $R = 0.81^{**}$ | $R^2 = 0.66$ | $F_{2,12} = 12.4^{**}$ |
| $DW = 1.94$ | SE(est) = 0.574 | |

Although the simple regression coefficient of May pond numbers on the number of May ponds

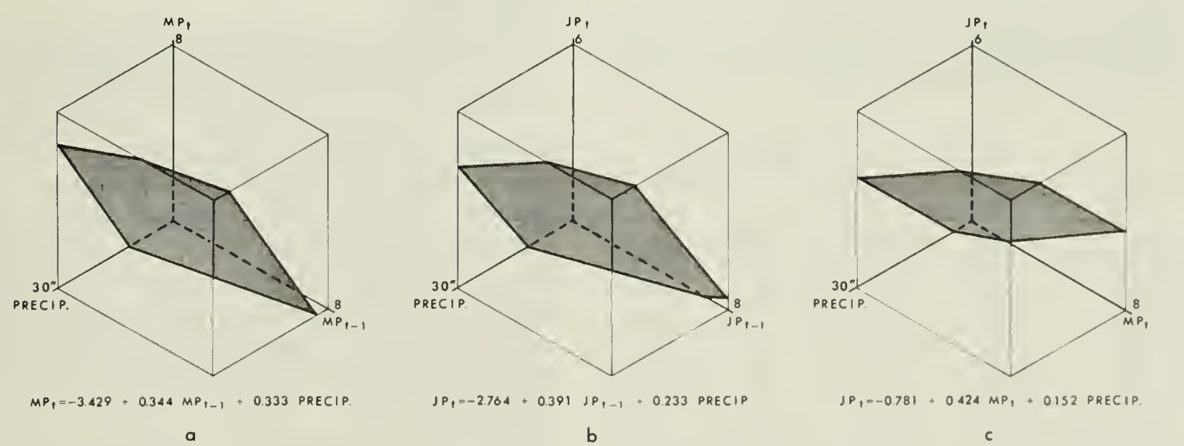


FIG. 9.—Multiple regression surfaces depicting the relationship between May and July ponds (in millions) as functions of precipitation (in inches) and ponds at some earlier time: a) May Ponds$_t$ as a function of May Ponds$_{t-1}$ and annual precipitation, b) July Ponds$_t$ as a function of July Ponds$_{t-1}$ and annual precipitation, and c) July Ponds$_t$ as a function of May Ponds$_t$ and May-July precipitation.

the previous year was not significant, the partial regression coefficient, when precipitation was included in the model, was significant ($t = 3.1^{*}$). As one would expect, precipitation is the more important of the two variables in the relationship (standard partial regression coefficients 0.74 and 0.51, respectively).

Since precipitation is an important factor in determining the number of May ponds in a given year, the timing of precipitation throughout the year was studied. For example, we might suspect that precipitation during April and May would be related to the number of May ponds, but that precipitation during September would be of little value. To study the effect of precipitation on the number of May ponds we started with basic relationship:

$$MP_t = a + bMP_{t-1} + cP_i$$

where $P_i$ represents precipitation, e.g.:

$P_1$ = May precipitation

$P_2$ = Apr. + May precipitation

$P_3$ = Mar. + Apr. + May precipitation

•

•

•

$P_{12}$ = June + July + , . . . , + Apr. + May precipitation

This scheme allowed an evaluation of cumulative precipitation over successive months.

The results of the evaluation of cumulative precipitation and its relationship to the number of May ponds is presented below:

| $i$ | $R^2$x100 | $t$ value ($MP_{t-1}$) | $t$ value (Precip.) | F, df = 2, 12 |
|---|---|---|---|---|
| 1 | 12 | 1.0 | 0.7 | 1.4 |
| 2 | 8 | 1.2 | 0.1 | 1.0 |
| 3 | 20 | 1.9 | 1.3 | 2.1 |
| 4 | 21 | 1.9 | 1.4 | 2.2 |
| 5 | 34 | 2.4* | 2.2* | 3.9* |
| 6 | 27 | 1.9 | 1.7 | 2.8 |
| 7 | 27 | 1.6 | 1.7 | 2.8 |
| 8 | 40 | 2.2* | 2.5* | 4.7* |
| 9 | 56 | 2.9** | 3.6** | 8.6** |
| 10 | 64 | 3.8** | 4.3** | 12.1** |
| 11 | 74 | 4.0** | 5.5** | 18.8** |
| 12 | 66 | 3.1** | 4.4** | 12.4** |

The above results suggest that the cumulative precipitation over a 10- to 12-month period is related to the number of May ponds. Simple correlation coefficients for the number of May ponds and the precipitation in a given month were low, ranging from 0.08 in March to 0.49 in August. These values suggest that precipitation in any given month is of minor importance compared with the cumulative effect of several months. These relationships pertain to the *Prairie-Parkland Area* and may not adequately describe pond-precipitation relationships for smaller geographic areas.

A multiple regression analysis was conducted to examine the effect of July pond numbers in year *t-1* and precipitation during the previous 12-month period (August 1-July 31) on pond numbers in year *t*. The results of the analysis (Fig. 9b) revealed the following important relationship:

$$JP_{(t)} = -2.764 + 0.391JP_{(t-1)} + 0.233\text{Precip.}$$

(millions & inches)

$t$ values 4.5** 8.5**

$R = 0.93^{**}$ $R^2 = 0.87$ $F_{2,12} = 41.3^{**}$

$DW = 1.92$ $SE(\text{est}) = 0.239$

Precipitation is relatively more important than pond numbers the previous year in its effect on pond numbers in July (standard partial regression coefficients 0.88 and 0.46, respectively).

The equations in this section are useful in describing the relationships, given the number of ponds at *t-1*. They are not useful in predicting a long sequence of pond values given only the initial number of ponds and a series of annual precipitation data.

## Relationships between May and July Ponds

As suggested by the pond-precipitation relationships, the numbers of May and July ponds are closely related (Fig. 10). The percentage of ponds remaining between the May and July survey periods is primarily a function of the amount of precipitation falling during May, June, and July (Fig. 11). July pond numbers were regressed against the number of May ponds and precipitation during May 1-July 31 (also see Fig. 9c). These results are summarized below, and the precipitation data are presented in Table 6.

$$JP_{(t)} = -0.781 + 0.424MP_{(t)} + 0.152\text{Precip.}$$

(millions & inches)

$t$ values 10.5** 4.5**

$R = 0.96^{**}$ $R^2 = 0.92$ $F_{2,13} = 75.8^{**}$

$SE(\text{est}) = 0.219$

These results suggest that precipitation during May, June, and July has an extremely important

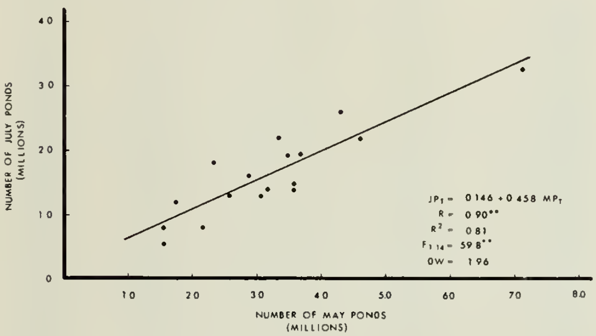


FIG. 10.—Relationship between the number of May Ponds ($MP_t$) and the number of July Ponds ($JP_t$), 1955–73.

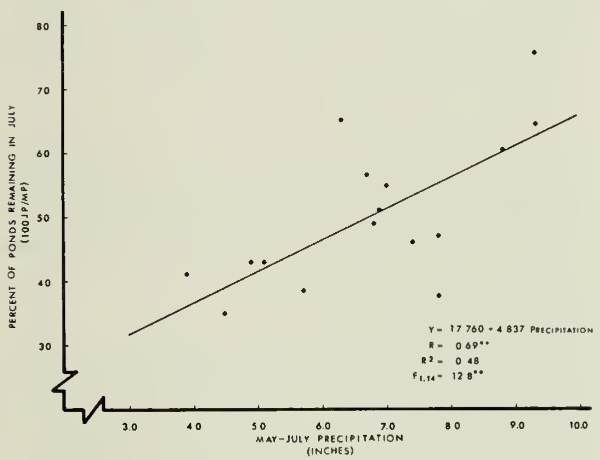


FIG. 11.—The relationship between the percentage of ponds remaining between May and July and precipitation received during May-July, 1955–73.

influence on the number of ponds in July in the *Prairie-Parkland Area.*

A simple regression analysis of the percentage of ponds remaining and average daily temperature during May-July was not significant ($r$ = –0.32, df = 14). A multiple regression analysis of the percentage of ponds remaining in July as a function of (1) precipitation during May-July and (2) average daily temperature during May-July also failed to detect the significance of temperature. We conclude that perhaps an inverse relationship exists, but the variation in average daily temperature is too small to detect significance with the small samples available.

In summary, the number of ponds (May or July) in year $t$ is primarily a function of the number of ponds the previous year and the amount of precipitation received during the previous 12-month period. These two variables account for approximately 66% of the variation in the number of May ponds and 87% of the variation in the number of July ponds. The models representing these relationships are highly significant. Insight into the annual number of May ponds is less well understood. The numbers of May and July ponds are correlated, and pond loss during this period is primarily a function of precipitation, and perhaps temperature, during May, June, and July.

The characteristics of the precipitation process, on both a monthly and an annual basis, are important to the production of mallards. The number of July ponds is closely related each year to the production of young mallards (Crissey 1969 and Geis et al. 1969), which compose a

TABLE 6. *Precipitation data (inches) during the mallard breeding seasons, 1955–70*

| Year | May-June-July | | | | May-June | | | |
|---|---|---|---|---|---|---|---|---|
| | Southern Alberta | Southern Saskatchewan | Southern Manitoba | Weighted average | Southern Alberta | Southern Saskatchewan | Southern Manitoba | Weighted average |
| 1955 | 6.80 | 7.09 | 9.25 | 7.39 | 3.87 | 3.92 | 6.30 | 4.33 |
| 1956 | 8.24 | 7.06 | 9.05 | 7.77 | 5.26 | 4.49 | 5.86 | 4.96 |
| 1957 | 4.48 | 4.21 | 8.79 | 5.11 | 3.05 | 2.27 | 5.70 | 3.12 |
| 1958 | 5.74 | 4.02 | 5.90 | 4.87 | 3.68 | 1.77 | 1.96 | 2.37 |
| 1959 | 6.53 | 5.52 | 8.08 | 6.28 | 4.87 | 4.36 | 6.03 | 4.81 |
| 1960 | 5.18 | 6.10 | 5.63 | 5.74 | 3.48 | 4.75 | 4.37 | 4.31 |
| 1961 | 6.30 | 3.77 | 3.82 | 4.53 | 3.46 | 2.77 | 1.72 | 2.78 |
| 1962 | 7.86 | 6.77 | 10.62 | 7.78 | 4.25 | 4.01 | 7.37 | 4.68 |
| 1963 | 8.93 | 9.17 | 10.34 | 9.31 | 5.62 | 6.28 | 7.00 | 6.21 |
| 1964 | 7.60 | 5.34 | 9.62 | 6.78 | 5.54 | 3.53 | 6.58 | 4.67 |
| 1965 | 10.27 | 8.58 | 9.62 | 9.26 | 7.77 | 6.66 | 5.96 | 6.86 |
| 1966 | 7.80 | 6.60 | 6.96 | 7.02 | 4.06 | 4.38 | 4.08 | 4.23 |
| 1967 | 5.03 | 3.28 | 4.08 | 3.94 | 3.78 | 1.96 | 2.10 | 2.52 |
| 1968 | 7.78 | 5.49 | 9.76 | 6.93 | 4.67 | 3.06 | 5.60 | 3.99 |
| 1969 | 7.17 | 5.77 | 8.74 | 6.72 | 4.11 | 2.52 | 4.80 | 3.40 |
| 1970 | 9.40 | 8.53 | 8.75 | 8.83 | 7.24 | 5.81 | 5.30 | 6.14 |
| Average | 7.19 | 6.08 | 8.06 | 6.77 | 4.67 | 3.91 | 5.05 | 4.34 |

significant fraction of the fall population. Since the number of ponds is strongly related to annual precipitation, it becomes important to understand the precipitation process in some detail. Annual precipitation fluctuates markedly, and the nature of these fluctuations must be understood if we are to understand effects on mallard population dynamics. Knowledge of the general behavior and possible predictability of precipitation has a number of important management and research implications. Since precipitation is basically a random variable, it is necessary to estimate the statistical distribution, autocovariance function, and any cyclic properties. A detailed analysis was made of precipitation records summarized over a 33-year period. Emphasis was placed on describing statistical properties.

## Precipitation

The basic precipitation data for August 1937 to July 1970 are presented in Table 7. The yearly figures represent precipitation from August 1 to July 31 and permit an examination of the effect of precipitation on the number of ponds present in July. Various summary statistics to quantify the precipitation series are presented in Table 8. Since 1937, southern Alberta, southern Saskatchewan, and southern Manitoba have received an average of 16.46 inches of precipitation annually (on an August 1 to July 31 basis). The variance (4.41) and the range (12.27-21.06) are somewhat large. On the average, Manitoba received the most precipitation (19.53 inches) and Saskatchewan received the least (14.92 inches). The standard deviations of the observations and the standard error of the mean were similar for each of the three Provinces. Furthermore, the range and coefficient of variation were similar among Provinces.

TABLE 7. *Basic precipitation data (inches), 1937–70*

| Year [1] | Southern Alberta | Southern Saskatchewan | Southern Manitoba | Weighted average [2] |
|---|---|---|---|---|
| 1937–38 | 17.00 | 14.11 | 17.03 | 15.49 |
| 1938–39 | 17.90 | 17.40 | 14.56 | 17.04 |
| 1939–40 | 17.88 | 13.13 | 17.31 | 15.28 |
| 1940–41 | 14.47 | 12.82 | 20.78 | 14.73 |
| 1941–42 | 20.75 | 17.15 | 23.53 | 19.36 |
| 1942–43 | 17.30 | 14.53 | 20.38 | 16.40 |
| 1943–44 | 17.43 | 15.44 | 20.13 | 16.87 |
| 1944–45 | 16.03 | 12.21 | 21.05 | 14.93 |
| 1945–46 | 18.22 | 13.80 | 17.48 | 15.77 |
| 1946–47 | 19.83 | 14.65 | 19.23 | 17.01 |
| 1947–48 | 23.93 | 17.34 | 22.75 | 20.26 |
| 1948–49 | 12.52 | 12.01 | 18.33 | 13.29 |
| 1949–50 | 13.02 | 14.69 | 21.93 | 15.49 |
| 1950–51 | 21.03 | 15.59 | 14.20 | 16.95 |
| 1951–52 | 20.03 | 16.41 | 16.43 | 17.48 |
| 1952–53 | 19.22 | 16.30 | 19.95 | 17.82 |
| 1953–54 | 15.68 | 17.12 | 19.74 | 17.16 |
| 1954–55 | 20.08 | 20.97 | 22.97 | 21.06 |
| 1955–56 | 16.72 | 15.55 | 21.46 | 16.95 |
| 1956–57 | 13.74 | 11.42 | 19.67 | 13.59 |
| 1957–58 | 17.92 | 12.71 | 16.96 | 15.01 |
| 1958–59 | 14.88 | 12.24 | 17.07 | 13.88 |
| 1959–60 | 15.46 | 16.18 | 21.77 | 16.97 |
| 1960–61 | 14.21 | 10.48 | 14.30 | 12.27 |
| 1961–62 | 15.47 | 13.19 | 20.61 | 15.19 |
| 1962–63 | 17.63 | 17.12 | 23.07 | 18.34 |
| 1963–64 | 15.29 | 12.57 | 19.36 | 14.59 |
| 1964–65 | 21.27 | 18.59 | 20.62 | 19.75 |
| 1965–66 | 18.27 | 15.66 | 20.67 | 17.33 |
| 1966–67 | 16.73 | 12.37 | 17.08 | 14.50 |
| 1967–68 | 14.71 | 13.31 | 19.22 | 14.78 |
| 1968–69 | 18.49 | 16.91 | 24.06 | 18.66 |
| 1969–70 | 19.02 | 18.47 | 20.96 | 19.08 |

[1] August 1 to July 31.
[2] For the three Provinees.

Significant correlations exist between precipitation in one Province and precipitation in the neighboring Province. Also, high correlation coefficients were estimated among pond numbers in the four reference areas in the *Prairie-Parkland Area* (see previous section). A correlation matrix of the precipitation data for

TABLE 8. *Summary statistics of annual (August 1 through July 31) precipitation, 1937–70*

| | Southern Alberta | Southern Saskatchewan | Southern Manitoba | Weighted mean [1] |
|---|---|---|---|---|
| Mean | 17.34 | 14.92 | 19.53 | 16.46 |
| Minimum value | 12.52 | 10.48 | 14.20 | 12.27 |
| Maximum value | 23.93 | 20.97 | 24.06 | 21.06 |
| Variance | 6.81 | 5.87 | 6.95 | 4.41 |
| Standard deviation | 2.61 | 2.42 | 2.64 | 2.10 |
| Standard error of mean | 0.45 | 0.42 | 0.46 | 0.37 |
| Coefficient of variation | 38.15 | 35.38 | 42.56 | 45.02 |
| Mean square successive differences | 13.90 | 10.66 | 12.34 | 8.62 |
| (Mean square successive differences)/(Variance) | 2.04 | 1.81 | 1.77 | 1.95 |
| Number of runs | 21.00 | 21.00 | 21.00 | 21.00 |
| Expected number of runs | 21.67 | 21.67 | 21.67 | 21.67 |
| Standard error of number of runs | 2.35 | 2.35 | 2.35 | 2.35 |
| (Actual runs-expected runs / Standard error) | 0.28 | 0.28 | 0.28 | 0.28 |
| Third moment about the mean | 0.07 | 0.09 | 0.14 | 0.06 |
| Fourth moment about the mean | 2.76 | 2.53 | 2.42 | 2.51 |
| Mean deviation | 2.07 | 2.03 | 2.12 | 1.71 |
| Expected mean deviation | 2.08 | 1.93 | 2.10 | 1.68 |

[1] For the three Provinces.

Alberta, Saskatchewan, and Manitoba, respectively, is shown below:

$$\begin{bmatrix} 1.00 & 0.67^{**} & 0.39^{*} \\ & 1.00 & 0.46^{**} \\ & & 1.00 \end{bmatrix} \mathrm{df} = 31$$

Each series of annual precipitation records were subjected to several tests to determine if they differed significantly from an independent random series. This was done in an effort to determine if previous precipitation data would be of value in predicting future precipitation. Nonparametric run tests (Table 8) were computed, but these tests failed to detect any statistically significant departures from an independent random series. Tests of randomness based on the mean-square-successive-difference divided by the variance (Hart 1942) also failed to reject the hypothesis that the annual precipitation series is independent and random. Although Lindgren (1968) explains that this test is also a measure of trend, no significant trend is suggested from the statistics presented in Table 8.

For analytical purposes it is useful to consider the 33 years of monthly precipitation data as a time series consisting of a composite of cyclical, trend, seasonal, and random components. Shiskin (1957) and Shiskin and Eisenpress (1957) presented sophisticated mathematical techniques to identify the various components in time series data. Decomposition statistics of the precipitation series are presented in Table 9. Nearly all of the series of monthly precipitation data are composed of a large random component and a strong seasonal component. Only a very small cyclic component could be detected. The mean random component was approximately 7.24 times as large as the cyclic component for the weighted average data. The seasonal component was 5.21 times as large as the cyclic component.

A histogram of monthly precipitation for the combined area is presented in Fig. 12 and depicts the strong seasonal component in the precipitation series. Approximately 55% of the annual precipitation occurred during May, June, July, and August. The histograms for the three individual Provinces were similar in form. The pronounced seasonal variation complicated the definition and identification of longer-term cycles in precipitation. Since only 33 years of data were analyzed, it is possible that a longer-term cycle exists in the precipitation process. However, a long-term cycle would be of little practical importance in waterfowl research or

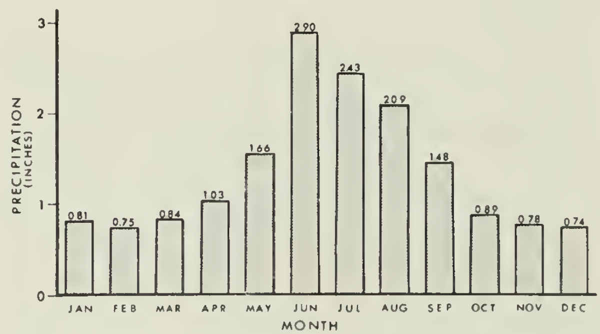


FIG. 12.—Monthly precipitation in the *Prairie-Parkland Area* during 1937–70.

TABLE 9. *Average monthly amplitude of the random, cyclical, and seasonal components and their relationships for monthly precipitation data in the southern portions of central Canada, 1937–70*

| | Southern Alberta | Southern Saskatchewan | Southern Manitoba | Weighted average [1] |
|---|---|---|---|---|
| Average month-to-month amplitude | | | | |
| Original series | 77.16 [2] | 77.15 | 92.96 | 60.54 |
| Random component | 58.75 | 53.83 | 69.02 | 42.83 |
| Cyclical component | 6.31 | 6.90 | 7.50 | 5.92 |
| Seasonal component | 33.20 | 32.99 | 38.68 | 30.84 |
| Ratios of the components | | | | |
| Random/original | 0.76 | 0.70 | 0.74 | 0.71 |
| Random/seasonal | 1.77 | 1.63 | 1.78 | 1.39 |
| Random/cyclical | 9.31 | 7.80 | 9.21 | 7.24 |
| Cyclical/original | 0.08 | 0.09 | 0.08 | 0.10 |
| Cyclical/random | 0.11 | 0.13 | 0.11 | 0.14 |
| Cyclical/seasonal | 0.19 | 0.21 | 0.19 | 0.19 |
| Seasonal/original | 0.43 | 0.43 | 0.42 | 0.51 |
| Seasonal/cyclical | 5.26 | 4.78 | 5.16 | 5.21 |
| Seasonal/random | 0.57 | 0.61 | 0.56 | 0.72 |

[1] Pooling data from the three Provinces reduces the effect of many extreme values, consequently the weighted average components are smaller than the components for an individual Province.
[2] The sum of the random, cyclical, and seasonal components will exceed the total due to covariance between the three components.

management because of the large seasonal and random components in the series.

Nonparametric tests for randomness suggested that yearly precipitation data can be described as an independent random process. Intuitively we might suspect that the data on an annual basis (August 1-July 31) would be nearly normally distributed. When average precipitation data for the three Provinces were compared to a normal distribution using a Chi-square test, that distribution was not rejected ($X^2 = 0.96$, 5 df). In addition, statistics based on the third and fourth moment about the mean were computed to determine if the data could be described adequately by the normal distribution. The third moment is a measure of relative skewness and has an expected value of zero (Duncan, 1965). Statistics in Table 8 for each Province are very near the expected values. Since no appreciable skewness could be detected, we conclude that the statistical distribution is nearly symmetrical. If the skewness suggested here were significant, some form of the Gamma distribution might be appropriate.

The fourth moment is a measure of kurtosis and has an expected value of 3.0. The statistics in Table 8 show values consistently below the expected value (2.42 to 2.76) and indicate a somewhat platykurtic distribution (Duncan 1965). Compared to the normal distribution, the precipitation data tended to have a flatter peak, fatter "shoulders," and thinner "tails." The departure of the fourth moment from its expected value is not statistically significant ($t$ values less than 0.2); however, the fourth moment is below the expected value in each instance.

The normal distribution has a theoretical mean deviation of $0.798 \times \sigma$. Mean deviations for the precipitation data are very close to the expected values (Table 8). Thus it appears that the annual precipitation data can be described reasonably well by the normal distribution (Fig. 13). Precipitation is one of the important exogenous variables affecting population dynamics of mallards. For this reason, considerable emphasis has been given to a description of its major properties. Particular attention was given to analyzing its distribution and independence because these are important properties of random variables.

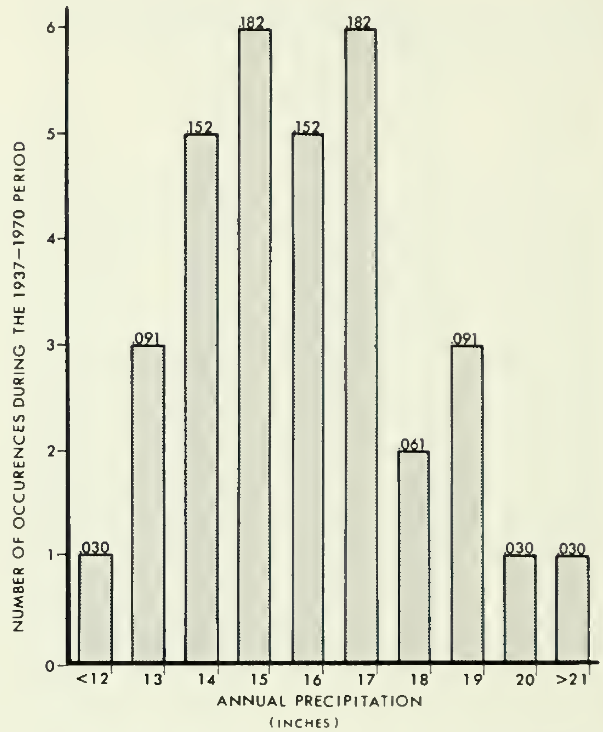


FIG. 13.—Annual precipitation for the southern portions of Alberta, Saskatchewan, and Manitoba, 1937–70.

Monthly precipitation data for each Province and the average of the three Provinces were used to compute autocovariance functions and power spectral densities. These functions appear to be very similar; therefore, only the weighted mean of the three Provinces is shown in Fig. 14. The autocovariance function identifies the strong seasonal component discussed earlier. The spectral density estimates indicate that the 1-year seasonal component is the only significant "cycle" in the data. Again, the possibility of a long-term cycle still exists since only 33 years of data were analyzed in this study.

The subject of longer-term precipitation cycles was investigated further by examining 91 years of precipitation data (1874-1964) from Winnipeg, Manitoba (from Anonymous 1964). No cycles in these data were detected or even suggested. In particular, autocorrelation coefficients for cycle periods of 10, 11, and 12 years were –0.07, –0.14, and 0.2, respectively; these small coefficients do not support the hypothesis

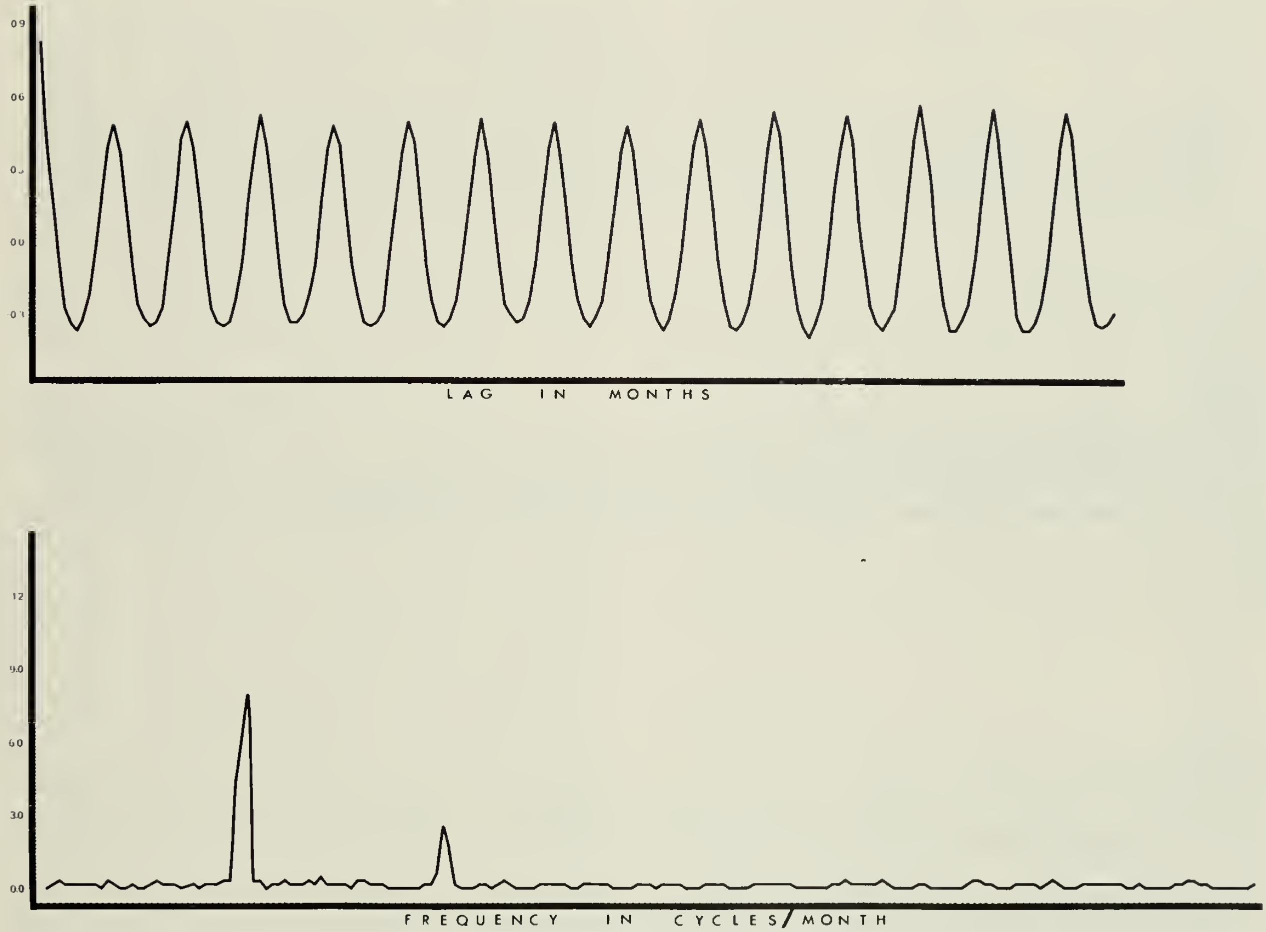


FIG. 14.—The autocovariance (top) and the power spectrum (bottom) of monthly precipitation in the southern portions of Alberta, Saskatchewan, and Manitoba, 1937–70.

of an 11-year cycle. The largest coefficient occurred at a 17-year period but accounted for less than 4% of the total variation. This, together with the analyses presented above, suggests that it is unlikely that significant precipitation cycles exist in the *Prairie-Parkland Area*.

The time series decomposition techniques developed by Shiskin (1957) and Shiskin and Eisenpress (1957) allow certain components of the process to be eliminated and new data sets to be generated. Three graphs of the three Provinces are presented in Fig. 15. These graphs give a pictorial representation of the summary statistics presented in Table 8. The top graph represents the original data and shows the strong seasonal and random components. The seasonal component has been removed from these data in the middle graph, but the random and cyclic components remain (no trend was present to remove). In the bottom graph, the random component was removed leaving only a very weak, drifting cyclic component.

An examination of the autocovariance function of the seasonally adjusted precipitation data (Fig. 14) indicated independence (absolute values of the autocorrelation coefficients of monthly precipitation as a function of the time lag varied from 0.0-0.14). This indicates strong evidence for independence on a month-to-month basis. An important theorem in mathematical statistics states that sums of independent random variables are also independent random variables. This theorem allows more confidence

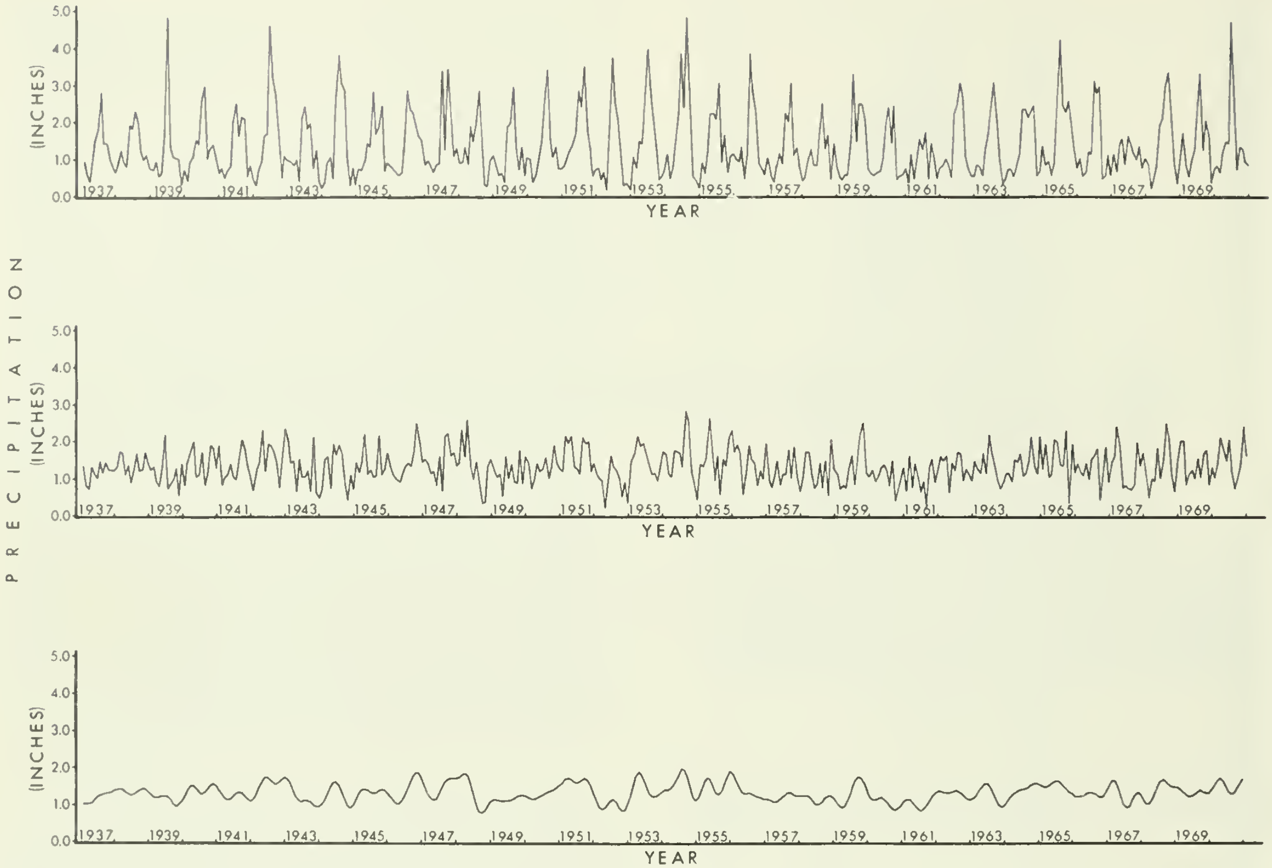


FIG. 15.—Representations of the monthly precipitation process using data from the southern portions of Alberta, Saskatchewan, and Manitoba, 1937–70: actual monthly precipitation data (top), the precipitation process with the seasonal component removed (middle), and the precipitation process with both the seasonal and random components removed (bottom).

in statements concerning the independence of precipitation on a year-to-year basis.

Yearly precipitation appears to be independent and random. If this is true, the amount of precipitation can change from one extreme to the other from one year to the next. However, the fact that annual precipitation is distributed nearly normally implies that the amount of precipitation occurring in a given year would probably be near average. The following table provides a rough guide to probabilities of varying amounts of precipitation on an August 1–July 31 basis. We constructed the probabilities (in percentages) using one and two standard deviations from a normal distribution with a mean of 16.46. The probabilities of various amounts of precipitation in year $t + 1$ are the same regardless of precipitation received in year $t$, since the process is time-independent.

| Precipitation in year $t$ | | Probability of occurrence |
|---|---|---|
| | (inches) | (percent) |
| Very wet | 20.67 - ✓ | 2.5 |
| Wet | 18.56 - 20.67 | 13.5 |
| Slightly wet | 16.46 - 18.56 | 34.0 |
| Slightly dry | 14.36 - 16.46 | 34.0 |
| Dry | 12.26 - 14.36 | 13.5 |
| Very dry | 0.00 - 12.26 | 2.5 |

An example will make this table clear: the percentage probability of a given year being a dry year (defined as 12.26 to 14.36 inches of precipitation) is approximately 13.5. This table shows a marked tendency toward "average" values. The probability of receiving extreme amounts of precipitation is much less than the probability of receiving "average" amounts. This occurs irrespective of the amount of precipitation received in a previous year due to the independent nature of precipitation.

While annual precipitation appears to be independent and random, and can change from one extreme to the other in successive years, the number of ponds will not vary to this degree. Since the number of ponds in a given year is related to the number of ponds the previous year, pond numbers are not likely to change drastically from one year to the next.

## Mathematical Model of Annual Precipitation

The strong seasonal component makes the series of monthly precipitation data difficult to study. Therefore, a series of data was constructed by dividing the monthly observations by the mean for the particular month. This series represented the degree to which precipitation in a given month was "average" for that month and eliminated the seasonal component. With this series of data we constructed a spectral model using an iterative maximum likelihood procedure (Kalman 1963; Astrom et al. 1965; and Astrom and Bohlin 1966). The final model was then modified by multiplying the vector of monthly means to reestablish the seasonal component. The equation was then summed for the 12-month period and simplified. The following equation can be used to produce sequences of annual precipitation data that will have statistical characteristics similar to the statistics calculated from the 33 years of observed precipitation data.

$$P_{(t)} = 11.97 + \sum_{i=1}^{12} [0.391 \times R_i \times \bar{M}_i]$$

where: $P_{(t)}$ = total annual precipitation in inches, in year $t$
$t = 1,2,3,\ldots$

$R_i$ = normally distributed random variable; mean 0, variance = 1. These values would change each year.

$\bar{M}_i$ = average precipitation in month $_i$. $_i$ = 1,2,3, . . . ,12 corresponding to January, February, March, . . . , December, respectively.

The $\bar{M}_i$ values (inches) were estimated to be: (see Fig. 12)

| | | |
|---|---|---|
| $M_1 = 0.81$ | $M_5 = 1.66$ | $M_9 = 1.48$ |
| $M_2 = 0.75$ | $M_6 = 2.90$ | $M_{10} = 0.89$ |
| $M_3 = 0.84$ | $M_7 = 2.43$ | $M_{11} = 0.78$ |
| $M_4 = 1.03$ | $M_8 = 2.09$ | $M_{12} = 0.74$ |

In summary, both annual and monthly precipitation data from the southern portions of Alberta, Saskatchewan, and Manitoba appear to be independent (autocorrelation coefficients near zero), random and nearly stationary, without a detectable trend, and without significant cycles. A strong seasonal component is present resulting in the bulk of the precipitation falling in May, June, July, and August. The data are approximately symmetrically distributed, nearly normal, but somewhat platykurtic. Treated as a time series, the precipitation series consists primarily of random and seasonal components.

## Temperature

Data on average daily temperature were obtained by river basin from the *Monthly Record* for 1940–70, and these figures were further summarized for each Province on an August 1–July 31 basis. Only data from the southern portions of Alberta, Saskatchewan, and Manitoba and a weighted average were analyzed in this study.

Correlation analyses detected only a weak relationship between average annual temperature and the number of July ponds ($r = -0.06$). Since no relationship was found between pond numbers and temperature, analytical results on the temperature data are not presented in detail. Temperatures during the breeding season will be studied further in later reports dealing with reproduction rates of mallards.

Basically, monthly and annual temperature data for the southern areas of central Canada appear to be independent random variables. A very strong and regular seasonal component dominates the temperature series. The random component is much less pronounced than in the precipitation process. No long-term cycles were detected or even suggested by the data. The data appear symmetrical on a yearly basis, but no attempt has been made to fit a statistical distribution.

# Breeding Population Estimates for Mallards—Weighting Factors

Portions of some reference areas, and in some cases complete reference areas, were not surveyed by standardized cooperative surveys. Although some of these areas are large, they generally consist of marginal habitat for breeding mallards. Since estimates of the total size of the mallard breeding population in North America were required for many purposes in the course of this study, estimates were made of the number of mallards in these "unsurveyed" areas. Fortunately, an average of 84% of the estimated mallard breeding population has been covered by aerial surveys. Remaining birds were widely scattered at low densities in peripheral areas.

Two approaches were used to estimate the size of breeding populations in these marginal areas: (1) mathematical techniques using banding and recovery distribution patterns, combined with estimates of recovery rates and size of harvest in various geographical areas, and (2) subjective estimates made by Federal, State, and Provincial biologists, or estimates previously made (e.g., Flyway Habitat Management Unit Project).

Several mathematical methods have been published to allow estimates of population size when the population is stratified in some manner (Schaefer 1951; Chapman and Junge 1956; Darroch 1961; and Overton and Davis 1969). Since Schaefer's method does not produce consistent estimates, and Darroch's method is extremely complex neither was used. All four of these methods are closely related and we used the methods of Chapman and Junge, and Overton and Davis. Both of these methods basically assume that population segments in each stratum are represented by banded samples, and that direct recovery rates and recovery distributions reflect patterns of harvest and harvest rates. Both methods require the solution of a system of simultaneous linear equations. Chapman and Junge's method depends on the direct inversion of the data matrix, whereas the method described by Overton and Davis utilizes an iterative method to obtain solutions. No useful estimates were obtained using either method. In all estimates, negative populations were indicated in several areas.

We can only speculate as to why the mathematical methods failed to produce reasonable results. Some possible reasons are: 1) samples of banded mallards from two reference areas were very small; 2) unedited banding and recovery data were used and may have been inaccurate; 3) the harvest information may have been incorrect, even on a relative basis; and 4) there may be substantial geographical variation in band reporting rates.

The disagreement between banding and harvest data is disturbing, and we intend to investigate this subject on a more intensive basis in a later report in this series. At that time improved estimates of harvest will be available and corrected banding and recovery data can be used.

We chose to use the data obtained from State and Provincial waterfowl breeding surveys (when they were available) to estimate mallard populations in areas not included in the cooperative survey. In areas not surveyed at all, subjective estimates by waterfowl biologists familiar with the areas were used.

Over the 19-year period of this study, the estimated size of the continental mallard breeding population has ranged from a high of 14.4 million in 1958 to a low of 7.1 million in 1965 (Fig. 16). Generally, the mallard population declined from 1958 to 1962 and remained below 10 million birds until 1970. The decline and consequent low level of the mallard population between 1959 and 1969 generally followed a period of poor habitat conditions in the major breeding ground area. The breeding population responded to improved habitat conditions since 1970 and rose to over 10 million birds in 1970-72.

Population levels during 1955–60 may be underestimated. The system of ground-air transects was not operational until 1961. Consequently, we lack visibility adjustment factors during the pre–1961 period. The estimates used during this period were based on average visibility rates during 1961–73. There are indica-

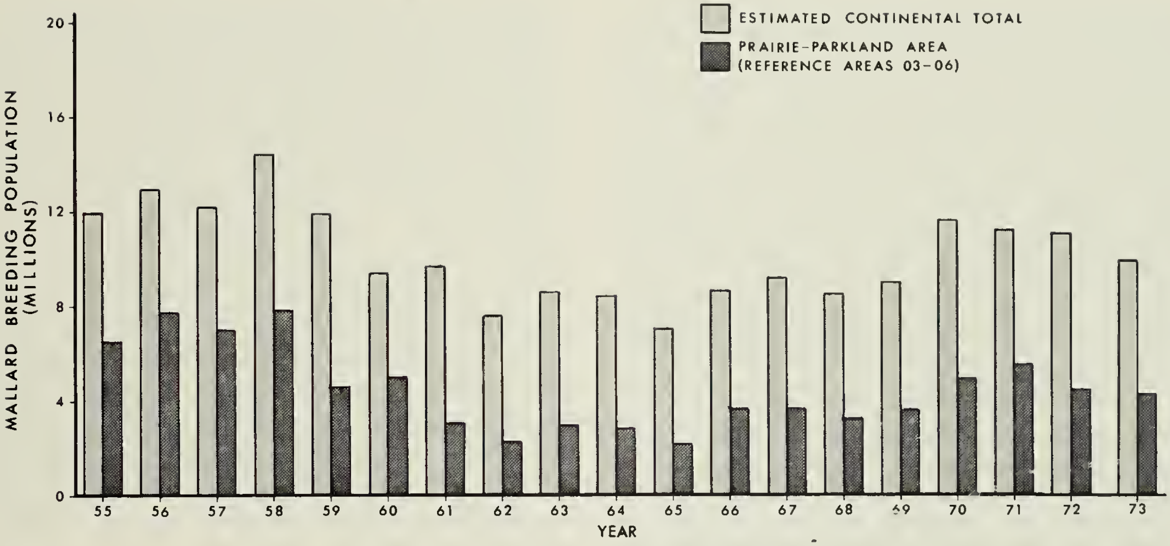


FIG. 16.—Estimated mallard breeding population, 1955–73.

tions, particularly in some areas, that visibility adjustment factors are inversely correlated with bird density (the proportion of birds that are seen and identified decreases as bird density increases). We were unable to quantify this relationship and using it to adjust the pre-1961 data is unwarranted. We believe that the 1955–60 population estimates may be biased somewhat downward by using average visibility adjustment factors.

## Surveyed Areas

Detailed, annual information pertaining to the size of mallard breeding populations was available for 19 of the 44 minor reference areas (See Appendixes B and C). During the 19-year history of mallard populations discussed in this report, an estimated average of 84% of the continental mallard population occurred within these 19 minor reference areas. Population estimates for survey strata were always converted to minor reference areas on the basis of land area as described in the METHODS section. In six minor reference areas, additional mallards were added to the estimate to account for birds outside the survey strata boundaries but within minor reference areas (see Appendix C for details). The important contribution of the *Prairie-Parkland Area* to the total population estimate is shown in Fig. 16.

## Unsurveyed Areas

In this report the 25 minor reference areas not included in standardized cooperative surveys are considered unsurveyed. However, many States conduct independent waterfowl surveys and information from these sources was used (when available) to estimate the number of mallards present. Details of these estimates are presented in Appendix Table B–20. In the 25 minor reference areas, a constant of 1.4 million mallards was estimated and added to the population estimate made from surveyed areas each year. The importance of these areas has ranged from a low of 10.9% of the total in 1958 to a high of 23.0% in 1965. (Appendix Table C–2).

# Utilization of Breeding Habitat by Waterfowl

The geographical and temporal distribution of waterfowl species on the breeding grounds is not random. Species arrive at different times and differ in habitat preferences. Dzubin (1969a) reported that most dabblers arrive before diving ducks at both the Roseneath (Manitoba) and Kindersley (Saskatchewan) districts. He noted that pintails (*Anas acuta*) were generally the first species to arrive, usually by the last week of March, followed by mallards, wigeon *(A. americana)*, green-winged teals *(A. carolinensis)*, shovelers *(A. clypeata)*, gadwalls *(A. strepera)*, and blue-winged teals *(A. discors)* during the first to third week of April. Redheads *(Aythya americana)* and canvasbacks *(Aythya valisineria)* arrived at about the same time as green-winged teals. Arrival times in the Saskatchewan and Alberta parklands are reported by Stoudt (1971) and Smith (1971).

With respect to habitat preferences of waterfowl, Hochbaum (1944:54) reported,

> "The species of ducks that breed in the Delta region [Manitoba] may be classed broadly in two groups, those that nest on dry land away from water, and those that nest over water. All of the river ducks, as well as two diving ducks, the Lesser Scaup and the White-winged Scoter, are land nesters . . . In all species there are occasional departures from normal behavior. Thus Mallards and Pintails sometimes build over water . . . ."

Hochbaum (1944:78) further stated,

> "Mallards prefer potholes over bay edge as territory . . . Pintails prefer more open shore lines than the Mallard; territorial pairs are found less frequently in potholes and small sloughs than in the mallard, more frequently along exposed edges and in the more open water areas bordering farm land."

Sowls (1955:75) reported similar findings for mallards and pintails and found that gadwall and blue-winged teal utilized more closed areas than mallards. Stoudt (1971) suggested that mallards in the Saskatchewan parklands had a preference for wooded (or closed) ponds; however, the data collected showed only a small difference. Dwyer (1970) showed that in agricultural land in Manitoba potholes, without or with few trees, received greater use by lesser scaup *(Aythya affinis)*, canvasback, redhead, American coot *(Fulica americana)*, and three species of grebes (Podicipedidae) than by other species. In nonagricultural land, potholes were completely surrounded by trees and were more attractive to blue-winged teal and mallards. Over twice as many dabbler broods as diver broods were censused on potholes on nonagricultural lands. Interspecific competition is probably minimized by differing temporal patterns and physiographic preferences of the species.

## Mallard Distribution on the Surveyed Breeding Grounds

Several authors, including Crissey (1969) and Dzubin and Gollop (1972), have noted that mallards are most abundant in the southern portions of the three Prairie Provinces. The percentage of the mallards that occur in surveyed areas in North America is shown in Table 10 for the years 1955–73. Surveys were not initiated in the north-central United States until 1958, thus, long-term average numbers of mallards were used when information was unavailable.

Drought in the *Prairie-Parkland Area* appears to cause mallards to "overfly" the area

TABLE 10. *The percentage of mallards in surveyed areas in North America, 1955–73*

| Year | Alaska Yukon | Northern Canada Northwest Territories | Prairie-Parkland Area | North-Central[1] United States | Total |
|---|---|---|---|---|---|
| 1955 | 2.7 | 21.2 | 63.4 | 12.6 | 99.9 |
| 1956 | 2.3 | 17.7 | 68.5 | 11.5 | 100.0 |
| 1957 | 1.7 | 19.8 | 66.3 | 12.3 | 100.1 |
| 1958 | 1.8 | 27.4 | 60.9 | 9.9 | 100.0 |
| 1959 | 4.5 | 43.6 | 44.7 | 7.2 | 100.0 |
| 1960 | 3.3 | 20.9 | 63.6 | 12.1 | 99.9 |
| 1961 | 5.8 | 41.2 | 40.6 | 12.4 | 100.0 |
| 1962 | 4.5 | 37.6 | 37.7 | 20.1 | 99.9 |
| 1963 | 5.3 | 30.6 | 43.1 | 21.0 | 100.0 |
| 1964 | 2.5 | 37.9 | 41.7 | 17.9 | 100.0 |
| 1965 | 5.1 | 32.1 | 40.3 | 22.5 | 100.0 |
| 1966 | 2.5 | 25.8 | 52.8 | 19.0 | 100.1 |
| 1967 | 3.4 | 30.3 | 48.9 | 17.4 | 100.0 |
| 1968 | 3.8 | 30.3 | 48.3 | 17.7 | 100.1 |
| 1969 | 2.6 | 29.7 | 48.8 | 18.9 | 100.0 |
| 1970 | 3.4 | 30.5 | 50.1 | 16.1 | 100.1 |
| 1971 | 2.3 | 24.0 | 57.5 | 16.1 | 99.9 |
| 1972 | 3.2 | 28.8 | 49.7 | 18.3 | 100.0 |
| 1973 | 2.8 | 28.6 | 51.9 | 16.6 | 99.9 |
| 1955–73 average | 3.3 | 29.4 | 51.5 | 15.8 | 100.0 |
| Percent of area | 41.8 | 34.6 | 11.9 | 11.6 | 99.9 |

[1] Includes surveyed portions of minor reference areas 112, 121, 122, 124, 131, and 132.

and distribute themselves over much of the Northwest Territories and the northern portions of Alberta, Saskatchewan, and Manitoba. This "trade-off" is illustrated in Fig. 17, where the percentage of the mallard population in the *Prairie-Parkland Area* is inversely correlated

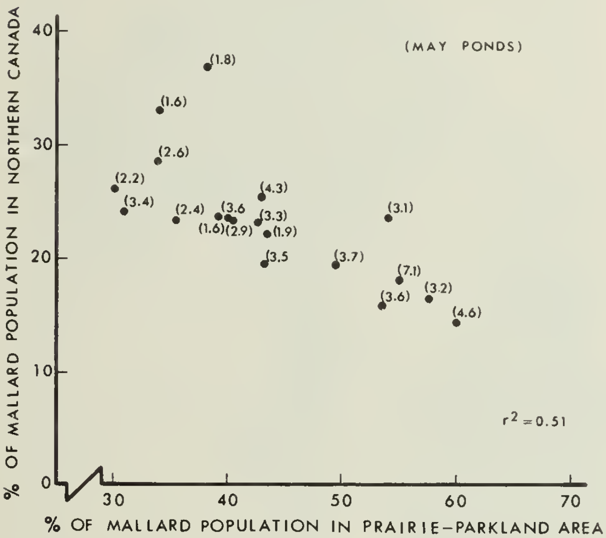


FIG. 17.—The relative distribution of the mallard breeding population in northern Canada and the *Prairie-Parkland Area*, 1955–73. The numbers of May ponds are given in parentheses. Generally, a high percentage of the mallard breeding population occurs in the *Prairie-Parkland Area* when May ponds are abundant. When few May ponds are present, the birds tend to fly into northern Canada.

($r^2$=0.51) with the percentage in the northern portions of the breeding range. Furthermore, the relative distribution may be influenced by the number and distribution of ponds on the breeding grounds in May. To test this hypothesis, the number of mallards in northern Canada was regressed against the number of mallards in the *Prairie-Parkland Area* and the number of May ponds in the *Prairie-Parklan Area*. The results of the multiple regression analysis supported the hypothesis that pond numbers are a causal factor ($t$=2.0*, df=17) in changes in the relative distribution of mallards on the breeding grounds. Patterns tend to exist between the percentage of mallards in the *Prairie-Parkland Area* vs. Alaska ($r$=0.60, df=17) and vs. the Dakotas and western Minnesota ($r$=0.44, df=17).

The degree to which mallard breeding populations are related between various reference areas is illustrated in the correlation matrix shown at the bottom of the page. Several aspects of mallard distribution can be seen from the correlation matrix: (1) mallard populations in northern Alberta (022, 023) and the Northwest Territories (021) are positively related, (2) mallard populations in reference areas in the *Prairie-Parkland Area* (031-061) are positively related, (3) substantial positive correlations exist between mallard populations in the reference areas in the

| | | 011 | 021 | 022 | 023 | 031 | 041 | 051 | 061 | 071 | 072 | 073 | 122 | 124 | 131 | 132 | Continental Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alaska | 011 1/ | 1.00 | 0.35 | 0.27 | 0.26 | 0.10 | 0.04 | -0.14 | -0.06 | 0.10 | 0.32 | 0.03 | 0.42 | 0.41 | 0.24 | 0.22 | 0.18 |
| Central Mackenzie | 021 2/ | | 1.00 | 0.91** | 0.88** | 0.35 | -0.02 | 0.10 | 0.47* | 0.06 | -0.22 | 0.03 | -0.10 | -0.13 | -0.13 | -0.14 | 0.44 |
| NE British Columbia-NW Alberta | 022 | | | 1.00 | 0.81** | 0.20 | -0.19 | 0.12 | 0.46* | -0.06 | -0.26 | -0.03 | -0.24 | -0.16 | -0.18 | -0.08 | 0.33 |
| NE Alberta | 023 2/ | | | | 1.00 | 0.28 | -0.08 | 0.20 | 0.48* | -0.15 | -0.31 | -0.01 | -0.31 | -0.26 | -0.27 | -0.15 | 0.41 |
| SW Alberta | 031 | | | | | 1.00 | 0.82** | 0.76** | 0.67** | 0.16 | 0.00 | -0.30 | 0.03 | -0.27* | -0.26 | -0.56* | 0.90** |
| NE So. Alberta-SW Saskatchewan | 041 | | | | | | 1.00 | 0.72** | 0.49* | 0.16 | 0.20 | -0.31 | 0.03 | -0.21 | -0.23 | -0.47* | 0.81** |
| SE Saskatchewan | 051 | | | | | | | 1.00 | 0.85** | 0.03 | -0.05 | -0.28 | -0.33 | -0.44 | -0.49* | -0.57* | 0.86** |
| SW Manitoba | 061 | | | | | | | | 1.00 | 0.26 | -0.02 | -0.32 | -0.36 | -0.45 | -0.49* | -0.57* | 0.84** |
| N Saskatchewan-SE Mackenzie | 071 | | | | | | | | | 1.00 | 0.80** | -0.21 | 0.55* | 0.32 | 0.35 | 0.05 | 0.27 |
| N Manitoba-SW Keewatin | 072 | | | | | | | | | | 1.00 | -0.12 | 0.66** | 0.53* | 0.44 | 0.28 | 0.15 |
| W Ontario | 073 | | | | | | | | | | | 1.00 | 0.20 | 0.23 | 0.27 | 0.51* | -0.29 |
| W North Dakota | 122 3/ | | | | | | | | | | | | 1.00 | 0.79** | 0.64** | 0.20 | 0.26 |
| W South Dakota | 124 4/ | | | | | | | | | | | | | 1.00 | 0.59* | 0.57* | 0.17 |
| E North Dakota | 131 3/ | | | | | | | | | | | | | | 1.00 | 0.46 | 0.20 |
| E South Dakota | 132 3/ | | | | | | | | | | | | | | | 1.00 | -0.18 |
| Continental Total | | | | | | | | | | | | | | | | | 1.00 |

1/ Correlation coefficients based on data during the 1957-73 period, d.f. = 15

2/ Correlation coefficients based on data during the 1956-73 period, d.f. = 16

3/ Correlation coefficients based on data during the 1958-73 period, d.f. = 14

4/ Correlation coefficients based on data during the 1959-73 period, d.f. = 13

Dakotas (122, 124, 131, and 132), and (4) inverse correlations are suggested between mallard breeding populations in the Dakotas vs. northern Alberta and the Northwest Territories, but none are significant. An inverse relationship is indicated between mallard breeding populations in the Dakotas vs. the *Prairie-Parkland Area*. In years of good water conditions in the Dakotas, many mallards stop there rather than fly further north into the *Prairie-Parkland Area* and into northern Alberta and the Northwest Territories. Only mallard populations in the reference areas in the *Prairie-Parkland Area* are significantly related to the continental total. These relationships are illustrated by the shaded portions of the correlation matrix, in the table above.

The center of mallard abundance during the breeding season is the *Prairie-Parkland Area* (6.4% of the area) in south-central Canada (Tables 10 and 11); an average of 51.5% of the mallards has been estimated in this area (range: 37.7% in 1962 to 68.5% in 1956). An average of 29.4% of the mallards was reported from nothern Canada and the Northwest Territories (Reference Areas 02 and 07), while 15.8% was estimated in the north-central United States (Reference Areas 12 and 13). Estimates of the percentage distribution of the mallard population, including both surveyed and unsurveyed areas, are presented in Appendix Table C–2. Statistics presented in Appendix C will be used for weighting band recovery data in future reports in this series. Adjustments in weighting factors may be presented in future reports to account for movement of birds between May and August. However, adjustments will be minimal since reference areas are relatively large.

The highest density of mallards per square mile (20.2), is in the *Prairie-Parkland Area* (Fig. 18). Long-term averages (Table 11) within the four reference areas in southern Canada were 19.9 mallards per square mile *(Southwestern Alberta)*, 21.4 *(Southwestern Saskatchewan)*, 24.7 *(Southeastern Saskatchewan)*, and 10.8 *(Southwestern Manitoba)*. Generally, an average of less than 5.0 mallards per square mile was found in *Northern Saskatchewan-Southeastern Mackenzie* and *Northern Manitoba-Southwestern Keewatin*; however an average of 4.6 was found in *Northeastern British Columbia-Northwestern Alberta*, and an average of 8.8 was reported from *Northeastern Alberta*. The higher value in *Northeastern Alberta* was influenced by fairly high densities of mallards nesting on the Athabaska River Delta. Fewer than 3.0 mallards per square mile were found in surveyed areas in *Alaska* and the *Yukon-Western Mackenzie* area, while less than 1.0 was found in *Western Ontario*. Average mallard densities in the north-central United States ranged from 3.8 to 8.0 in the Dakotas and Montana; and was 3.0 in *Western Minnesota*.

## Species Composition on the Breeding Grounds

Reports on the species composition of waterfowl on the breeding grounds are few, however,

TABLE 11. *The average density of breeding mallards and total ducks per square mile in surveyed areas*

| Reference area | Time period | Mallards per square mile | Total ducks per square mile | Percent mallards |
|---|---|---|---|---|
| *Alaska* (011) | 1957–73 | 2.0 | 45.4 | 4.5 |
| *Yukon-Western Mackenzie* (012) | 1956–73 | 0.8 | 21.4 | 3.8 |
| *Central Mackenzie* (021) | 1956–73 | 2.2 | 20.2 | 10.8 |
| *Northeastern British Columbia-Northwestern Alberta* (022) | 1955–73 | 4.6 | 22.2 | 22.1 |
| *Northeastern Alberta* (023) | 1956–73 | 8.8 | 37.2 | 24.0 |
| *Southwestern Alberta* (031) | 1955–73 | 19.9 | 72.2 | 27.5 |
| *Southwestern Saskatchewan* (041) | 1955–73 | 21.4 | 76.2 | 28.3 |
| *Southeastern Saskatchewan* (051) | 1955–73 | 24.7 | 81.8 | 29.2 |
| *Southwestern Manitoba* (061) | 1955–73 | 10.8 | 55.6 | 19.2 |
| *Northern Saskatchewan-Southeastern Mackenzie* (071) | 1955–73 | 3.7 | 14.6 | 26.0 |
| *Northern Manitoba-Southwestern Keewatin* (072) | 1955–73 | 3.4 | 13.3 | 25.9 |
| *Western Ontario* (073) [1] | 1955–73 | 0.8 | 4.4 | 17.8 |
| *Western Montana* (112) | 1965–73 | 7.3 | 25.7 | 28.4 |
| *Eastern Montana* (121) | 1965–73 | 5.6 | 17.2 | 32.6 |
| *Western North Dakota* (122) | 1958–73 | 3.8 | 16.0 | 24.0 |
| *Western South Dakota* (124) | 1959–73 | 5.4 | 17.6 | 31.4 |
| *Eastern North Dakota* (131) | 1958–73 | 8.0 | 45.3 | 18.5 |
| *Eastern South Dakota* (132) | 1959–73 | 6.1 | 35.4 | 17.5 |
| *Western Minnesota* (133) | 1958–67 | 3.0 | 13.7 | 21.9 |

[1] No data for 1971.

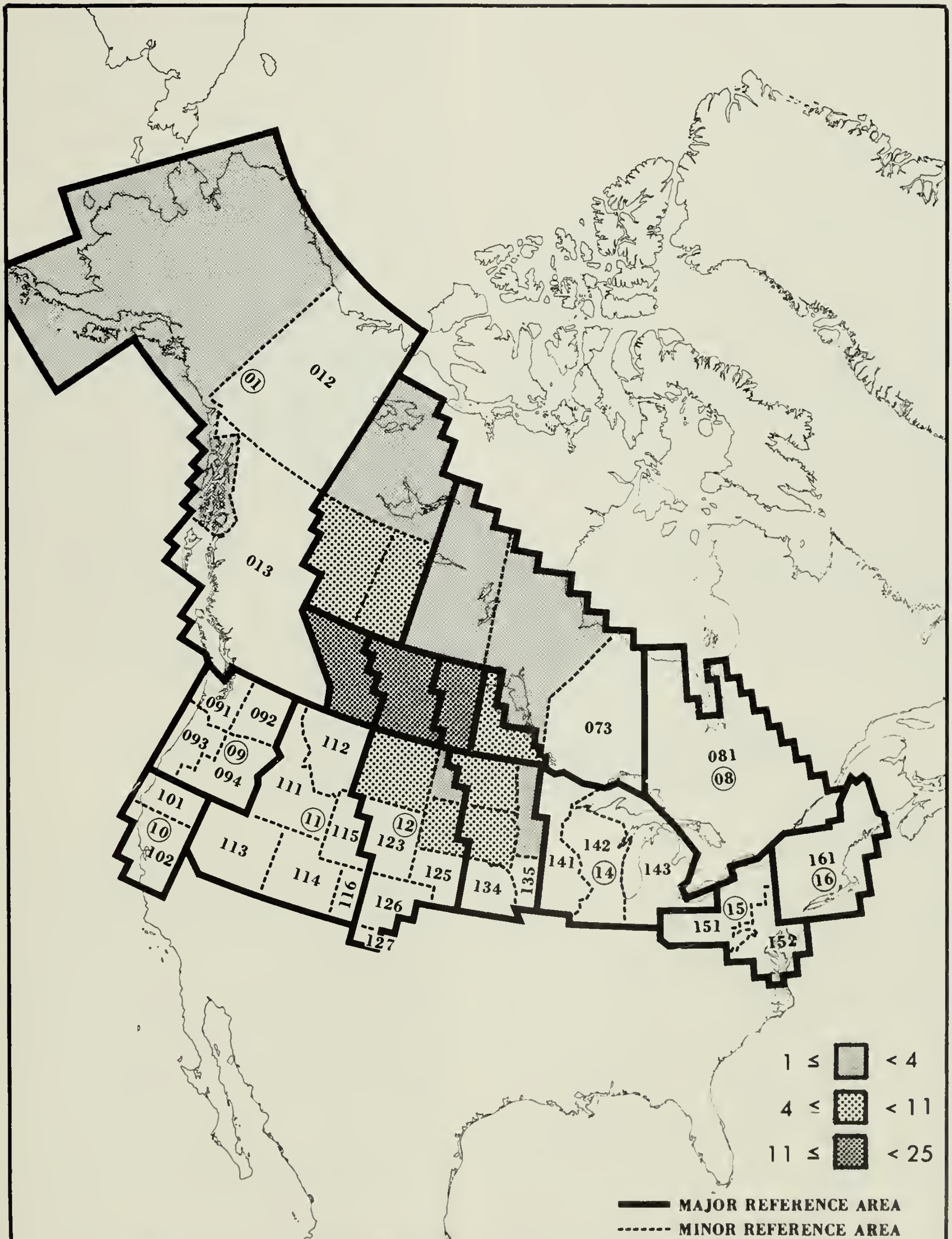


FIG. 18.—Average density of mallards per square mile in surveyed areas, 1955–73.

the long-term studies by Stoudt (1971) and Smith (1971) yield some information. Stoudt indicated that during 1952–65, mallards averaged 42.2% of the breeding population of ducks at Redvers, Saskatchewan. For a similar period (1953–65), Smith reported 28.5% mallards among breeding ducks at Lousana, Alberta. Duzbin (1969a) reported mallards averaging 42.8% of the breeding duck population at Kindersley, Saskatchewan, from 1956 to 1959; and 33.1% at Roseneath, Manitoba, from 1952 to 1955. Kiel et al. (1972) estimated that 27% of the waterfowl breeding population on the Minnedosa District in Manitoba were mallards.

The long-term average obtained from the May aerial survey indicates that mallards represent about 28% of the breeding duck populations in all surveyed areas except those in the far north (Alaska, the Yukon, and the Northwest Territories, Table 11). Thus, with this exception, the distribution of mallards (Fig. 18) tends to parallel the distribution of total breeding ducks (Fig. 19). Annual fluctuations do occur in the species composition within given areas, but these changes will not be discussed here.

### Numbers of Breeding Ducks per Pond

The number of breeding mallards and the number of total breeding ducks (all species) per May pond for the four reference areas in the *Prairie-Parkland Area* is illustrated in Fig. 20. These data suggest substantial variation in occupancy of ponds by breeding ducks, particularly mallards. Pond occupancy rates were highest during the late 1950's when duck numbers were high and pond numbers were rapidly declining. The average number of birds per pond in the *Prairie-Parkland Area* was highest in the west and lowest in the east, toward *Southwestern Manitoba*.

The influence of bird occupancy rates on production or production rates will be discussed in a later section of this report. It should be recognized, however, that the occupancy rates presented here relate to all ponds available and not to ponds actually used. The total number of birds in an area was merely divided by the total number of ponds in that area. This may conceal essentially important points, because the variable of interest may be the number of birds per occupied pond (i.e., some ponds which are unoccupied may not be important to breeding waterfowl).

## Relationships Between Mallard Breeding Populations, Habitat, and Indices to Production

### Production Statistics

The July Production Survey was designed to measure mid-summer habitat conditions and waterfowl production prospects. An accurate measure of production is not possible in July because renesting, incubation, and brood-rearing are all in progress and cannot be measured directly. Estimates of brood indices, brood sizes, late nesting indices, and the number of July ponds result from the July Production Survey. Crissey (1969) estimated that an average of 57% of the mallards and 47% of the total game ducks in North America nested in the *Prairie-Parkland Area* of Canada during 1955–64; thus, the data from this area will be emphasized. Data collected in several other reference areas are presented in Appendix B.

Aerial observations allow only fairly crude estimates of brood sizes, the number of broods, the index to late nesting and production, and the number of July ponds (see Evans et al. 1952; Blankenship et al. 1953; Diem and Lu 1960; Dzubin and Gollop 1972). Changes in visibility, survey crews, and habitat conditions make completely accurate and precise estimates impossible. Ecological succession and human activities create long-term changes in habitat that can result in differing visibility (Fig. 21). The following sections present the best estimates available from the July Production Survey. The importance of many of these factors will be better understood when estimates of mallard production are presented in a future report in this series.

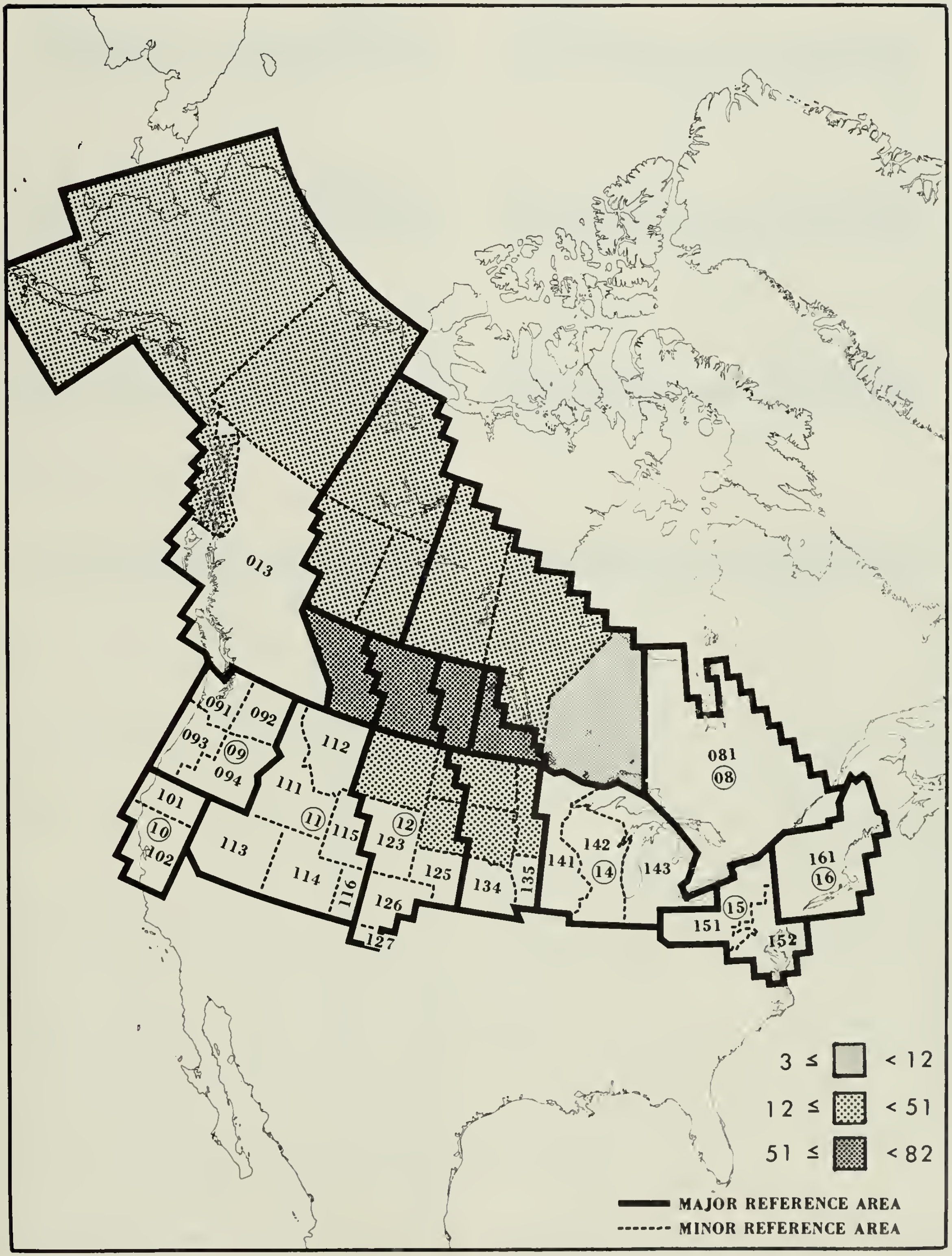


FIG. 19.—Average density of total breeding ducks per square mile in surveyed areas, 1955–73.


FIG. 20.—Pond occupancy (birds per pond) of total breeding ducks (left) and mallards (right) in the *Prairie-Parkland Area*, 1955–73.

*Average brood size.*—The size of class II and III duck broods (for classification see Gollop and Marshall 1954) has been recorded as part of the July Production Survey in the *Prairie-Parkland Area* of Canada since 1955 Species identification of duck broods from aircraft has not been possible; therefore, duck broods represent all species. However, the mallard is the most abundant duck, and mallard broods make up a significant but not necessarily constant proportion of the total number of broods.

The average size of broods in the western breeding areas tends to be larger than that of broods in the eastern breeding areas (Table 12 and 13). Data in Table 12 also indicate a lower rate of loss between class II and III broods in the west, even though most brood mortality probably takes place at the class I stage (Keith 1961; and summary by Dzubin and Gollop 1972). Differences in average brood size from west to east are apparently not a result of the species composition from west to east. Henny et al. (1972:4) show that the species composition of birds in the *Prairie-Parkland Area* are fairly similar for the major species. It seems unlikely that these differences in species composition would result in the observed differences in average brood size.

The annual variation in brood size within reference areas was small. The average size of class III broods was less variable than that of class II broods during 1955–73. The average brood size for both class II and III broods (Table 12) is smaller than that reported by Stoudt (1971) from an intensive study area near Redvers, Saskatchewan. Class II and III brood sizes in the western breeding areas (Reference Areas 03 and 04) and the eastern breeding areas (Reference Areas 05 and 06) were significantly correlated ($r = 0.90^{**}$ and $0.47^{*}$, respectively, 17 df). These correlations may be partially due to the correlation between the number of July ponds and brood size

TABLE 12. *Average brood size of class II and III broods in the* Prairie-Parkland Area, *1955–73*

| Year | *Southwestern Alberta* (03) | | *Southwestern Saskatchewan* (04) | | *Southeastern Saskatchewan* (05) | | *Southwestern Manitoba* (06) | |
|---|---|---|---|---|---|---|---|---|
| | Class II | Class III | Class II | Class III | Class II | Class III | Class II | Class III |
| 1955 | 6.25 | 5.75 | 6.62 | 5.88 | 6.87 | 6.30 | 7.91 | 5.29 |
| 1956 | 6.26 | 5.77 | 6.28 | 5.91 | 6.22 | 5.53 | 5.65 | 4.61 |
| 1957 | 6.38 | 6.16 | 6.53 | 6.19 | 6.25 | 4.81 | 6.12 | 4.83 |
| 1958 | 6.41 | 5.98 | 5.74 | 5.32 | 4.52 | 4.70 | 6.96 | 6.46 |
| 1959 | 4.01 | 5.62 | 3.70 | 4.81 | 4.86 | 5.10 | 5.44 | 6.25 |
| 5-year mean | 5.46 | 5.87 | 5.77 | 5.62 | 5.74 | 5.29 | 6.42 | 5.49 |
| 1960 | 6.00 | 6.02 | 6.00 | 5.18 | 5.10 | 4.10 | 5.45 | 5.62 |
| 1961 | 5.64 | 5.76 | 5.60 | 5.35 | 5.25 | 4.95 | 5.70 | 5.45 |
| 1962 | 5.84 | 5.25 | 5.82 | 5.11 | 3.88 | 3.97 | 5.10 | 5.01 |
| 1963 | 6.11 | 5.88 | 6.05 | 5.80 | 6.27 | 4.93 | 5.92 | 4.82 |
| 1964 | 6.00 | 5.43 | 6.03 | 5.58 | 5.58 | 6.46 | 5.38 | 4.84 |
| 5-year mean | 5.92 | 5.67 | 5.90 | 5.40 | 5.22 | 4.88 | 5.51 | 5.15 |
| 1965 | 6.34 | 5.87 | 6.35 | 5.81 | 6.12 | 5.23 | 5.51 | 5.59 |
| 1966 | 6.99 | 6.11 | 6.57 | 5.82 | 6.02 | 5.05 | 5.61 | 4.55 |
| 1967 | 6.30 | 5.32 | 5.74 | 5.13 | 5.61 | 5.65 | 5.73 | 5.35 |
| 1968 | 5.10 | 4.83 | 5.26 | 4.73 | 6.10 | 4.67 | 5.77 | 4.75 |
| 1969 | 6.08 | 6.13 | 6.07 | 5.48 | 5.87 | 5.64 | 6.11 | 4.62 |
| 5-year mean | 6.16 | 5.65 | 6.00 | 5.39 | 5.94 | 5.25 | 5.75 | 4.97 |
| 1970 | 5.90 | 5.22 | 5.50 | 5.10 | 6.04 | 5.00 | 5.80 | 5.31 |
| 1971 | 6.11 | 5.23 | 5.93 | 5.00 | 5.85 | 4.70 | 5.41 | 5.15 |
| 1972 | 5.06 | 4.82 | 5.52 | 4.82 | 5.26 | 5.08 | 5.20 | 5.95 |
| 1973 | 5.14 | 4.55 | 4.81 | 4.59 | 5.09 | 5.32 | 5.42 | 5.73 |
| 4-year mean | 5.55 | 4.96 | 5.44 | 4.88 | 5.56 | 5.03 | 5.46 | 5.54 |
| 19-year mean | 5.89 | 5.56 | 5.80 | 5.35 | 5.62 | 5.12 | 5.80 | 5.27 |
| 19-year mean loss between II and III | 0.33 | | 0.45 | | 0.50 | | 0.53 | |
| Coefficient of variance (x 100) | 11.3 | 8.7 | 11.8 | 8.7 | 12.8 | 12.2 | 11.3 | 10.6 |

TABLE 13. *Average brood size of class II and III broods (combined) in the* Prairie-Parkland Area, *1955–73*

| Year | *Southwestern Alberta* (03) | *Southwestern Saskatchewan* (04) | *Southeastern Saskatchewan* (05) | *Southwestern Manitoba* (06) | Weighted mean [1] |
|---|---|---|---|---|---|
| 1955 | 5.96 | 6.27 | 6.70 | 6.32 | 6.31 |
| 1956 | 6.03 | 6.09 | 5.92 | 5.18 | 5.89 |
| 1957 | 6.26 | 6.32 | 5.57 | 5.62 | 6.01 |
| 1958 | 6.21 | 5.53 | 4.62 | 6.68 | 5.65 |
| 1959 | 4.49 | 3.90 | 4.86 | 5.50 | 4.52 |
| 5-year mean | 5.79 | 5.62 | 5.53 | 5.86 | 5.68 |
| 1960 | 5.99 | 5.67 | 4.68 | 5.52 | 5.48 |
| 1961 | 5.70 | 5.44 | 4.96 | 5.59 | 5.41 |
| 1962 | 5.51 | 5.49 | 3.91 | 5.09 | 5.06 |
| 1963 | 5.99 | 5.94 | 5.64 | 5.33 | 5.78 |
| 1964 | 5.85 | 5.92 | 5.79 | 5.28 | 5.77 |
| 5-year mean | 5.81 | 5.69 | 5.00 | 5.36 | 5.50 |
| 1965 | 6.11 | 6.12 | 5.89 | 5.51 | 5.96 |
| 1966 | 6.60 | 6.26 | 5.66 | 5.37 | 6.04 |
| 1967 | 5.94 | 5.53 | 5.53 | 5.59 | 5.63 |
| 1968 | 5.02 | 5.10 | 5.61 | 5.43 | 5.26 |
| 1969 | 6.10 | 5.87 | 5.72 | 5.91 | 5.89 |
| 5-year mean | 5.95 | 5.78 | 5.68 | 5.56 | 5.76 |
| 1970 | 5.51 | 5.31 | 5.67 | 5.70 | 5.50 |
| 1971 | 5.72 | 5.41 | 5.27 | 5.24 | 5.41 |
| 1972 | 4.97 | 5.15 | 5.26 | 5.27 | 5.16 |
| 1973 | 5.03 | 4.73 | 5.16 | 5.42 | 5.01 |
| 4-year mean | 5.31 | 5.15 | 5.34 | 5.41 | 5.27 |
| 19-year mean | 5.74 | 5.58 | 5.39 | 5.56 | 5.57 |
| Coefficient of variance (x 100) | 9.3 | 10.7 | 11.3 | 7.0 | 7.8 |

[1] Based on the size of each area.

($r=0.44^{**}$, 49 df) in the *Prairie-Parkland Area* (Henny et al. 1972). Stoudt (1971) noted that brood mortality generally increased in drought years and decreased in wet years. In our study, data on brood mortality from class II to class III was not correlated with the number of July ponds (correlation coefficients less than 0.10).

*Brood indices.* — It is important to recognize the variety of methodological problems inherent in aerial surveys of the number of duck broods.

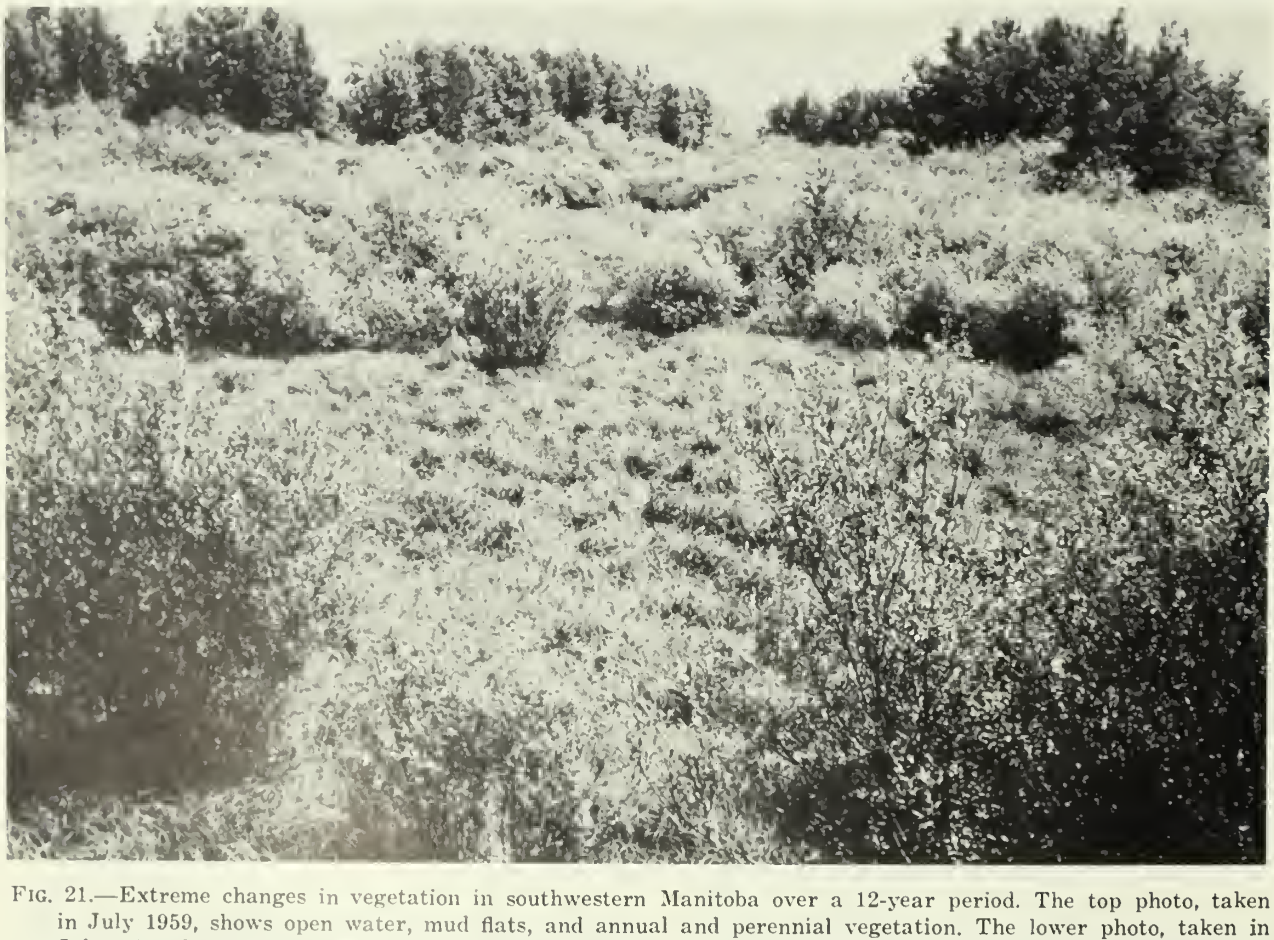

FIG. 21.—Extreme changes in vegetation in southwestern Manitoba over a 12-year period. The top photo, taken in July 1959, shows open water, mud flats, and annual and perennial vegetation. The lower photo, taken in July 1971, shows the encroachment of woody vegetation and dense ground cover. (Photo by Arthur S. Hawkins, Bureau of Sport Fisheries and Wildlife.)

Realizing these limitations, we have attempted to summarize the large amount of basic data collected since 1955. Final synthesis of the data will be presented in a later report when estimates of mallard production are examined. Brood indices (uncorrected for visibility) for the four reference areas in the *Prairie-Parkland Area* of Canada are presented in Table 14 for 1955–73. The annual numbers of broods recorded have been highly variable, as reflected by the large coefficients of variation (40.3 to 79.6%). Brood indices have been most variable in the center of the prairie area, particularly Reference Area 05. These indices are difficult to interpret because visibility rates may have varied from year to year. More importantly, for no apparent reason, the production of class I broods observed has increased in several areas in recent years. The final column in Table 14 presents a series of data (from Henny et al. 1972) that have been adjusted for the varying proportions of class I, II, and III broods. It is not possible at this time to determine whether the adjusted or unadjusted brood index is more appropriate. The adjustments were based on ground:air comparison data from the July Production Survey, 1961–64. The visibility rate for class I broods was markedly lower than those for class II and III broods (8, 47, and 80%, respectively). Since the proportion of class I broods has become larger in recent years, the adjustment makes a large difference.

The number of duck broods per 100 July ponds (Table 15) suggests a striking decrease in brood production from west to east in the *Prairie-Parkland Area*. The number of duck broods per 100 square miles also indicates the same decrease in observed brood production from west to east (Table 16). The magnitude of the difference in observed brood production in the four reference areas is illustrated in Fig. 22. The differences are primarily related to the density of breeding birds in each area (Fig. 20) and may be at least partially caused by (1) better visibility of broods in the west and (2) earlier nesting chronology in the west. Earlier nesting chronology in the west is suggested from comparison of the percentage of class III broods during 1955–62 as follows: Alberta 42.5%, Saskatchewan 31.1%, and Manitoba 18.8% (Henny et al. 1972). The size of the brood index in an area is correlated with the index in adjacent areas (correlation coefficients between Reference Areas 03 and 04, 04 and 05, and 05 and 06 were 0.90**, 0.81**, and 0.47*, 17 df, respectively).

TABLE 14. *Brood indices (all species) of class II and III broods, 1955–73 (in thousands)*

| Year | *Southwestern Alberta* (03) | *Southwestern Saskatchewan* (04) | *Southeastern Saskatchewan* (05) | *Southwestern Manitoba* (06) | Total | Adjusted total![1] |
|---|---|---|---|---|---|---|
| 1955 | 206.2 | 185.8 | 163.4 | 30.5 | 585.9 | 2,311.5 |
| 1956 | 175.0 | 258.7 | 218.7 | 32.1 | 684.5 | 3,181.4 |
| 1957 | 226.0 | 382.8 | 165.3 | 67.0 | 841.1 | 3,314.7 |
| 1958 | 235.5 | 255.1 | 179.3 | 72.3 | 742.0 | 3,163.1 |
| 1959 | 140.4 | 137.4 | 64.0 | 38.5 | 380.3 | 1,717.3 |
| 5-year mean | 196.6 | 244.0 | 158.1 | 48.1 | 646.8 | 2,737.6 |
| 1960 | 122.1 | 116.2 | 75.0 | 36.6 | 349.9 | 1,559.9 |
| 1961 | 126.3 | 146.8 | 24.7 | 37.4 | 335.2 | 1,342.4 |
| 1962 | 82.2 | 71.8 | 18.2 | 17.5 | 189.7 | 736.4 |
| 1963 | 128.2 | 109.6 | 20.3 | 34.2 | 292.3 | 1,073.4 |
| 1964 | 113.0 | 120.5 | 37.3 | 31.9 | 302.7 | 1,181.1 |
| 5-year mean | 114.4 | 113.0 | 35.1 | 31.5 | 294.0 | 1,178.6 |
| 1965 | 72.0 | 66.3 | 20.3 | 21.4 | 180.0 | 887.7 |
| 1966 | 109.4 | 129.0 | 39.7 | 36.5 | 314.6 | 1,622.1 |
| 1967 | 112.4 | 110.1 | 53.5 | 42.0 | 318.0 | 1,803.9 |
| 1968 | 59.8 | 94.0 | 36.8 | 24.9 | 216.3 | 1,085.8 |
| 1969 | 106.5 | 191.8 | 63.9 | 36.9 | 399.1 | 1,835.6 |
| 5-year mean | 92.0 | 118.2 | 42.8 | 32.3 | 285.6 | 1,447.0 |
| 1970 | 65.8 | 121.4 | 54.5 | 31.2 | 272.9 | 1,239.2 |
| 1971 | 72.3 | 161.6 | 61.7 | 24.2 | 319.8 | 1,422.3 |
| 1972 | 69.8 | 151.5 | 68.5 | 33.9 | 232.7 | ------ |
| 1973 | 47.4 | 90.4 | 35.0 | 16.6 | 189.4 | ------ |
| 4-year mean | 63.8 | 131.2 | 54.9 | 26.5 | 276.5 | 1,330.7 |
| 19-year mean | 119.5 | 152.7 | 72.6 | 35.0 | 380.9 | 1,734.0 |
| Coefficient of variance (x 100) | 46.8 | 50.4 | 79.6 | 40.3 | 50.3 | 46.5 |

[1] Taken from Henny et al., 1972 (includes class I broods).

*Late nesting indices.*—The late nesting index represents a measure of late production caused by a generally late nesting season or a significant renesting effort, and has been recorded with fair comparability since 1955. The late nesting index for mallards varies markedly from year to year (Table 17). There appears to be a general correlation in late nesting indices between adjacent areas (correlation coefficients between Reference Areas 03 and 04, 04 and 05,

TABLE 15. *The number of duck broods per 100 July ponds, 1955–73*

| Year | *Southwestern Alberta* (03) | *Southwestern Saskatchewan* (04) | *Southeastern Saskatchewan* (05) | *Southwestern Manitoba* (06) | Weighted mean [1] | Adjusted total [2] |
|---|---|---|---|---|---|---|
| 1955 | 48.4 | 20.8 | 10.3 | 4.7 | 21.4 | 70.7 |
| 1956 | 40.0 | 40.0 | 26.1 | 7.6 | 31.3 | 146.0 |
| 1957 | 77.7 | 97.1 | 31.8 | 26.6 | 65.9 | 244.0 |
| 1958 | 75.4 | 76.8 | 62.8 | 14.1 | 62.7 | 235.2 |
| 1959 | 61.3 | 46.2 | 17.8 | 9.6 | 36.6 | 143.7 |
| 5-year mean | 60.6 | 56.2 | 29.8 | 12.5 | 43.6 | 167.9 |
| 1960 | 46.9 | 30.9 | 16.0 | 9.7 | 27.2 | 113.2 |
| 1961 | 82.1 | 73.0 | 23.5 | 29.1 | 55.9 | 243.8 |
| 1962 | 36.4 | 27.3 | 10.3 | 7.7 | 21.9 | 88.5 |
| 1963 | 27.2 | 16.4 | 4.9 | 10.5 | 15.0 | 60.6 |
| 1964 | 44.1 | 44.5 | 9.2 | 7.1 | 29.9 | 92.1 |
| 5-year mean | 47.3 | 38.4 | 12.8 | 12.8 | 30.0 | 119.6 |
| 1965 | 12.0 | 8.1 | 4.1 | 5.6 | 7.6 | 41.0 |
| 1966 | 31.6 | 19.9 | 5.7 | 8.9 | 17.2 | 83.1 |
| 1967 | 26.4 | 21.0 | 15.8 | 15.2 | 19.9 | 121.9 |
| 1968 | 27.0 | 33.8 | 18.9 | 15.7 | 25.8 | 135.2 |
| 1969 | 45.3 | 28.4 | 13.2 | 10.4 | 25.4 | 112.4 |
| 5-year mean | 28.5 | 22.2 | 11.5 | 11.2 | 19.2 | 98.7 |
| 1970 | 22.2 | 10.7 | 5.8 | 7.4 | 12.0 | 47.7 |
| 1971 | 22.0 | 21.3 | 9.8 | 5.9 | 17.0 | 71.6 |
| 1972 | 35.9 | 34.6 | 14.6 | 11.8 | 26.4 | --- |
| 1973 | 13.8 | 15.4 | 5.0 | 7.3 | 11.3 | --- |
| 4-year mean | 23.5 | 20.5 | 8.8 | 8.1 | 16.7 | 59.7 |
| 19-year mean | 40.8 | 35.1 | 16.1 | 11.3 | 27.9 | 120.6 |
| Coefficient of variance (x 100) | 50.9 | 68.1 | 85.0 | 58.5 | 59.9 | 54.2 |

[1] Based on the size of each area.
[2] Adjusted for the visibility rate and proportion of Class I, II and III broods.

TABLE 16. *The number of duck broods per 100 square miles, 1955–73 (in thousands)*

| Year | *Southwestern Alberta* (03) | *Southwestern Saskatchewan* (04) | *Southeastern Saskatchewan* (05) | *Southwestern Manitoba* (06) | Weighted mean [1] | Adjusted total [2] |
|---|---|---|---|---|---|---|
| 1955 | 436.6 | 212.3 | 309.0 | 80.8 | 260.0 | 1,025.8 |
| 1956 | 370.5 | 295.6 | 413.6 | 85.1 | 303.8 | 1,411.9 |
| 1957 | 478.5 | 437.4 | 312.6 | 177.5 | 373.2 | 1,471.0 |
| 1958 | 498.6 | 291.5 | 339.1 | 191.7 | 329.4 | 1,403.8 |
| 1959 | 297.3 | 157.0 | 121.0 | 102.1 | 168.8 | 762.1 |
| 5-year mean | 416.3 | 278.8 | 299.1 | 127.4 | 287.0 | 1,214.9 |
| 1960 | 258.5 | 132.8 | 141.8 | 97.1 | 155.3 | 692.3 |
| 1961 | 267.4 | 167.7 | 46.7 | 99.2 | 148.7 | 595.7 |
| 1962 | 174.0 | 82.0 | 34.4 | 46.4 | 84.2 | 326.8 |
| 1963 | 271.4 | 125.2 | 38.4 | 90.7 | 129.7 | 476.4 |
| 1964 | 239.3 | 137.7 | 70.5 | 84.6 | 134.3 | 524.2 |
| 5-year mean | 242.1 | 129.1 | 66.4 | 83.6 | 130.4 | 523.1 |
| 1965 | 152.4 | 75.8 | 38.4 | 56.7 | 79.9 | 394.0 |
| 1966 | 231.6 | 147.4 | 75.1 | 96.8 | 139.6 | 719.9 |
| 1967 | 238.0 | 125.8 | 101.2 | 111.4 | 141.1 | 800.6 |
| 1968 | 126.6 | 107.4 | 69.6 | 66.0 | 95.6 | 481.9 |
| 1969 | 225.5 | 219.2 | 120.9 | 97.9 | 177.2 | 814.6 |
| 5-year mean | 194.8 | 135.1 | 81.0 | 85.8 | 126.7 | 642.2 |
| 1970 | 139.3 | 138.7 | 103.1 | 82.7 | 121.1 | 549.9 |
| 1971 | 153.1 | 184.7 | 116.7 | 64.2 | 142.0 | 631.1 |
| 1972 | 147.8 | 173.1 | 129.6 | 89.9 | 143.7 | ---- |
| 1973 | 100.4 | 103.3 | 66.2 | 44.0 | 84.1 | ---- |
| 4-year mean | 135.2 | 150.0 | 103.9 | 70.2 | 122.7 | 590.5 |
| 19-year mean | 253.0 | 174.5 | 139.4 | 92.9 | 169.0 | 769.5 |
| Coefficient of variance (x 100) | 46.8 | 50.4 | 82.3 | 40.3 | 50.3 | 46.5 |

[1] Based on the size of each area.
[2] Adjusted for the visibility rate and proportion of class I, II and III broods.

and 05 and 06 are 0.29, 0.85**, and 0.62**, respectively, 17 df).

A significant relationship was found between the late nesting index and the number of July ponds each year in the *Prairie-Parkland Area* ($r$ = 0.81**, df = 17). Late nesting or renesting efforts seem strongest during years when mid-summer water conditions are good. Henny et al. (1972) found a correlation between the late nesting index, the size of the breeding population, and the number of July ponds ($r$ = 0.71**). For proper interpretation of these findings one should recognize that the late nesting index is only a very crude index to late nesting and renesting effort. In addition, it is unlikely that the late nesting index can be equated with the number of "potential late broods" in a given year.

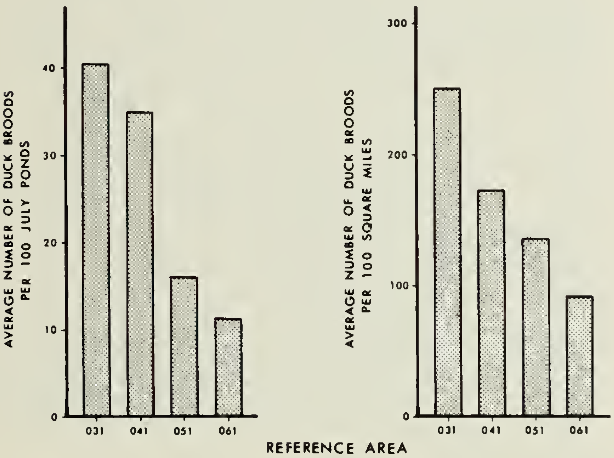


FIG. 22.—Average numbers of duck broods per 100 July ponds and 100 square miles in the *Prairie-Parkland Area* during 1955–73.

## General Patterns in Reproductive Performance

The material presented here focuses on data collected during the May Breeding Population Survey and the July Production Survey. This approach was necessary because revised production estimates, derived from age ratios in the harvest and adjusted for differential vulnerability due to hunting pressure, are not yet available and will be presented in a future report. In addition, the examination of production indices from the July Production Survey is important in its own right.

Unfortunately, the species of broods sampled during the July survey are not identified; therefore, most of our analysis of production statistics relate to all species of ducks combined. We recognize the problems associated with this

TABLE 17. *Mallard late nesting indices, 1955–73 (in thousands)*

| Year | *Southwestern Alberta* [1] (03) | *Southwestern Saskatchewan* (04) | *Southeastern Saskatchewan* (05) | *Southwestern Manitoba* (06) | Total |
|---|---|---|---|---|---|
| 1955 | 6.7 | 112.5 | 77.7 | 25.8 | 222.7 |
| 1956 | 3.6 | 37.6 | 46.9 | 22.7 | 110.8 |
| 1957 | 3.1 | 15.9 | 34.4 | 15.8 | 69.2 |
| 1958 | 4.2 | 43.7 | 53.2 | 12.3 | 113.4 |
| 1959 | 6.2 | 25.7 | 24.6 | 20.6 | 77.1 |
| 5-year mean | 4.8 | 47.1 | 47.4 | 19.4 | 118.6 |
| 1960 | 2.4 | 43.6 | 36.4 | 22.1 | 104.5 |
| 1961 | 0.6 | 12.2 | 12.3 | 11.4 | 36.5 |
| 1962 | 1.2 | 6.2 | 11.3 | 13.8 | 32.5 |
| 1963 | 1.3 | 18.3 | 8.2 | 12.9 | 40.7 |
| 1964 | 3.0 | 16.4 | 10.0 | 11.5 | 40.9 |
| 5-year mean | 1.7 | 19.3 | 15.6 | 14.3 | 51.0 |
| 1965 | 9.0 | 37.3 | 14.3 | 16.0 | 76.6 |
| 1966 | 11.1 | 28.9 | 21.5 | 8.9 | 70.4 |
| 1967 | 11.1 | 21.6 | 10.8 | 11.0 | 54.5 |
| 1968 | 11.0 | 18.3 | 10.7 | 5.7 | 45.7 |
| 1969 | 6.4 | 29.9 | 22.6 | 18.0 | 76.9 |
| 5-year mean | 9.7 | 27.2 | 16.0 | 11.9 | 64.8 |
| 1970 | 10.1 | 69.8 | 52.4 | 14.7 | 147.0 |
| 1971 | 14.4 | 46.0 | 24.9 | 17.9 | 103.2 |
| 1972 | 11.3 | 34.6 | 18.0 | 15.1 | 79.0 |
| 1973 | 12.2 | 40.6 | 38.4 | 14.4 | 105.6 |
| 4-year mean | 12.0 | 47.8 | 33.4 | 15.5 | 108.7 |
| 19-year mean | 6.8 | 34.7 | 27.8 | 15.3 | 84.6 |
| Coefficient of variance (x 100) | 64.3 | 69.5 | 68.3 | 32.8 | 54.0 |

[1] Major crew changes have occurred since 1964 and probably account for the large late nesting indices in recent year.

approach (see Dzubin 1969b), but it is the only one available at present. Fortunately, the size of the mallard breeding population (1961–73) is significantly related to the size of the total duck breeding population in North America, excluding mallards ($r = 0.86^{**}$, df = 11). Also, mallards are the most abundant breeding duck in North America, composing an average of aproximately 23% of the total duck breeding population in surveyed areas. The late nesting index of mallards is significantly correlated with the late nesting index for other ducks ($r = 0.76^{**}$, df = 17) in the *Prairie-Parkland Area*. In addition, an average of 32% of the late nesting index is composed of mallards. In view of these relationships, it appears acceptable to substitute information for all ducks when specific information on the mallard is lacking. It is important to recognize this assumption and interpret the results in this section accordingly.

Much of the analysis presented below relates to the *Prairie-Parkland Area* of Canada where our best information—both in quantity and quality—was collected. Also, aerial data are complemented by several field studies in the southern portions of Alberta, Saskatchewan, and Manitoba. Information on population size, habitat conditions, and production has been collected on a comparable basis in this area since 1955. To a degree, the data collected during the 19 years are confounded. The early years (1955–58) were characterized by good habitat, large breeding populations, and large brood indices. In contrast, the early 1960's (1960–64) were characterized by poor habitat conditions, smaller breeding populations and low brood indices. Because of these correlations, the study of relationships among the variables is difficult. Some of the correlations and trends may not necessarily reflect a cause-effect relationship and this point should be recognized when interpreting the following material. In addition, an analysis of production is complicated by a number of factors including large sampling errors and changes in the proportions of broods present that are seen from aircraft because of annual habitat changes and changes in the aerial crews.

Both quality and quantity of wetland habitat and upland nesting cover are important in influencing the distribution of ducks on the breeding grounds. We lack data on the qualitative aspects of both wetland and upland cover, and information on the quantity of suitable upland nesting cover is not available over a wide geographic area. The following is a discussion of density and distribution of breeding ducks in terms of pond numbers, a measure of wetland quantity.

*Spacing mechanisms and their influence on the geographic distribution of the breeding population.*—Breeding ducks seem to space themselves in relation to the available habitat (e.g., the number, size, and distribution of ponds) in the *Prairie-Parkland Area*. When the limit in a particular year has been reached, the ducks without established territories continue north or northwest into less favorable habitats and do not impair the success of the pairs that have already established territories (for further discussion see Bellrose et al. 1961; Crissey 1969; and Dzubin 1969a). It is not known whether the spacing mechanism, operating through a complex social behavior, is a pair response or a flock response.

Changes in the geographic distribution of mallards on the breeding grounds are presented in the form of a correlation matrix on page 31. Information illustrated in Fig. 17 suggests that annual changes in geographic distribution may be influenced by the number of May ponds. Thus it appears that the number of breeding ducks in the *Prairie-Parkland Area* has been carefully regulated each year.

The number of breeding ducks (and indirectly the proportion) in the *Prairie-Parkland Area* appears to be a function of the size of the continental breeding population, the number of May ponds present, and perhaps other habitat factors. We cannot estimate the relative importance of these two variables, but both must be important in determining the distribution of breeding ducks in a given year.

Dzubin (1969a) has pointed out that spacing mechanisms are particularly important in waterfowl populations. He suggests that displacement resulting from density-dependent intolerance and hostile behavior precludes densities which might have an inhibitive effect on reproductive success when a bounded area is considered. He cites studies by Kluijver and Tinbergen (1953) and Lack (1966) on great tits (*Parus major*) and Jenkins et al. (1963) on red grouse (*Lagopus l. scoticus*) to show examples of density-dependent displacement.

*Relationships between the brood index and population size and density.*—First, we hypothesized that the production rate of waterfowl in the principal breeding area was dependent on the density (birds per square mile) of the breeding population. To test this hypothesis, a production rate index was computed (brood index/ breeding population size). The following equation represents the hypothesis:

$$\text{Production Rate Index} = \frac{\text{Brood Index}}{\text{Breeding Population}} = a + b\left(\frac{\text{Breeding Population}}{\text{Square Miles}}\right)$$

The equation (above) was rearranged by simply multiplying both sides by the size of the breeding population, BP:

$$\text{Brood Index} = a(BP) + b(BP^2)$$

This simplified the equation for analysis. The number of square miles, a constant for a particular area, was dropped without affecting the equation or the density-dependent hypothesis it represents. To consider our hypothesis further the $b$ coefficient should be significant.

Data collected in the four reference areas in the *Prairie-Parkland Area* were used to test the hypothesis. Since the areas were of different size and probably somewhat different in several other respects, each of the four reference areas was analyzed separately. While the size of the breeding population was significant for three of the four areas, the size of the breeding population squared was not ($t$ values were low, in the 0.8 range, 17 df). This suggests that the index to production rate is not a function of the density of breeding birds.

Second, to examine the production rate further, if the brood index was regressed against the size of the breeding population (a density-independent hypothesis if the relationship is linear):

$$\text{Brood Index} = a + b(BP)$$

Simple regression analyses were performed on the data collected in each of the four reference areas. In three of the four areas, the relationship was statistically significant and estimated correlation coefficients were 0.35, 0.52*, 0.66**, and 0.97** for reference areas 03, 04, 05 and 06, respectively. Equivalently, and perhaps easier to understand, we have studied the relationship between brood density and duck density. Essentially, both sides of the equation are divided by the number of square miles in the reference area. These relationships are presented in Fig. 23 with the relevant statistics. Further analyses failed to detect any asymptotic or other nonlinear relationship between the brood index and the size of the breeding population. This suggests that the index to production rate is not inversely related to the density of ducks present in an area. It is important to distinguish between the concept that the brood index depends on density (number of breeders per square mile) but that the index to production rate is not dependent on density.

The regression equations shown in Fig. 23 have significantly different slopes (regression coefficients) indicating that the reference areas considered are somewhat unique regarding the capability to produce young birds at a given breeding population density. Unfortunately, the regression coefficients are not definitive measures of habitat capability for waterfowl production because various habitat types and crew areas (i.e., different ground:air visibility rates) are also involved.

Similar results were obtained from intensive field data presented by Smith (1971) and Stoudt (1971) working in Alberta and Saskatchewan, respectively (Fig. 24). Since the sizes of their study areas were fixed throughout the study period, the relationship of total broods and breeding pairs of waterfowl is analogous to the situation described above. These data, collected in parkland habitat, are not confounded by the problems present in aerial survey data due to annual changes in habitat and survey crews. Similarities in the size of the regression coefficients could represent a measure of reproductive capacity in parkland habitats.

Third, the brood index was postulated to be a function of the size of the breeding population and the number of May or July ponds in the

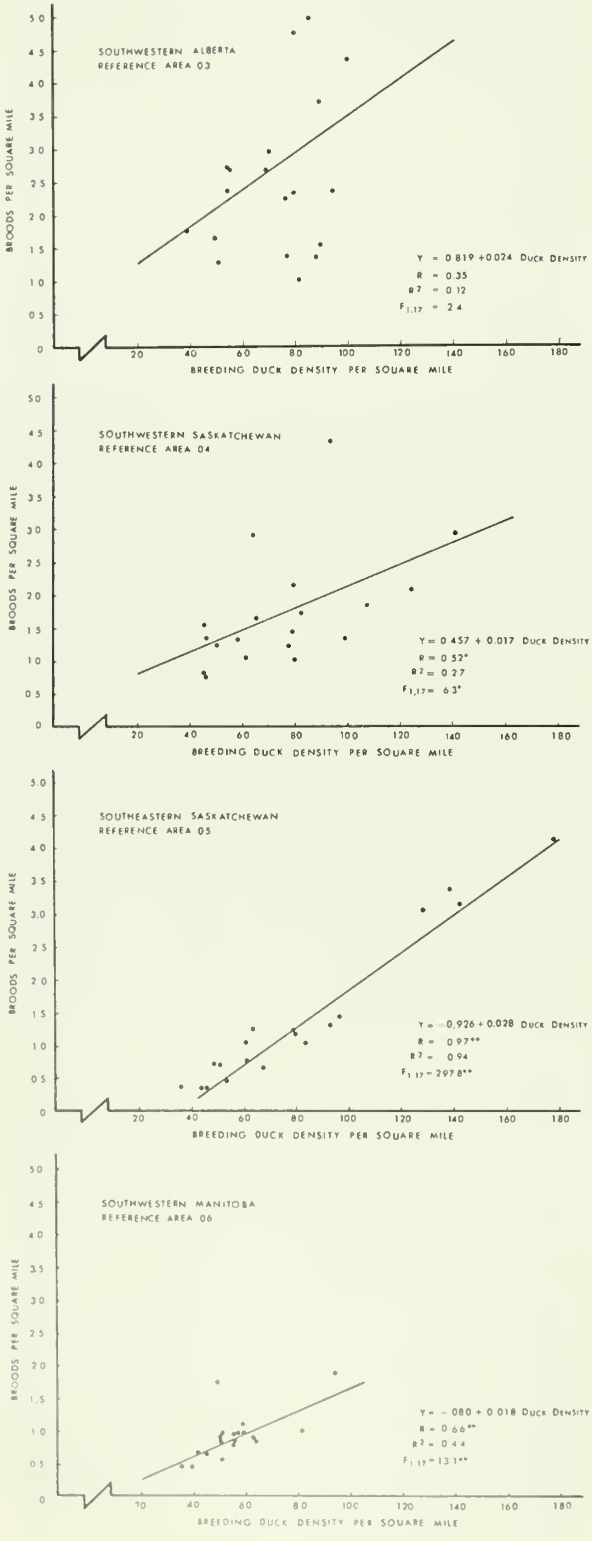


FIG. 23.—The relationship between duck broods and duck density in the four reference areas of the *Prairie-Parkland Area*, 1955–73.

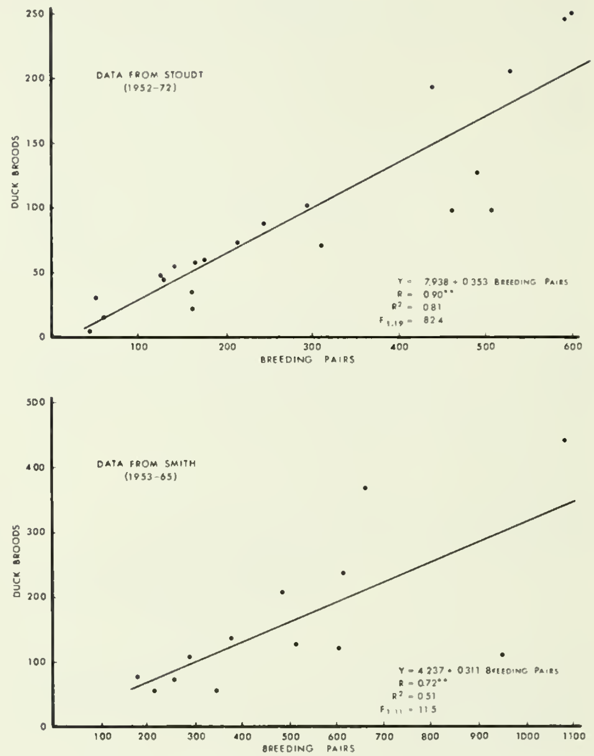


FIG. 24.—The relationship between duck broods and breeding pairs on two ground study areas in southern Alberta and southern Saskatchewan. (Data are from Smith (1971) and Stoudt (1971)). (Stoudt's data have been updated through 1972.)

*Prairie-Parkland Area.* However, neither May nor July ponds could be shown to be significantly related to the brood index ($t = 1.17$ and 1.91 respectively, 17 df). No relationships could be detected between the brood index and the size of the breeding population per pond (either May or July). In addition, the above independent variables were not related to the production rate index (brood index breeding population size). As we acknowledged earlier, other variables, such as the quality and quantity of upland nesting cover, may also be important.

*Relationships between an index to the number of young and population size and density.*—An index to the number of young in a particular areas was computed as the product of the brood index and the average brood size. Using this index we performed a series of analyses and hypothesis tests similar to the approach used in the previous section. Only the primary results are summarized.

The hypothesis that the index to production rate was related to the size of the breeding population could not be supported. The results of regression analyses suggest that the index to the number of young is a positive linear function of the size of the breeding population. Production appears to be a significant function of population size ($t$ values ranged from 1.6 to 17.3, 17 df), but not the rate of production. The rate of production appears to be independent of density in the *Prairie-Parkland Area.*

*Production indices in northern breeding areas.*—We next examined the production rate index in northern Canada, the area supporting many displaced birds from more southern breeding areas, particularly in dry years. Unfortunately, the July Survey was not initiated in northern Alberta until 1969, however, data for 12 years are available from northern Saskatchewan and northern Manitoba. Only data from north Saskatchewan and northern Manitoba are sufficient for analysis here.

Again, as with the data from southern Canada, we tested the hypotheses using regression analysis. The results at each step were similar. A significant linear relationship ($r = 0.74^{**}$, 12 df) was found between the brood index and the number of breeding ducks (Fig. 25). This fails to suggest a density-dependent reproductive rate within the range of breeding

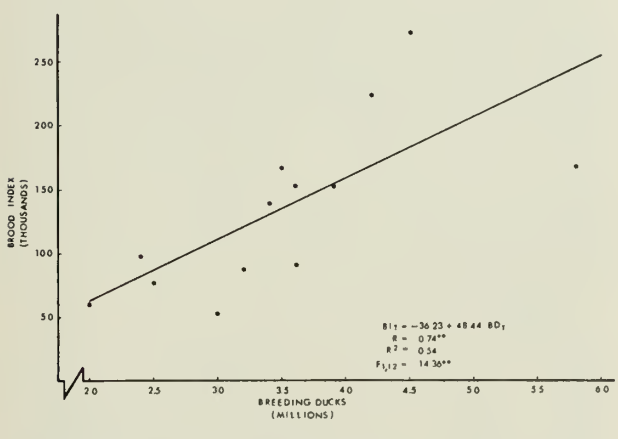


FIG. 25.—The relationship between brood index and breeding population size in the northern portions of Saskatchewan and Manitoba, 1959–60 and 1962–73.

densities reported in northern Canada. At present we have no concrete estimates of production rate of mallards in northern Canada, although they are presumably lower than the production rate in southern Canada. Smith (1970) showed significantly lower age ratios in the harvest of pintails during years when a higher proportion of the pintail population was present in the north.

The apparent absence of density-dependent production rate in breeding mallards in prairie and parkland habitats was discussed by Dzubin and Gollop (1972):

> The role of Mallard spacing behavior and mutual intolerance as a contributory force controlling breeding population density or leading to more efficient resource apportionment is complex. . . . Where a preponderance of ponds are less than 1.5 acres (0.6 ha.) in size; e.g., in parkland, spacing behavior disperses pairs among ponds and may play an important role in determining breeding densities or dispersing some later arriving pairs to other habitats. No definitive data exists which show increased adult deaths or reduced progeny output from pairs so displaced. . . . Considering the compensatory processes of emigration, delayed breeding and high mobility in prairie-pond habitats, we suggest that spacing mechanisms play a minor, but little understood, role in regulating local pair abundance and further influencing continental reproductive output (for other view see Crissey, 1969). Arguments for density regulated reproductive success and proposals that social behavior is the ultimate factor limiting populations remain speculative. . . .

Dzubin (1969a) has provided the most intensive discussion of density regulators in waterfowl. His interpretations are given below:

> 1. Some pairs make long-distance emigrations to new habitats and successfully breed and produce young in these newly colonized areas. Emigration may be selectively advantageous if the move from dense to less dense populated areas confers some added chance of survival on the parents or their young (Lidiker, 1962). Emigration may not only be triggered by density effects but by density-independent factors, e.g., climate and its effect on pond availability and pond quality. (Density control through emigration.) (Crissey, 1957, 1969).
>
> 2. Some pairs remain in the densely populated locality and do not attempt to breed or nest only once, and are not predisposed to

renest. (Density control through nonbreeding or low renesting rates.) (Smith, 1959).

3. Some pairs are forced into or choose to use suboptimal portions of the habitat and fail to produce any young. Grassland and parkland pairs may be forced into the forested areas where production in these displaced pairs is much reduced (Hansen and McKnight, 1964). (Density control through emigration and no recruitment of young.)

4. Some pairs adapt to increasing density by reducing tolerance distance and are able to nest successfully. Yet with increasing densities birth rates are reduced indirectly through self-regulatory mechanisms associated with long distance, over-dispersion of nests from water, and high loss of young. (Density control through low recruitment of young.) (Kindersley area, 1957).

5. Parental stress may increase and affect later survival of young, i.e., survival of broods is predetermined by the physiological and psychological condition of the parents. Direct contact between pairs is not necessary as even visual stimuli may somehow affect parent birds. (Jenkins, 1961, 1963, on gray partridge.) (Density control through increased brood mortality.)

6. Mortality of broods reared in overcrowded ponds increases and reduces over-all recruitment rate. Constant brood mixing leads to more orphaned young. (Density control through lower recruitment of young.) (Kindersley area; see also Beard, 1964.)

7. Mortality of adults may increase associated with density-dependent effects on physiology of birds and with continued interference of birds attempting to utilize food, loafing spots, or nesting cover resources which are in short supply. Pairs may channel more time and energy toward pair encounters or fleeing than to breeding purposes. Also, in dense wild populations, rape of incubating and brood hens by gangs of drakes leads to added hen mortality, especially in pintails, more rarely in mallards. Broods may be dispersed by frequent molestation of hens. (Density control through increased mortality of adults.)

8. Some pairs may be able to adapt to dense population levels through asynchronous breeding periods staggered through the season so that the habitat is being utilized to its fullest potential. Dense pair populations and associated aggressive coactions may in some way affect ovulation in hens and prevent laying. As the breeding season progresses pair densities and chasing decrease, and ovulation may again occur. (Density control through staggered or protracted breeding seasons.) (McKinney, *in litt.*—shovelers).

9. On dense nesting islands gadwall ducks may show increased desertion rates of clutches or increased incidence of dropped eggs (Hammond and Mann, 1956). The number of infertile eggs and a tendency toward nest parasitism may also increase. However, vastly increased hatching success on islands outweighs any density effects on egg production or number of eggs hatched. Deubbert [sic] (1966) suggests an increase in embryonic mortality associated with increased harassment of hens by males. Similar studies on Canada geese are summarized by Munro (1960) and Collias and Jahn (1959). (Minor density control through increased effects on fertility.)

*Size of broods as a function of population size and density.*—The relationship between average brood size and the density of breeding ducks was examined. Estimates of average brood size are relatively crude and are subject to a large number of uncontrolled factors, including visibility rates, phenology, and the species composition of the broods. Only in *Southwestern Manitoba* did the average number of ducklings per brood increase ($r$ = 0.64**, 17 df) as population density increased. This seems unrealistic and is perhaps confounded by the fact that the early years not only had high breeding population densities but also had excellent habitat conditions. Consequently, duckling survival under such conditions could be expected to be higher. Significant relationships between average brood size and population density could not be established for other reference areas in the *Prairie-Parkland Area* (correlation coefficients ranged from 0.15 to 0.33).

Survival of ducklings from class II to III was not related to the size of the breeding population in any of the four reference areas. The relationship between the number and size of broods vs. population density may be confounded by predation. Intensive field studies suggest that production rates may be lower in drought years at least partially, because of increased predation on nests. Fewer ponds and breeding-nesting sites tend to concentrate birds in drought years and predation can be severe.

Smith (1971:34) summarized predation losses on nests during predrought years (1952-58), drought years (1959-63), and postdrought years (1964-65) in the Alberta parklands. Nest losses to predators (both mammalian and avian) averaged 46% in the predrought years when

May pond numbers averaged 197, 63% during drought years when May pond numbers averaged 120, and 58% during the postdrought period when May pond number (excluding Type I) averaged 156. The importance of predation as a factor affecting production throughout the breeding range of the mallard is unknown, but it is thought to be substantial.

The examination of waterfowl production information based on total ducks, rather than individual species, allows only broad generalizations to be made. Important exceptions may exist, particularly in diving ducks. The use of information on total ducks fails to recognize the variety of interspecific interactions of ducks on the breeding grounds.

During 1955–73, a 19-year period with wide fluctuations in waterfowl population densities (Table 18), it appeared that densities of breeding ducks were not in a range where density measurably limited or inhibited the production rate in the *Prairie-Parkland Area*. Ducks that remain and nest in the *Prairie-Parkland Area* seem to produce broods at a rate independent of density of breeding ducks since the brood index appears to be a positive linear function of the number of breeding birds in the area. We consider these last two sentences primarily a statement of a hypothesis rather than a finding or result. This seems like the best hypothesis at this time, and we will re-examine the subject in a future report when information on production rates from Wing Surveys and banding is available.

Production rates of most ducks breeding in North America appear to be regulated by both density-dependent and density-independent factors. The following summarizes the main points of our hypothesis:

1. Substantial numbers of ducks, particularly dabblers, initially attempt to establish territories in the *Prairie-Parkland Area*. Both the number of breeding ducks and the percentage of the total that remain in the *Prairie-Parkland Area* are largely dependent upon the size of the total population of breeding ducks and the number of May ponds and other wetland and upland habitat characteristics, both quantitative and qualitative, in the *Prairie-Parkland Area*. Ponds during the breeding season provide sites for breeding, loafing, feeding, territorial defense, and other activities.

2. Habitat factors, such as the number of May ponds in the *Prairie-Parkland Area*, have a very substantial influence on duck densities that actually occur in the prime breeding areas. Remaining ducks are dispersed north and northwest into environments less favorable for successful reproduction. The mechanism causing this dispersal may be a complex social behavior that has evolved and is manifested primarily through territoriality and related display. The spacing and social behavior strongly influence not only densities of breeding ducks on the prime breeding areas, but also the distribution of ducks throughout the entire breeding grounds, in both favorable and unfavorable habitats. Thus, the density and distribution of breeding ducks may be regulated through a spacing mechanism that is at least partially dependent on measurable environmental factors. The result is a density-dependent process operating to ultimately affect the production and production rate of breeding ducks on a continent-wide basis. Production, and

TABLE 18. *Summary of average population densities of mallards and total ducks in the* Prairie-Parkland Area, *1955–73*

| | *Southwestern Alberta* (03) | | *Southwestern Saskatchewan* (04) | | *Southeastern Saskatchewan* (05) | | *Southwestern Manitoba* (06) | |
|---|---|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High | Low | High |
| Mallard breeding population per | | | | | | | | |
| Square mile | 11.2 | 28.1 | 10.0 | 36.9 | 10.3 | 61.3 | 5.4 | 22.5 |
| May pond | 0.9 | 3.0 | 0.8 | 3.3 | 0.6 | 3.2 | 0.4 | 1.4 |
| July pond | 0.8 | 7.6 | 1.1 | 10.2 | 1.2 | 18.6 | 0.8 | 4.9 |
| Total duck breeding population per | | | | | | | | |
| Square mile | 37.9 | 99.2 | 45.7 | 140.5 | 35.9 | 177.9 | 36.4 | 93.7 |
| May pond | 3.8 | 11.0 | 3.8 | 10.6 | 2.5 | 11.8 | 1.5 | 6.1 |
| July pond | 3.8 | 21.3 | 5.2 | 30.3 | 4.9 | 30.3 | 3.5 | 16.8 |

therefore the size of the fall population, may be partially regulated by the number of birds that are distributed north and northwest into environments less favorable for successful reproduction. Thus, spacing of the birds on the *Prairie-Parkland Area* and the movement of a fraction of the birds out of the prime breeding areas are key factors in the density-dependent regulation of the total population.

3. Breeding populations remaining in prime breeding habitats (after density-dependent emigration has taken place and ducks without established territories have flown further north) appear to produce young at a rate independent of density. The number of young in these areas appears to be a linear function of the number of breeding ducks in the area. At this point in time, and in these prime breeding areas, the production rate appears to be density-independent. More limited information suggests that production rates in the northern portions of the breeding grounds (northern Saskatchewan and northern Manitoba) are also density-independent. It should be noted that the number of ducks per square mile in these northern habitats is only a small fraction of the densities in the *Prairie-Parkland Area*.

Other significant factors are also affecting the breeding population and the production of young throughout all breeding areas. Some of these factors are:

a) age and sex composition of the breeding population—breeding populations with a high proportion of experienced breeders can be expected to be more successful in reproduction than breeding populations composed mostly of first-year birds. Homing rates for a population segment are also partially dependent upon the age composition of the population.
b) renesting effort—a function of predation rates, other types of nest losses, midsummer habitat conditions (e.g., the number of July ponds), and other factors.
c) weather and other exogenous factors.
d) predation rates.

It is not known whether such factors as timing of migration, arrival times on the breeding grounds, tendency to remain in the *Prairie-Parkland Area* (rather than continuing north), and production success in general are age-specific processes.

## SUMMARY

1. This report is the second in a comprehensive study of the population ecology of the mallard; it is based on data collected as a result of research and management programs during 1955–73. Results of aerial surveys conducted in May and July were the primary source of information on the status of the population and breeding habitat.

2. The primary objectives of this study were to: (a) describe trends and annual changes in breeding habitat conditions for mallards in North America, 1955–73, (b) discuss the breeding habitat of mallards in relation to climatological variables, (c) present annual estimates of the mallard breeding population and distribution throughout the breeding range, (d) describe relationships between the mallard breeding population, habitat, and indices to productivity, and (e) establish weighting factors for mallards in various portions of the breeding range for use in future reports.

3. Programs dealing with the wetlands of North America provide an example of conflict in resource utilization. They have simultaneously promoted wetland drainage and wetland preservation. Subsidized drainage programs began with the Swamp Land Act of 1849 and led to the Agricultural Conservation Program (ACP). The resulting loss of wetlands has been only partially offset by the Federal Aid to Wildlife Restoration Act and the Waterfowl Production Area Program. The net result has been a significant loss of wetland habitat valuable to waterfowl.

4. Drainage of productive waterfowl marshes to create more acreage suitable for wheat in

the Northern Great Plains was a major reason for the decline of the continental waterfowl population. There has been a progressive and irreplaceable loss of waterfowl habitat in the Northern Prairie region of the United States from a combination of causes including agricultural drainage, land leveling and filling, soil washing and siltation, wind erosion, road building and urban occupancy, and pollution. Of these, the first is the most important and probably best understood.

5. In Canada both draining and filling of pothole nesting habitat have probably increased in recent years. In certain Provinces, governmental assistance is provided for draining and clearing land for crop production. The uncertain future of waterfowl breeding grounds in Canada and the United States is considered to be the major problem facing the waterfowl resource.

6. Basic information collected during the May and July surveys (1955–73) concerning the number of water areas was reported and discussed. The number of ponds in May in the *Prairie-Parkland Area* ranged from a high of 7.1 million in 1955 to a low of 1.6 million in 1961 and 1968. July ponds ranged from a high of 3.3 million in 1955 to a low of 0.6 million in 1961. Generally, the number of water areas peaked during the mid-1950's, reached a low in the early 1960's, and returned to an intermediate level in the late 1960's and early 1970's. The number of ponds per square mile in May generally increased from west to east in the *Prairie-Parkland Area;* however, this pattern was not as pronounced in July because, in the east, a higher percentage of May ponds were dry by July. A correlation analysis of pond numbers in the four reference areas in the *Prairie-Parkland Area* indicated that pond numbers among these areas were significantly related.

7. The effects of precipitation on the number of ponds in the *Prairie-Parkland Area* were studied in detail. Pond numbers in a particular year were a function of the number of ponds the previous year and the amount of precipitation during the previous 10 to 12 months. Furthermore, the number of July ponds in a particular year was a function of May ponds that year and the precipitation received during the May 1-July 31 period.

8. Analyses of data from the *Prairie-Parkland Area* suggest that cumulative precipitation over a 10- to 12-month period is important in determining pond numbers. Precipitation in any individual month is only weakly correlated with the number of ponds in a given year.

9. An analysis of 33 years of monthly precipitation data from the *Prairie-Parkland Area* failed to reveal any significant cycles in precipitation. Precipitation appears to be strongly influenced by very substantial seasonal and random components. Recognizing the seasonal component in precipitation, the monthly and annual precipitation data probably represent an independent random series.

10. Although annual precipitation appears to be independent and random and can change from one extreme to another in successive years, the number of ponds will not vary to this degree. Since the number of ponds in a given year is related to the number of ponds the previous year, pond numbers are unlikely to change so drastically as precipitation from one year to the next.

11. Aerial surveys in North America sample an average of 84% of the estimated mallard breeding population. A detailed analysis was made of data collected in 1955–73. In addition, estimates were made of the number of mallards in unsurveyed areas to provide a basis for weighting band recovery information in future reports.

12. The estimated size of the continental mallard population in May has ranged from a high of 14.4 million in 1958 to a low of 7.1 million in 1965. Generally, the mallard population began to decline after the 1958 peak until 1962, and remained below 10 million birds until 1970. The decline and consequent low level of the mallard population between 1959 and 1969 generally coincides with a period of poor habitat conditions on the major breeding grounds.

13. The center of mallard abundance during during the breeding season is the *Prairie-Parkland Area* in south-central Canada; an average of 51.5% of the mallard population breeds

there. This area has the highest density of mallards (20.2) per square mile. Average densities per square mile in other areas were markedly lower: (1) 5.0 mallards in northern Canada (Reference Area 02 and 07), 4.6 in *Northeastern British Columbia—Northwestern Alberta*, and 8.8 in *Northeastern Alberta*. (2) Less than 3.0 mallards were found in survey areas in *Alaska* and the *Yukon-Western Mackenzie* area. (3) Less than 1.0 mallard was found in *Western Ontario*. (4) Average mallard densities in the north-central United States ranged from 3.8 to 8.0 in the Dakotas and Montana, and was 3.0 in *Western Minnesota*.

14. The proportion of the continental mallard breeding population in the *Prairie-Parkland Area* ranged from 37.7% in 1962 to 68.5% in 1956 (surveyed areas only). An average of 29% of the mallards was found in northern Canada and the Northwest Territories, while 16% was found in the north-central United States, and 4% in the Alaska-Yukon area.

15. The degree to which mallard breeding populations are related among various reference areas was quantified. Mallard populations were positively related in reference areas in northern Alberta, in the Northwest Territories, and in the *Prairie-Parkland Area*. Substantial positive correlations were found between mallard populations in reference areas in the Dakotas.

16. Long-term averages obtained from the May Aerial Survey indicate that mallards usually represent about 28% of the breeding duck population in all surveyed areas except those in the far north. With these exceptions, the distribution of mallards usually tends to parallel the distribution of total breeding ducks.

17. Pond occupancy rates (mallards/May pond) varied substantially both temporally and geographically. They were highest during the late 1950's when duck numbers were high and pond numbers were rapidly declining. The average number of birds per pond in the *Prairie-Parkland Area* was highest in the west and lowest in the east, toward *Southwestern Manitoba*.

18. Estimates of midsummer habitat conditions and indices to production from the July Production Survey were studied in detail. The average size of broods (all species combined) tends to be larger in the western breeding areas than in the eastern breeding areas. The rate of loss of birds from class II to III birds decreased from west to east (0.33, 0.45, 0.50, and 0.53 in the four reference areas, respectively) in the *Prairie-Parkland Area*. The coefficient of variation for mean brood size during 1955–73 was small, ranging from 9 to 13% in the four reference areas in the *Prairie-Parkland Area*.

19. Late nesting indices appear to be related to water conditions because a significant relationship was found between the late nesting index and the number of July ponds each year in the *Prairie-Parkland Area*. Late nesting and renesting efforts seem greatest during years when midsummer water conditions are good.

20. Brood indices presently provide the most reliable prehunting season indication of annual reproductive performance. Estimates of production rates based on an analysis of weighted band recoveries and Wing Survey data will be presented in a later report. Since broods are not identified to species, only a brood index relating to all species was available for analysis.

21. The average number of duck broods per 100 square miles decreased markedly from west to east in the *Prairie-Parkland Area* (253.0, 174.5, 139.4, and 92.9 in Reference Areas 03, 04, 05, and 06, respectively). The number of duck broods per July pond also suggests a striking decrease in brood production from west to east in the *Prairie-Parkland Area*.

22. *Spacing of the birds in the Prairie-Parkland Area* appears to be a key factor in the density-dependent regulation of the population. These spacing mechanisms, in conjunction with habitat conditions, influence some birds to "overfly" the primary breeding grounds into less favorable habitat to the north and northwest where the production rate may be suppressed.

23. Production rates of most ducks breeding in North America appear to be regulated by density-dependent and density-independent factors.

24. The production rate of waterfowl in the

*Prairie-Parkland Area* appears to be independent of density (after emigration has taken place) because the production index appears to be a linear function of the number of breeders in the area. Similarly, the production rate of waterfowl in northern Saskatchewan and northern Manitoba (the only northern areas where sufficient data were available for analysis) appears to be independent of density. Production indices appear to be a linear function of the size of the breeding population.

25. Spacing and social behavior strongly influence not only densities of breeding ducks on the prime breeding areas, but also the distribution of ducks throughout the entire breeding grounds, in both favorable and unfavorable habitats. Thus, the density and distribution of breeding ducks may be regulated through a spacing mechanism that is at least partially dependent on measurable environmental factors, and the result of a density-dependent process operating to ultimately affect the production and production rate of breeding ducks on a continent-wide basis. Production, and therefore the size of the fall population, may be partially regulated by the number of birds that are distributed north and northwest into environments less favorable for successful reproduction than those in the prime breeding areas. Thus, spacing of the birds on the *Prairie-Parkland Area* and the movement of a fraction of the birds out of the prime breeding areas are key factors in the density-dependent regulation of the total population.

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# APPENDIX A

The following individuals have cooperated in the aerial and ground:air surveys of waterfowl breeding populations in North America, and their contribution is acknowledged.

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Grieb, J. R.
Haddock, L.
Hall, D. L.
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Hancox, R.
Hansen, H. A.
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Hawkins, A. S.
Hayes, C. R.
Hensler, J.
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Lensink, C. J.
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Lovrien, H. T.
Lundy, M. H.
Lynch, J. J.
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Martin, P. W.
Matlock, J. M.
McCartney, K. M.
McCourt, K. H.
McFall, P.
McIntosh, D. J.
McKean, J. W.
McLanders, R.
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Minick, J. E.
Moholt, W. K.
Naylor, A. E.
Nelson, J. L.
Newcomb, W. C.
Nieman, D. J.
Noltemeier, A. P.
Norman, K. D.
Norris, J. R.
Nun, G. J.
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Olson, S. T.
Orton, G. V.
Perret, N. G.
Perroux, J. W.
Pinkham, H.
Planz, T.
Pospichal, G.
Poston, B.
Pryor, S. P.
Purinton, R. D.
Randall, J. E.
Russell, W.
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Seelye, O. E.
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Sutton, E. L.
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Szymczak, M. R.
Thayer, A. S.
Thompson, F. A.
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Timm, D.
Tremblay, R. H.
Vaughn, C.
Voelzer, J. F.
Von Dane, R. B.
Weaver, H. R.
Weinrich, A. E.
Wellein, E. G.
Wendler, J. D.
Wheeler, R. H.
Wieland, D. E.
Wills, L. C.
Wilson, G. H.
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# APPENDIX B

## Breeding Population and Habitat Statistics

Appendix Tables B-1 through B-20 present annual and summary information pertaining to mallard
the 44 minor reference areas, and population

TABLE B–1. *Summary of breeding population and habitat*
*(Data compiled from May Breeding*

| Statistic | Year 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 112.0 | 140.7 | 174.4 | 131.1 | 218.8 | 136.7 | 180.8 |
| Mallard density (birds per square mile) | 1.5 | 1.8 | 2.3 | 1.7 | 2.9 | 1.8 | 2.4 |
| Density of other ducks (birds per square mile) | 32.4 | 39.4 | 41.7 | 38.3 | 39.6 | 51.0 | 48.7 |

TABLE B–2. *Summary of breeding population and habitat statistics*
*(Data compiled from May Breeding*

| Statistic | Year 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 98.2 | 56.5 | 74.6 | 273.3 | 118.4 | 240.6 | 128.6 | 182.2 |
| Mallard density (birds per square mile) | 0.7 | 0.4 | 0.6 | 2.0 | 0.9 | 1.8 | 1.0 | 1.4 |
| Density of other ducks (birds per square mile) | 20.7 | 18.4 | 21.6 | 33.8 | 31.0 | 27.1 | 20.2 | 18.4 |

TABLE B–3. *Summary of breeding population and habitat statistics*
*(Data compiled from May Breeding*

| Statistic | Year 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 310.1 | 311.6 | 509.8 | 1,057.3 | 206.8 | 598.8 | 348.9 | 384.0 |
| Mallard density (birds per square mile) | 1.8 | 1.8 | 3.0 | 6.2 | 1.2 | 3.5 | 2.0 | 2.2 |
| Density of other ducks (birds per square mile) | 11.8 | 15.6 | 16.2 | 38.6 | 15.4 | 21.7 | 14.1 | 14.1 |
| Total brood index (all ducks) | | | | | | | | |
| Average class II brood size (all ducks) | | | | | | | | |
| Average class III brood size (all ducks) | | | | | | | | |
| Average brood size (all ducks) | | | | | | | | |
| Broods per square mile | | | | | | | | |
| Mallard late nesting index (thousands) | | | | | | | | |
| Late nesting index other ducks (thousands) | | | | | | | | |
| Late nesting index + broods (all ducks) | | | | | | | | |

TABLE B–4. *Summary of breeding population and habitat statistics for Northeastern*
*(Data compiled from May Breeding*

| Statistic | Year 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 439.4 | 200.1 | 394.5 | 784.9 | 1,137.5 | 282.0 | 871.8 | 407.9 | 432.0 |
| Mallard Density (birds per square mile) | 0.4 | 2.2 | 4.4 | 8.7 | 12.6 | 3.1 | 9.7 | 4.5 | 4.8 |
| Density of other ducks (birds per square mile) | 0.9 | 17.2 | 15.6 | 37.6 | 44.1 | 19.6 | 33.9 | 12.6 | 13.4 |
| Total brood index (all ducks) | | | | | | | | | |
| Average class II brood size (all ducks) | | | | | | | | | |
| Average class III brood size (all ducks) | | | | | | | | | |
| Average brood size (all ducks) | | | | | | | | | |
| Broods per square mile | | | | | | | | | |
| Mallard late nesting index (thousands) | | | | | | | | | |
| Late nesting index other ducks (thousands) | | | | | | | | | |
| Late nesting index + broods (all ducks) | | | | | | | | | |

breeding population levels and related habitat statistics. Detailed information is presented for 19 of estimates for the remaining 25.

*statistics for Alaska (Minor Reference Area 011) 1957–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1957–73 |
| 82.0 | 144.7 | 89.5 | 183.8 | 170.4 | 113.7 | 211.2 | 118.1 | 241.2 | 179.7 | 82.0 | 241.2 | 159.3 | 154.6 |
| 1.1 | 1.9 | 1.2 | 2.4 | 2.2 | 1.5 | 2.8 | 1.5 | 3.1 | 2.3 | 1.1 | 3.1 | 2.1 | 2.0 |
| 42.2 | 34.4 | 40.3 | 40.6 | 64.1 | 44.4 | 45.7 | 39.2 | 44.1 | 51.5 | 32.4 | 64.1 | 45.0 | 43.4 |

*for Yukon—Western Mackenzie (Minor Reference Area 012), 1956–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1956–73 |
| 77.5 | 123.8 | 76.1 | 62.6 | 81.5 | 68.2 | 120.3 | 97.2 | 56.1 | 48.7 | 48.7 | 273.3 | 104.9 | 110.2 |
| 0.6 | 0.9 | 0.6 | 0.5 | 0.6 | 0.5 | 0.9 | 0.7 | 0.4 | 0.4 | 0.4 | 2.0 | 0.8 | 0.8 |
| 21.5 | 19.0 | 16.8 | 15.3 | 12.2 | 19.9 | 21.0 | 16.6 | 18.5 | 18.0 | 12.2 | 33.8 | 18.8 | 20.6 |

*for Central Mackenzie (Minor Reference Area 021), 1956–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1956–73 |
| 410.9 | 152.5 | 305.7 | 263.2 | 201.6 | 169.9 | 360.4 | 405.6 | 593.3 | 333.2 | 152.5 | 1,057.3 | 348.3 | 384.6 |
| 2.4 | 0.9 | 1.8 | 1.5 | 1.2 | 1.0 | 2.1 | 2.4 | 3.5 | 1.9 | 0.9 | 6.2 | 2.0 | 2.2 |
| 20.2 | 15.0 | 17.1 | 14.5 | 10.3 | 11.7 | 17.5 | 18.2 | 31.2 | 21.0 | 10.3 | 38.6 | 17.4 | 18.0 |
| | | | | | | | | | | | | 1966–73 | |
| | | 110.7 | 38.2 | 125.1 | 64.6 | 110.2 | 91.9 | 62.5 | 176.3 | 38.2 | 176.3 | 97.4 | |
| | | 5.33 | 6.74 | 4.81 | 5.41 | 5.78 | 5.34 | 5.10 | 5.63 | 4.81 | 6.74 | 5.52 | |
| | | 5.05 | ---- | 4.70 | 4.87 | 5.86 | 5.18 | ---- | 5.83 | 4.70 | 5.86 | 5.25 | |
| | | 5.15 | 6.74 | 4.72 | 5.07 | 5.78 | 5.31 | 5.10 | 5.65 | 4.72 | 6.74 | 5.44 | |
| | | 0.6 | 0.2 | 0.7 | 0.4 | 0.6 | 0.5 | 0.4 | 1.0 | 0.2 | 1.0 | 0.6 | |
| | | 0.0 | 2.2 | 0.0 | 14.8 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 | 14.8 | 2.8 | |
| | | 37.3 | 22.7 | 86.3 | 56.6 | 10.7 | 3.9 | 0.0 | 0.0 | 0.0 | 86.3 | 27.2 | |
| | | 148.0 | 63.2 | 211.5 | 136.0 | 126.0 | 95.8 | 62.5 | 176.3 | 62.5 | 211.5 | 127.4 | |

*British Columbia—Northwestern Alberta (Minor Reference Area 022), 1955–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1955–73 |
| 515.9 | 281.9 | 312.5 | 222.6 | 272.5 | 244.8 | 292.9 | 311.5 | 535.2 | 408.8 | 200.1 | 1,137.5 | 393.1 | 439.4 |
| 5.7 | 3.1 | 3.5 | 2.5 | 3.0 | 2.7 | 3.3 | 3.5 | 6.0 | 4.5 | 0.4 | 12.6 | 4.4 | 4.6 |
| 24.9 | 18.5 | 18.4 | 9.8 | 10.1 | 6.5 | 9.2 | 11.8 | 16.9 | 12.4 | 0.9 | 44.1 | 15.3 | 17.5 |
| | | | | | | | | | | | | 1969–73 | |
| | | | | | 58.1 | 44.7 | 21.9 | 17.3 | 21.1 | 17.3 | 58.1 | 32.6 | |
| | | | | | 5.38 | 4.60 | 6.57 | 5.33 | 4.27 | 4.27 | 6.57 | 5.23 | |
| | | | | | 5.63 | 4.94 | 5.35 | 4.48 | 4.63 | 4.48 | 5.63 | 5.01 | |
| | | | | | 5.48 | 4.78 | 6.03 | 4.93 | 4.39 | 4.39 | 6.03 | 5.12 | |
| | | | | | 0.65 | 0.50 | 0.24 | 0.19 | 0.23 | 0.19 | 0.65 | 0.36 | |
| | | | | | 4.0 | 2.6 | 2.3 | 1.2 | 6.5 | 1.2 | 6.5 | 3.3 | |
| | | | | | 26.2 | 7.3 | 5.7 | 8.9 | 14.5 | 5.7 | 26.2 | 12.5 | |
| | | | | | 88.3 | 54.6 | 30.0 | 27.4 | 42.2 | 27.4 | 88.3 | 48.5 | |

TABLE B–5. *Summary of breeding population and habitat statistics*
*(Data compiled from May Breeding*

| Statistic | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 567.7 | 750.0 | 1,030.0 | 1,294.7 | 506.1 | 1,236.9 | 723.7 | 652.9 |
| Mallard density (birds per square mile) | 7.2 | 9.5 | 13.0 | 16.3 | 6.4 | 15.6 | 9.1 | 8.2 |
| Density of other ducks (birds per square mile) | 26.1 | 27.1 | 43.7 | 55.3 | 26.8 | 47.8 | 22.9 | 23.8 |
| Total brood index (all ducks) | | | | | | | | |
| Average class II brood size (all ducks) | | | | | | | | |
| Average class III brood size (all ducks) | | | | | | | | |
| Average brood size (all ducks) | | | | | | | | |
| Broods per square mile | | | | | | | | |
| Mallard late nesting index (thousands) | | | | | | | | |
| Late nesting index other ducks (thousands) | | | | | | | | |
| Late nesting index + broods (all ducks) | | | | | | | | |

TABLE B–6. *Summary of breeding population and habitat statistics*
*(Data compiled from May Breeding*

| Statistic | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 1,298.1 | 1,169.2 | 1,221.3 | 1,325.6 | 1,077.2 | 894.9 | 782.5 | 567.1 | 675.1 |
| Mallard density (birds per square mile) | 27.5 | 24.8 | 25.9 | 28.1 | 22.8 | 19.0 | 16.6 | 12.0 | 14.3 |
| Density of other ducks (birds per square mile) | 71.8 | 63.2 | 52.8 | 56.9 | 47.4 | 49.7 | 39.0 | 25.9 | 39.0 |
| May pond estimate (thousands) | 867.7 | 671.7 | 425.0 | 518.3 | 359.2 | 628.9 | 418.9 | 301.2 | 460.9 |
| May pond density (ponds per square mile) | 18.4 | 14.2 | 9.0 | 11.0 | 7.6 | 13.3 | 8.9 | 6.4 | 9.8 |
| Mallards per May pond | 1.5 | 1.7 | 2.9 | 2.6 | 3.0 | 1.4 | 1.9 | 1.9 | 1.5 |
| Other ducks per May pond | 3.9 | 4.4 | 5.9 | 5.2 | 6.2 | 3.7 | 4.4 | 4.1 | 4.0 |
| July pond estimate (thousands) | 425.7 | 437.3 | 290.9 | 312.1 | 228.9 | 260.2 | 153.8 | 225.7 | 471.8 |
| July pond density (ponds per square mile) | 9.0 | 9.3 | 6.2 | 6.6 | 4.8 | 5.5 | 3.3 | 4.8 | 10.0 |
| Breeding mallards per July pond | 4.2 | 3.3 | 4.9 | 5.7 | 7.6 | 5.0 | 5.0 | 3.3 | 1.7 |
| Other breeding ducks per July pond | 11.6 | 9.5 | 12.8 | 13.6 | 19.8 | 16.4 | 19.0 | 9.1 | 4.2 |
| Percent of ponds remaining (May-July) | 49.1 | 65.1 | 68.4 | 60.2 | 63.7 | 41.4 | 36.7 | 74.9 | 102.4 |
| Total brood index (all ducks) | 206.2 | 175.0 | 226.0 | 235.5 | 140.4 | 122.1 | 126.3 | 82.2 | 128.2 |
| Average class II brood size (all ducks) | 6.25 | 6.26 | 6.38 | 6.41 | 4.01 | 6.00 | 5.64 | 5.84 | 6.11 |
| Average class III brood size (all ducks) | 5.75 | 5.77 | 6.16 | 5.98 | 5.62 | 6.02 | 5.76 | 5.25 | 5.88 |
| Average brood size (all ducks) | 5.96 | 6.03 | 6.26 | 6.21 | 4.49 | 6.01 | 5.70 | 5.51 | 5.99 |
| Broods per July pond | 0.48 | 0.40 | 0.78 | 0.75 | 0.61 | 0.47 | 0.82 | 0.36 | 0.27 |
| Broods per square mile | 4.37 | 3.70 | 4.79 | 4.99 | 2.97 | 2.59 | 2.67 | 1.74 | 2.71 |
| Mallards late nesting index (thousands) | 6.7 | 3.6 | 3.1 | 4.2 | 6.2 | 2.4 | 0.6 | 1.2 | 1.3 |
| Late nesting index other ducks (thousands) | 26.8 | 19.1 | 15.7 | 18.6 | 25.2 | 10.9 | 5.8 | 2.3 | 4.4 |
| Late nesting index + broods (all ducks) | 239.7 | 197.7 | 244.8 | 258.3 | 171.7 | 135.5 | 132.6 | 85.7 | 133.9 |

TABLE B–7. *Summary of breeding population and habitat statistics for Northcast*
*(Data compiled from May Breeding*

| Statistic | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 2,729.5 | 3,228.1 | 2,581.3 | 2,366.0 | 1,473.1 | 1,684.9 | 1,402.8 | 919.3 | 1,311.8 |
| Mallard density (birds per square mile) | 31.2 | 36.9 | 29.5 | 27.0 | 16.8 | 19.3 | 16.0 | 10.5 | 15.0 |
| Density of other ducks (birds per square mile) | 92.1 | 103.6 | 64.1 | 37.3 | 28.9 | 38.7 | 49.4 | 35.7 | 35.8 |
| May pond estimate (thousands) | 2,110.9 | 1,412.8 | 819.6 | 914.7 | 446.7 | 957.9 | 538.1 | 765.4 | 733.8 |
| May pond density (ponds per square mile) | 25.2 | 17.2 | 9.8 | 10.9 | 5.3 | 11.4 | 6.4 | 9.1 | 8.8 |
| Mallards per May pond | 1.3 | 2.2 | 3.1 | 2.6 | 3.3 | 1.8 | 2.6 | 1.2 | 1.8 |
| Other ducks per May pond | 3.8 | 6.3 | 6.8 | 3.6 | 5.7 | 3.5 | 8.0 | 4.1 | 4.3 |
| July pond estimate (thousands) | 854.0 | 618.7 | 379.6 | 315.5 | 286.5 | 357.9 | 188.8 | 247.7 | 636.1 |
| July pond density (ponds per square mile) | 10.2 | 7.4 | 4.5 | 3.8 | 3.4 | 4.3 | 2.3 | 3.0 | 7.6 |
| Breeding mallards per July pond | 4.4 | 6.7 | 7.8 | 10.2 | 7.1 | 5.7 | 6.2 | 3.8 | 1.8 |
| Other breeding ducks per July pond | 10.9 | 15.3 | 18.3 | 15.6 | 15.4 | 13.3 | 18.3 | 11.0 | 4.3 |
| Percent of ponds remaining (May-July) | 40.5 | 42.9 | 46.3 | 34.5 | 64.1 | 37.4 | 35.1 | 32.4 | 86.7 |
| Total brood index (all ducks) | 185.8 | 258.7 | 382.8 | 255.1 | 137.4 | 116.2 | 146.8 | 71.8 | 109.6 |
| Average class II brood size (all ducks) | 6.62 | 6.28 | 6.53 | 5.74 | 3.70 | 6.00 | 5.60 | 5.82 | 6.05 |
| Average classIII brood size (all ducks) | 5.88 | 5.91 | 6.19 | 5.32 | 4.81 | 5.18 | 5.35 | 5.11 | 5.80 |
| Average brood size (all ducks) | 6.27 | 6.09 | 6.32 | 5.53 | 3.90 | 5.67 | 5.44 | 5.49 | 5.94 |
| Broods per July pond | 0.21 | 0.40 | 0.96 | 0.77 | 0.46 | 0.31 | 0.74 | 0.28 | 0.16 |
| Broods per square mile | 2.12 | 2.96 | 4.37 | 2.92 | 1.57 | 1.33 | 1.68 | 0.82 | 1.25 |
| Mallard late nesting index (thousands) | 112.5 | 37.6 | 15.9 | 43.7 | 25.7 | 43.6 | 12.2 | 6.2 | 18.3 |
| Late nesting index other ducks (thousands) | 171.4 | 93.9 | 37.2 | 46.7 | 36.0 | 48.8 | 10.3 | 10.1 | 32.3 |
| Late nesting index + broods (all ducks) | 469.8 | 390.2 | 435.8 | 345.5 | 199.1 | 208.6 | 169.3 | 88.2 | 160.2 |

*for Northeastern Alberta (Minor Reference Area 023), 1956–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1956–73 |
| 746.6 | 521.6 | 559.2 | 434.2 | 452.7 | 464.9 | 569.5 | 653.1 | 779.8 | 684.6 | 434.2 | 1,294.7 | 652.3 | 701.6 |
| 9.4 | 6.6 | 7.1 | 5.5 | 5.7 | 5.9 | 7.2 | 8.2 | 9.8 | 8.6 | 5.5 | 16.3 | 8.2 | 8.8 |
| 33.6 | 27.3 | 26.8 | 19.1 | 18.6 | 15.3 | 18.3 | 23.0 | 29.3 | 25.2 | 15.3 | 55.3 | 25.5 | 28.3 |
| | | | | | | | | | | | | 1969–73 | |
| | | | | | 86.5 | 67.2 | 45.6 | 37.4 | 43.1 | 37.4 | 86.5 | 56.0 | |
| | | | | | 5.86 | 5.12 | 6.29 | 5.47 | 5.13 | 5.12 | 6.29 | 5.57 | |
| | | | | | 5.91 | 5.14 | 5.61 | 4.56 | 4.98 | 4.56 | 5.91 | 5.24 | |
| | | | | | 5.88 | 5.12 | 5.94 | 5.09 | 5.07 | 5.07 | 5.94 | 5.42 | |
| | | | | | 1.09 | 0.85 | 0.58 | 0.47 | 0.54 | 0.47 | 1.09 | 0.71 | |
| | | | | | 8.1 | 5.4 | 3.8 | 2.5 | 8.6 | 2.5 | 8.6 | 5.7 | |
| | | | | | 31.3 | 20.2 | 15.5 | 17.0 | 21.6 | 15.5 | 31.3 | 21.1 | |
| | | | | | 125.9 | 92.8 | 64.9 | 56.9 | 73.3 | 56.9 | 125.9 | 82.8 | |

*for Southwestern Alberta (Minor Reference Area 031), 1955–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1955–73 |
| 672.2 | 527.7 | 960.0 | 1,000.5 | 578.6 | 748.3 | 993.1 | 1,123.9 | 1,116.0 | 1,084.7 | 527.7 | 1,325.6 | 833.1 | 937.7 |
| 14.2 | 11.2 | 20.3 | 21.2 | 12.3 | 15.9 | 21.0 | 23.8 | 23.6 | 23.0 | 11.2 | 28.1 | 17.6 | 19.9 |
| 39.4 | 37.7 | 58.1 | 72.2 | 38.2 | 61.0 | 55.8 | 64.9 | 64.2 | 58.4 | 25.9 | 72.2 | 50.3 | 52.4 |
| 397.5 | 610.1 | 512.6 | 541.6 | 318.5 | 412.8 | 442.2 | 381.7 | 375.1 | 368.2 | 301.2 | 867.7 | 426.3 | 474.3 |
| 8.4 | 12.9 | 10.9 | 11.5 | 6.7 | 8.7 | 9.4 | 8.1 | 7.9 | 7.8 | 6.4 | 18.4 | 9.0 | 10.0 |
| 1.7 | 0.9 | 1.9 | 1.8 | 1.8 | 1.8 | 2.2 | 2.9 | 3.0 | 2.9 | 0.9 | 3.0 | 2.0 | 2.1 |
| 4.7 | 2.9 | 5.4 | 6.3 | 5.7 | 7.0 | 6.0 | 8.0 | 8.1 | 7.5 | 2.9 | 8.1 | 5.7 | 5.4 |
| 256.1 | 599.0 | 345.9 | 425.9 | 221.6 | 235.4 | 296.2 | 329.4 | 194.2 | 342.8 | 153.8 | 599.0 | 315.2 | 318.6 |
| 5.4 | 12.7 | 7.3 | 9.0 | 4.7 | 5.0 | 6.3 | 7.0 | 4.1 | 7.3 | 3.3 | 12.7 | 6.7 | 6.8 |
| 3.6 | 0.8 | 2.5 | 2.0 | 2.9 | 3.3 | 3.3 | 4.0 | 5.8 | 3.1 | 0.8 | 7.6 | 3.2 | 3.8 |
| 10.8 | 2.8 | 10.5 | 9.0 | 7.7 | 13.4 | 9.5 | 10.3 | 15.6 | 8.0 | 2.8 | 19.8 | 10.0 | 11.2 |
| 64.4 | 98.2 | 67.5 | 78.6 | 69.6 | 57.0 | 67.0 | 86.3 | 51.6 | 93.6 | 36.7 | 102.4 | 72.9 | 68.2 |
| 113.0 | 72.0 | 109.4 | 112.4 | 59.8 | 106.5 | 65.8 | 72.3 | 69.8 | 47.4 | 47.4 | 235.5 | 89.6 | 119.5 |
| 6.00 | 6.34 | 6.99 | 6.30 | 5.10 | 6.08 | 5.90 | 6.11 | 5.06 | 5.14 | 4.01 | 6.99 | 5.89 | 5,89 |
| 5.43 | 5.87 | 6.11 | 5.32 | 4.83 | 6.13 | 5.22 | 5.23 | 4.82 | 4.55 | 4.82 | 6.16 | 5.42 | 5.56 |
| 5.85 | 6.11 | 6.60 | 5.94 | 5.02 | 6.10 | 5.51 | 5.72 | 4.97 | 5.03 | 4.49 | 6.60 | 5.70 | 5.74 |
| 0.44 | 0.12 | 0.32 | 0.26 | 0.27 | 0.45 | 0.22 | 0.22 | 0.36 | 0.14 | 0.12 | 0.82 | 0.33 | 0.41 |
| 2.39 | 1.52 | 2.32 | 2.38 | 1.27 | 2.26 | 1.39 | 1.53 | 1.48 | 1.00 | 1.00 | 4.99 | 1.90 | 2.53 |
| 3.0 | 9.0 | 11.1 | 11.1 | 11.0 | 6.4 | 10.1 | 14.4 | 11.3 | 12.2 | 0.6 | 14.4 | 7.9 | 6.8 |
| 7.2 | 40.7 | 36.1 | 32.4 | 33.0 | 41.7 | 39.9 | 47.7 | 38.4 | 31.3 | 2.3 | 47.7 | 27.8 | 25.1 |
| 123.1 | 121.7 | 156.7 | 155.9 | 103.8 | 154.7 | 115.9 | 134.5 | 119.4 | 90.9 | 85.7 | 258.3 | 125.3 | 151.4 |

*Southern Alberta—Southwestern Saskatchewan (Minor Reference Area 041), 1955–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1955–73 |
| 1,047.3 | 853.8 | 1,700.8 | 1,611.9 | 1,755.1 | 1,683.5 | 2,325.4 | 2,872.3 | 2,027.0 | 2,048.0 | 853.8 | 3,228.4 | 1,658.4 | 1,874.9 |
| 12.0 | 10.0 | 19.4 | 18.4 | 20.1 | 19.2 | 26.6 | 32.8 | 23.2 | 23.4 | 10.0 | 36.9 | 19.0 | 21.4 |
| 35.1 | 37.1 | 59.2 | 59.0 | 41.0 | 60.3 | 72.3 | 73.9 | 59.1 | 57.5 | 28.8 | 103.6 | 52.0 | 54.7 |
| 559.0 | 1,091.8 | 980.7 | 1,087.8 | 545.3 | 1,186.8 | 1,437.9 | 1,145.7 | 942.3 | 704.7 | 446.7 | 2,110.9 | 901.5 | 969.0 |
| 6.7 | 13.0 | 11.7 | 13.0 | 6.5 | 14.2 | 17.2 | 13.7 | 11.3 | 8.4 | 5.3 | 25.2 | 10.8 | 11.6 |
| 1.9 | 0.8 | 1.7 | 1.5 | 3.2 | 1.4 | 1.6 | 2.5 | 2.2 | 2.9 | 0.8 | 3.3 | 1.9 | 2.1 |
| 5.5 | 3.0 | 5.3 | 4.7 | 6.6 | 4.4 | 4.4 | 5.6 | 5.5 | 7.1 | 3.0 | 8.0 | 5.3 | 5.2 |
| 256.3 | 783.4 | 621.4 | 503.8 | 266.9 | 645.9 | 1,088.3 | 725.5 | 415.4 | 561.8 | 188.8 | 1,088.3 | 533.9 | 513.3 |
| 3.1 | 9.4 | 7.4 | 6.0 | 3.2 | 7.7 | 13.0 | 8.7 | 5.0 | 6.7 | 2.3 | 13.0 | 6.4 | 6.1 |
| 4.7 | 1.1 | 2.6 | 3.1 | 6.4 | 2.5 | 2.1 | 4.1 | 4.6 | 3.5 | 1.1 | 10.2 | 3.6 | 4.7 |
| 15.2 | 4.2 | 9.7 | 11.4 | 12.6 | 8.9 | 5.9 | 7.8 | 11.8 | 8.6 | 4.2 | 18.3 | 10.0 | 11.5 |
| 45.8 | 71.8 | 63.4 | 46.3 | 48.9 | 54.4 | 75.7 | 63.3 | 44.4 | 79.6 | 32.4 | 86.7 | 57.5 | 53.3 |
| 120.5 | 66.3 | 129.0 | 110.1 | 94.0 | 191.8 | 121.4 | 161.6 | 151.5 | 90.4 | 66.3 | 382.8 | 120.4 | 152.7 |
| 6.03 | 6.35 | 6.57 | 5.74 | 5.26 | 6.07 | 5.50 | 5.93 | 5.52 | 4.81 | 3.70 | 6.62 | 5.79 | 5.80 |
| 5.58 | 5.81 | 5.82 | 5.13 | 4.73 | 5.48 | 5.10 | 5.00 | 4.82 | 4.59 | 4.59 | 6.19 | 5.26 | 5.35 |
| 5.92 | 6.12 | 6.26 | 5.53 | 5.10 | 5.86 | 5.31 | 5.41 | 5.15 | 4.73 | 3.90 | 6.32 | 5.56 | 5.58 |
| 0.45 | 0.08 | 0.20 | 0.21 | 0.34 | 0.28 | 0.11 | 0.21 | 0.35 | 0.15 | 0.08 | 0.96 | 0.27 | 0.35 |
| 1.38 | 0.76 | 1.47 | 1.26 | 1.08 | 2.19 | 1.39 | 1.85 | 1.73 | 1.03 | 0.76 | 4.37 | 1.38 | 1.75 |
| 16.4 | 37.3 | 28.9 | 21.6 | 18.3 | 29.9 | 69.8 | 46.0 | 34.6 | 40.6 | 6.2 | 112.5 | 29.2 | 34.7 |
| 14.3 | 77.1 | 74.8 | 76.4 | 49.0 | 105.3 | 225.9 | 139.8 | 84.7 | 123.8 | 10.1 | 225.9 | 78.8 | 76.7 |
| 151.2 | 180.7 | 232.6 | 208.1 | 161.3 | 327.0 | 417.0 | 347.3 | 270.9 | 254.9 | 88.2 | 469.8 | 228.4 | 262.1 |

TABLE B–8. *Summary of breeding population and habitat statistics (Data compiled from May Breeding*

| Statistic | Year 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 1,968.8 | 2,664.5 | 2,565.0 | 3,238.7 | 1,275.0 | 1,963.6 | 768.1 | 576.9 | 713.6 |
| Mallard density (birds per square mile) | 37.2 | 50.4 | 48.5 | 61.2 | 24.1 | 37.1 | 14.5 | 10.9 | 13.5 |
| Density of other ducks (birds per square mile) | 91.0 | 127.5 | 94.3 | 78.4 | 55.1 | 59.7 | 38.5 | 35.6 | 22.4 |
| May pond estimate (thousands) | 2,744.6 | 1,579.5 | 1,310.8 | 1,111.7 | 464.9 | 1,438.9 | 237.6 | 742.2 | 554.4 |
| May pond density (ponds per square mile) | 58.9 | 33.9 | 28.1 | 23.9 | 10.0 | 30.9 | 5.1 | 15.9 | 11.9 |
| Mallards per May pond | 0.7 | 1.7 | 2.0 | 2.9 | 2.7 | 1.4 | 3.2 | 0.8 | 1.3 |
| Other ducks per May pond | 1.8 | 4.3 | 3.8 | 3.7 | 6.3 | 2.2 | 8.6 | 2.5 | 2.1 |
| July pond estimate (thousands) | 1,396.7 | 737.2 | 456.1 | 250.5 | 315.3 | 416.8 | 92.4 | 152.2 | 363.8 |
| July pond density (ponds per square mile) | 30.0 | 15.8 | 9.8 | 5.4 | 6.8 | 8.9 | 2.0 | 3.3 | 7.8 |
| Breeding mallards per July pond | 1.6 | 3.8 | 6.4 | 18.6 | 5.3 | 4.9 | 7.3 | 3.5 | 1.6 |
| Other breeding ducks per July pond | 4.0 | 8.8 | 11.2 | 17.7 | 11.9 | 7.6 | 22.2 | 9.6 | 2.8 |
| Percent of ponds remaining (May-July) | 50.9 | 46.7 | 34.8 | 22.5 | 67.8 | 29.0 | 38.9 | 20.5 | 65.6 |
| Total brood index (all ducks) | 163.4 | 218.7 | 165.3 | 179.3 | 64.0 | 75.0 | 24.7 | 18.2 | 20.3 |
| Average class II brood size (all ducks) | 6.87 | 6.22 | 6.25 | 4.53 | 4.86 | 5.10 | 5.25 | 3.88 | 6.27 |
| Average class III brood size (all ducks) | 6.30 | 5.53 | 4.81 | 4.70 | 5.10 | 4.10 | 4.95 | 3.97 | 4.93 |
| Average brood size (all ducks) | 6.70 | 5.92 | 5.57 | 4.62 | 4.86 | 4.68 | 4.96 | 3.91 | 5.64 |
| Broods per July pond | 0.10 | 0.26 | 0.32 | 0.63 | 0.18 | 0.16 | 0.24 | 0.11 | 0.05 |
| Broods per square mile | 3.09 | 4.13 | 3.12 | 3.39 | 1.21 | 1.42 | 0.47 | 0.34 | 0.38 |
| Mallard late nesting index (thousands) | 77.7 | 46.9 | 34.4 | 53.2 | 24.6 | 36.4 | 12.3 | 11.3 | 8.2 |
| Late nesting index other ducks (thousands) | 128.8 | 86.8 | 37.1 | 79.0 | 41.5 | 48.4 | 12.1 | 12.5 | 21.9 |
| Late nesting index + broods (all ducks) | 369.9 | 352.4 | 236.7 | 311.5 | 130.0 | 159.8 | 49.1 | 42.0 | 50.5 |

TABLE B–9. *Summary of breeding population and habitat statistics (Data compiled from May Breeding*

| Statistic | Year 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 511.1 | 675.5 | 624.5 | 849.0 | 473.1 | 465.6 | 325.8 | 203.2 | 328.3 |
| Mallard density (birds per square mile) | 13.6 | 17.9 | 16.6 | 22.5 | 12.5 | 12.3 | 8.6 | 5.4 | 8.7 |
| Density of other ducks (birds per square mile) | 41.6 | 33.0 | 33.1 | 71.2 | 68.9 | 47.0 | 43.0 | 31.0 | 41.3 |
| May pond estimate (thousands) | 1,391.6 | 950.9 | 611.4 | 598.7 | 571.0 | 531.8 | 379.5 | 400.4 | 602.2 |
| May pond density (ponds per square mile) | 40.5 | 27.6 | 17.8 | 17.4 | 16.6 | 15.5 | 11.0 | 11.6 | 17.5 |
| Mallards per May pond | 0.4 | 0.7 | 1.0 | 1.4 | 0.8 | 0.9 | 0.9 | 0.5 | 0.5 |
| Other ducks per May pond | 1.1 | 1.3 | 2.0 | 4.5 | 4.5 | 3.3 | 4.3 | 2.9 | 2.6 |
| July pond estimate (thousands) | 592.7 | 386.4 | 231.7 | 466.9 | 364.1 | 342.6 | 115.7 | 206.2 | 300.1 |
| July pond density (ponds per square mile) | 17.2 | 11.2 | 6.7 | 13.6 | 10.6 | 10.0 | 3.4 | 6.0 | 8.7 |
| Breeding mallards per July pond | 1.6 | 3.1 | 4.9 | 3.2 | 1.8 | 2.0 | 2.9 | 1.1 | 1.0 |
| Other breeding ducks per July pond | 3.8 | 4.1 | 6.8 | 6.4 | 7.5 | 5.6 | 17.3 | 5.9 | 4.3 |
| Percent of ponds remaining (May-July) | 42.6 | 40.6 | 37.9 | 78.0 | 63.8 | 64.4 | 30.5 | 51.5 | 49.8 |
| Total brood index (all ducks) | 30.5 | 32.1 | 67.0 | 72.3 | 38.5 | 36.6 | 37.4 | 17.5 | 34.2 |
| Average class II brood size (all ducks) | 7.91 | 5.65 | 6.12 | 6.96 | 5.44 | 5.45 | 5.70 | 5.10 | 5.92 |
| Average class III brood size (all ducks) | 5.29 | 4.61 | 4.83 | 6.46 | 6.25 | 5.62 | 5.45 | 5.01 | 4.82 |
| Average brood size (all ducks) | 6.32 | 5.18 | 5.62 | 6.68 | 5.50 | 5.52 | 5.59 | 5.09 | 5.33 |
| Broods per July pond | 0.05 | 0.08 | 0.26 | 0.14 | 0.10 | 0.10 | 0.29 | 0.08 | 0.10 |
| Broods per square mile | 0.81 | 0.85 | 1.78 | 1.92 | 1.02 | 0.97 | 0.99 | 0.46 | 0.91 |
| Mallard late nesting index (thousands) | 25.8 | 22.7 | 15.8 | 12.3 | 20.6 | 22.1 | 11.4 | 13.8 | 12.9 |
| Late nesting index other ducks (thousands) | 35.1 | 36.1 | 18.0 | 75.8 | 48.1 | 33.8 | 25.3 | 13.8 | 29.3 |
| Late nesting index + broods (all ducks) | 91.5 | 90.9 | 100.8 | 160.5 | 108.3 | 92.5 | 74.1 | 45.1 | 76.5 |

TABLE B–10. *Summary of breeding population and habitat statistics for Northern (Data compiled from May Breeding*

| Statistic | Year 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 405.1 | 481.1 | 366.8 | 625.1 | 635.5 | 314.7 | 272.8 | 263.3 | 349.4 |
| Mallard density (birds per square mile) | 3.1 | 3.7 | 2.8 | 4.7 | 4.8 | 2.4 | 2.1 | 2.0 | 2.7 |
| Density of other ducks (birds per square mile) | 9.9 | 5.8 | 6.8 | 7.1 | 12.4 | 5.6 | 8.3 | 9.3 | 10.4 |
| Total brood index (all ducks) | | | | | 72.3 | 35.1 | | 38.3 | 56.0 |
| Average class II brood size (all ducks) | | | | | 4.85 | 4.93 | | 5.19 | 5.33 |
| Average class III brood size (all ducks) | | | | | 4.62 | 5.44 | | 5.27 | 3.39 |
| Average brood size (all ducks) | | | | | 4.71 | 5.25 | | 5.23 | 5.14 |
| Broods per square mile | | | | | 0.55 | 0.27 | | 0.29 | 0.43 |
| Mallard late nesting index (thousands) | | | | | 21.0 | 8.4 | | 21.1 | 28.7 |
| Late nesting index other ducks (thousands) | | | | | 27.7 | 55.2 | | 70.2 | 57.4 |
| Late nesting index + broods (all ducks) | | | | | 120.9 | 98.7 | | 129.6 | 142.2 |

*for Southeastern Saskatchewan (Minor Reference Area 051), 1955–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1955–73 |
| 728.2 | 544.2 | 780.0 | 769.1 | 757.6 | 861.7 | 1,218.5 | 1,235.9 | 1,240.7 | 954.4 | 544.2 | 3,238.7 | 857.6 | 1,306.6 |
| 13.8 | 10.3 | 14.7 | 14.5 | 14.3 | 16.3 | 23.0 | 23.4 | 23.5 | 18.0 | 10.3 | 61.3 | 16.2 | 24.7 |
| 37.5 | 34.1 | 47.1 | 46.2 | 34.1 | 46.9 | 60.1 | 56.7 | 69.3 | 49.7 | 22.4 | 127.5 | 44.5 | 57.1 |
| 943.7 | 919.6 | 1,229.2 | 1,199.3 | 399.6 | 867.1 | 1,667.6 | 1,467.6 | 1,264.1 | 554.4 | 237.6 | 2,744.6 | 926.6 | 1,089.3 |
| 20.3 | 19.7 | 26.4 | 25.7 | 8.6 | 18.6 | 35.8 | 31.5 | 27.1 | 11.9 | 5.1 | 58.9 | 19.9 | 23.4 |
| 0.8 | 0.6 | 0.6 | 0.6 | 1.9 | 1.0 | 0.7 | 0.8 | 1.0 | 1.7 | 0.6 | 3.2 | 1.2 | 1.4 |
| 2.1 | 2.0 | 2.0 | 2.0 | 4.5 | 2.9 | 1.9 | 2.0 | 2.9 | 4.7 | 1.8 | 8.6 | 3.1 | 3.3 |
| 359.2 | 431.7 | 610.0 | 300.0 | 171.6 | 427.2 | 826.6 | 560.5 | 413.8 | 611.5 | 92.4 | 1,396.7 | 409.3 | 468.1 |
| 7.7 | 9.3 | 13.1 | 6.4 | 3.7 | 9.2 | 17.7 | 12.0 | 8.9 | 13.1 | 2.0 | 30.0 | 8.7 | 10.0 |
| 1.6 | 1.5 | 1.2 | 2.8 | 4.5 | 1.9 | 1.3 | 2.1 | 2.6 | 1.4 | 1.2 | 18.6 | 2.6 | 3.9 |
| 4.5 | 3.4 | 3.6 | 8.2 | 9.9 | 5.3 | 3.8 | 4.8 | 7.8 | 3.8 | 2.8 | 22.2 | 6.9 | 7.9 |
| 38.1 | 46.9 | 49.6 | 25.0 | 42.9 | 49.3 | 49.6 | 38.2 | 32.8 | 110.1 | 20.5 | 110.1 | 46.7 | 45.2 |
| 37.3 | 20.3 | 39.7 | 53.5 | 36.8 | 63.9 | 54.5 | 61.7 | 68.5 | 35.0 | 18.2 | 218.7 | 41.1 | 73.7 |
| 5.58 | 6.13 | 6.03 | 5.61 | 6.10 | 5.87 | 6.04 | 5.85 | 5.26 | 5.08 | 3.88 | 6.87 | 5.61 | 5.62 |
| 6.46 | 5.23 | 5.05 | 5.65 | 4.67 | 5.64 | 5.00 | 4.70 | 5.09 | 5.32 | 3.97 | 6.46 | 5.13 | 5.12 |
| 5.79 | 5.89 | 5.66 | 5.63 | 5.61 | 5.72 | 5.67 | 5.27 | 5.26 | 5.16 | 3.91 | 6.70 | 5.39 | 5.39 |
| 0.09 | 0.04 | 0.06 | 0.16 | 0.19 | 0.13 | 0.06 | 0.10 | 0.15 | 0.05 | 0.04 | 0.63 | 0.11 | 0.16 |
| 0.71 | 0.38 | 0.75 | 1.01 | 0.70 | 1.21 | 1.03 | 1.17 | 1.30 | 0.66 | 0.34 | 4.13 | 0.78 | 1.39 |
| 10.0 | 14.3 | 21.5 | 10.8 | 10.7 | 22.6 | 52.4 | 24.9 | 18.0 | 38.4 | 8.2 | 77.7 | 19.6 | 27.8 |
| 21.3 | 24.4 | 42.4 | 29.4 | 16.3 | 52.7 | 60.2 | 57.8 | 44.9 | 50.7 | 12.1 | 128.8 | 34.4 | 45.7 |
| 68.6 | 59.0 | 103.6 | 93.7 | 63.8 | 139.1 | 167.1 | 144.5 | 131.4 | 124.0 | 42.0 | 369.9 | 95.1 | 147.2 |

*for Southwestern Manitoba (Minor Reference Area 061), 1955–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1955–73 |
| 400.8 | 261.2 | 301.6 | 303.8 | 254.5 | 342.8 | 472.1 | 305.1 | 364.0 | 253.7 | 203.2 | 849.0 | 316.7 | 406.1 |
| 10.6 | 6.9 | 8.0 | 8.1 | 6.7 | 9.1 | 12.5 | 8.1 | 9.7 | 6.7 | 5.4 | 22.5 | 8.4 | 10.8 |
| 46.1 | 44.4 | 47.6 | 49.9 | 34.8 | 47.3 | 51.0 | 36.3 | 52.5 | 31.7 | 31.0 | 71.2 | 42.8 | 44.8 |
| 701.3 | 732.9 | 818.1 | 784.5 | 319.2 | 430.1 | 749.5 | 737.2 | 726.4 | 237.8 | 237.8 | 1,391.6 | 586.1 | 646.0 |
| 20.4 | 21.3 | 23.8 | 22.8 | 9.3 | 12.5 | 21.8 | 21.4 | 21.1 | 6.9 | 6.9 | 40.5 | 17.0 | 18.8 |
| 0.6 | 0.4 | 0.4 | 0.4 | 0.8 | 0.8 | 0.6 | 0.4 | 0.5 | 1.1 | 0.4 | 1.4 | 0.6 | 0.7 |
| 2.5 | 2.3 | 2.2 | 2.4 | 4.1 | 4.1 | 2.6 | 1.9 | 2.7 | 5.0 | 1.1 | 5.0 | 3.0 | 3.0 |
| 411.5 | 350.7 | 375.4 | 250.2 | 143.3 | 324.2 | 386.4 | 371.3 | 260.0 | 204.7 | 115.7 | 592.7 | 284.6 | 320.2 |
| 12.0 | 10.2 | 10.9 | 7.3 | 4.2 | 9.4 | 11.2 | 10.8 | 7.6 | 6.0 | 3.4 | 17.2 | 8.3 | 9.3 |
| 0.8 | 1.0 | 1.2 | 1.7 | 2.5 | 1.3 | 1.4 | 1.1 | 1.3 | 1.1 | 0.8 | 4.9 | 1.4 | 1.8 |
| 3.3 | 3.9 | 4.1 | 7.0 | 8.6 | 5.1 | 5.1 | 3.8 | 6.9 | 5.3 | 3.8 | 17.3 | 6.2 | 6.0 |
| 58.7 | 47.9 | 45.9 | 31.9 | 44.9 | 75.4 | 51.6 | 50.4 | 36.0 | 86.8 | 30.5 | 86.8 | 50.9 | 52.0 |
| 31.9 | 21.4 | 36.5 | 42.0 | 24.9 | 36.9 | 31.2 | 24.2 | 33.9 | 16.6 | 16.6 | 72.3 | 29.9 | 35.0 |
| 5.38 | 5.51 | 5.61 | 5.73 | 5.77 | 6.11 | 5.80 | 5.41 | 5.20 | 5.42 | 5.10 | 7.91 | 5.59 | 5.80 |
| 4.84 | 5.59 | 4.55 | 5.35 | 4.75 | 4.62 | 5.31 | 5.15 | 5.95 | 5.73 | 4.55 | 6.46 | 5.16 | 5.27 |
| 5.28 | 5.51 | 5.37 | 5.59 | 5.43 | 5.91 | 5.70 | 5.24 | 5.27 | 5.42 | 5.09 | 6.68 | 5.44 | 5.56 |
| 0.07 | 0.06 | 0.09 | 0.15 | 0.16 | 0.10 | 0.07 | 0.06 | 0.12 | 0.07 | 0.05 | 0.29 | 0.11 | 0.11 |
| 0.85 | 0.57 | 0.97 | 1.11 | 0.66 | 0.98 | 0.83 | 0.64 | 0.90 | 0.44 | 0.44 | 1.92 | 0.79 | 0.93 |
| 11.5 | 16.0 | 8.9 | 11.0 | 5.7 | 18.0 | 14.7 | 17.9 | 15.1 | 14.4 | 5.7 | 25.8 | 13.2 | 15.3 |
| 31.9 | 31.3 | 25.6 | 23.0 | 14.2 | 41.7 | 28.0 | 26.4 | 18.8 | 15.1 | 13.8 | 75.8 | 25.0 | 30.1 |
| 75.4 | 68.7 | 71.0 | 76.0 | 44.9 | 96.7 | 73.9 | 68.6 | 67.8 | 46.0 | 44.9 | 160.5 | 68.1 | 80.5 |

*Saskatchewan—Southeastern Mackenzie (Minor Reference Area 071), 1955–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1955–73 |
| 579.7 | 456.1 | 381.8 | 750.8 | 548.8 | 652.3 | 884.6 | 520.7 | 414.8 | 422.8 | 263.3 | 884.6 | 499.8 | 490.9 |
| 4.4 | 3.5 | 2.9 | 5.7 | 4.2 | 5.0 | 6.7 | 4.0 | 3.1 | 3.2 | 2.0 | 6.7 | 3.8 | 3.7 |
| 20.1 | 12.0 | 10.1 | 10.2 | 11.6 | 12.1 | 17.4 | 12.9 | 12.5 | 12.1 | 5.6 | 20.1 | 12.2 | 10.9 |
| | | | | | | | | | | | | 1962–73 | |
| 112.3 | 37.5 | 55.5 | 99.4 | 153.1 | 153.5 | 84.7 | 78.7 | 97.1 | 51.8 | 35.1 | 153.5 | 84.8 | |
| 5.59 | 5.62 | 5.72 | 5.20 | 6.45 | 5.80 | 6.40 | 5.34 | 5.63 | 5.78 | 4.85 | 6.45 | 5.67 | |
| 5.01 | 4.91 | 5.14 | 3.85 | 5.52 | 5.48 | 5.99 | 5.76 | 4.42 | 5.01 | 3.39 | 5.99 | 4.98 | |
| 5.46 | 5.40 | 5.47 | 4.69 | 6.06 | 5.66 | 6.18 | 5.57 | 5.21 | 5.78 | 4.69 | 6.18 | 5.46 | |
| 0.85 | 0.29 | 0.42 | 0.75 | 1.16 | 1.17 | 0.64 | 0.60 | 0.74 | 0.39 | 0.27 | 1.17 | 0.64 | |
| 21.6 | 14.3 | 12.8 | 13.2 | 18.6 | 17.3 | 26.8 | 20.1 | 11.0 | 8.0 | 8.0 | 28.7 | 17.8 | |
| 51.9 | 41.4 | 39.6 | 27.0 | 25.1 | 84.4 | 52.9 | 38.2 | 32.6 | 24.6 | 24.6 | 84.4 | 45.4 | |
| 185.7 | 93.2 | 108.0 | 139.6 | 196.8 | 255.2 | 164.4 | 137.0 | 140.7 | 84.4 | 84.4 | 255.2 | 148.1 | |

TABLE B–11. *Summary of breeding population and habitat statistics for Northern*
*(Data compiled from May Breeding*

| Statistic | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
| Mallard population estimate (thousands) | 197.5 | 266.2 | 185.0 | 410.7 | 225.9 | 153.0 | 203.7 | 207.5 | 169.6 |
| Mallard density (birds per square mile) | 2.2 | 3.0 | 2.1 | 4.6 | 2.5 | 1.7 | 2.3 | 2.3 | 1.9 |
| Density of other ducks (birds per square mile) | 6.4 | 3.3 | 7.8 | 7.4 | 12.6 | 8.4 | 6.1 | 6.6 | 6.3 |
| Total brood index (all ducks) | | | | | 20.8 | 25.4 | 51.4 | 20.1 | 20.0 |
| Broods per square mile | | | | | 0.25 | 0.30 | 0.61 | 0.24 | 0.24 |
| Mallard late nesting index (thousands) | | | | | 16.5 | 6.2 | 10.2 | 7.7 | 11.3 |
| Late nesting index other ducks (thousands) | | | | | 16.8 | 22.6 | 28.0 | 17.9 | 31.7 |
| Late nesting index + broods (all ducks) | | | | | 37.6 | 48.0 | 74.0 | 38.0 | 51.7 |

TABLE B–12. *Summary of breeding population and habitat statistics*
*(Data compiled from May Breeding*

| Statistic | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
| Mallard population estimate (thousands) | 35.5 | 158.3 | 59.8 | 124.1 | 109.7 | 169.7 | 141.0 | 312.0 | 160.0 |
| Mallard density (birds per square mile) | 0.2 | 0.9 | 0.3 | 0.7 | 0.6 | 1.0 | 0.8 | 1.8 | 0.9 |
| Density of other ducks (birds per square mile) | 1.7 | 3.6 | 1.2 | 2.8 | 3.7 | 3.5 | 3.1 | 5.3 | 3.8 |
| Total brood index (all ducks) | | | | | | 25.6 | | 26.6 | 19.3 |
| Average class II brood size (all ducks) | | | | | | 4.93 | | 5.76 | 5.20 |
| Average class III brood size (all ducks) | | | | | | 4.54 | | 4.71 | 6.00 |
| Average brood size (all ducks) | | | | | | 4.69 | | 5.50 | 5.29 |
| Broods per square mile | | | | | | 0.14 | | 0.15 | 0.11 |
| Mallard late nesting index (thousands) | | | | | | 3.0 | | 2.8 | 12.2 |
| Late nesting index other ducks (thousands) | | | | | | 36.3 | | 42.8 | 47.0 |
| Late nesting index + broods (all ducks) | | | | | | 64.8 | | 72.2 | 78.5 |

TABLE B–13. *Summary of breeding population and habitat statistics*
*(Data compiled from May Breeding*

| Statistic | Year | | | |
|---|---|---|---|---|
| | 1965 | 1966 | 1967 | 1968 |
| Mallard population estimate (thousands) | 124.4 | 195.7 | 134.9 | 67.9 |
| Mallard density (birds per square mile) | 7.6 | 12.0 | 8.3 | 4.2 |
| Density of other ducks (birds per square mile) | 24.6 | 22.0 | 24.6 | 11.2 |
| May pond estimate (thousands) | 57.9 | 51.2 | 42.7 | 26.0 |
| May pond density (ponds per square mile) | 3.6 | 3.1 | 2.6 | 1.6 |
| Mallards per May pond | 2.1 | 3.8 | 3.2 | 2.6 |
| Other ducks per May pond | 6.9 | 7.0 | 9.4 | 7.0 |
| July pond estimate (thousands) | | 30.7 | 28.2 | 21.6 |
| July pond density (ponds per square mile) | | 1.9 | 1.7 | 1.3 |
| Breeding mallards per July pond | | 7.4 | 4.4 | 3.5 |
| Other breeding ducks per July pond | | 16.3 | 16.3 | 12.1 |
| Percent of ponds remaining (May-July) | | 59.9 | 66.0 | 83.1 |
| Total brood index (all ducks) | | 17.7 | 14.1 | 11.9 |
| Average class II brood size (all ducks) | | 5.19 | 5.18 | 5.26 |
| Average class III brood size (all ducks) | | 5.15 | 4.71 | 4.57 |
| Average brood size (all ducks) | | 5.18 | 4.95 | 4.90 |
| Broods per July pond | | 0.58 | 0.50 | 0.55 |
| Broods per square mile | | 1.09 | 0.87 | 0.73 |
| Mallard late nesting index (thousands) | | 0.7 | 1.3 | 1.2 |
| Late nesting index other ducks (thousands) | | 1.4 | 2.4 | 2.2 |
| Late nesting index + broods (all ducks) | | 19.8 | 17.8 | 15.3 |

*Manitoba—Southwestern Keewatin (Minor Reference Area 072), 1955–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1955–73 |
| 144.9 | 282.5 | 119.9 | 461.0 | 514.9 | 556.0 | 800.2 | 329.6 | 252.7 | 336.1 | 119.9 | 800.2 | 336.8 | 306.2 |
| 1.6 | 3.2 | 1.3 | 5.2 | 5.8 | 6.2 | 8.9 | 3.7 | 2.8 | 3.8 | 1.3 | 8.9 | 3.8 | 3.4 |
| 5.9 | 8.0 | 6.8 | 10.0 | 18.0 | 18.7 | 20.9 | 12.0 | 12.3 | 9.2 | 3.3 | 20.9 | 10.6 | 9.7 |
| 41.4 | 17.2 | 43.2 | 69.1 | 71.6 | 120.0 | 84.5 | 75.8 | 42.7 | 35.7 | 17.2 | 120.0 | 53.3 | 49.3 |
| 0.49 | 0.21 | 0.52 | 0.82 | 0.85 | 1.43 | 1.01 | 0.90 | 0.48 | 0.40 | 0.21 | 1.43 | 0.63 | 0.58 |
| 9.4 | 8.5 | 4.7 | 10.2 | 6.6 | 14.7 | 14.5 | 12.1 | 7.3 | 6.9 | 4.7 | 16.5 | 9.5 | 9.8 |
| 29.3 | 22.0 | 24.7 | 23.8 | 15.1 | 62.4 | 36.0 | 35.2 | 28.5 | 13.0 | 13.0 | 62.4 | 28.3 | 27.1 |
| 70.7 | 39.2 | 67.9 | 92.9 | 86.7 | 182.4 | 120.5 | 111.0 | 78.4 | 55.7 | 37.6 | 182.4 | 82.2 | 77.0 |

*for Western Ontario (Minor Reference Area 073), 1955–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1955–73 |
| 189.6 | 46.1 | 133.4 | 147.6 | 105.3 | 117.7 | 134.2 | | 163.0 | 195.8 | 35.5 | 312.0 | 153.8 | 139.0 |
| 1.1 | 0.3 | 0.8 | 0.8 | 0.6 | 0.7 | 0.8 | | 0.9 | 1.1 | 0.2 | 1.8 | 0.9 | 0.8 |
| 3.3 | 1.5 | 4.0 | 3.5 | 6.9 | 4.1 | 4.2 | | 4.9 | 4.4 | 1.2 | 6.9 | 4.1 | 3.6 |
| | | | | | | | | | | | | 1960–64 | |
| 19.2 | | | | | | | | | | 19.2 | 26.6 | 22.7 | |
| 5.33 | | | | | | | | | | 4.93 | 5.76 | 5.30 | |
| 3.00 | | | | | | | | | | 3.00 | 6.00 | 4.56 | |
| 5.10 | | | | | | | | | | 4.69 | 5.50 | 5.14 | |
| 0.11 | | | | | | | | | | 0.11 | 0.15 | 0.13 | |
| 2.5 | | | | | | | | | | 2.5 | 12.2 | 5.1 | |
| 26.7 | | | | | | | | | | 26.7 | 47.0 | 38.2 | |
| 48.4 | | | | | | | | | | 48.4 | 78.5 | 66.0 | |

*for Western Montana (Minor Reference Area 112), 1965–73 Ground Survey and July Production Survey.)*

| Year | | | | | Range | | Averages |
|---|---|---|---|---|---|---|---|
| 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1965–1973 |
| 106.6 | 112.4 | 98.6 | 141.8 | 82.4 | 67.9 | 195.7 | 118.3 |
| 6.5 | 6.9 | 6.0 | 8.7 | 5.1 | 4.2 | 12.0 | 7.3 |
| 22.2 | 17.2 | 12.9 | 18.2 | 12.6 | 11.2 | 24.6 | 18.4 |
| 66.2 | 56.3 | 59.3 | 70.7 | 49.5 | 26.0 | 70.7 | 53.3 |
| 4.1 | 3.5 | 3.6 | 4.3 | 3.0 | 1.6 | 4.3 | 3.3 |
| 1.6 | 2.0 | 1.7 | 2.0 | 1.7 | 1.6 | 3.8 | 2.3 |
| 5.5 | 5.0 | 3.6 | 4.2 | 4.2 | 3.6 | 9.4 | 5.9 |
| | | | | | | | 1966–73 |
| 44.3 | 29.8 | | 60.0 | 52.5 | 21.6 | 60.0 | 38.2 |
| 2.7 | 1.8 | | 3.7 | 3.2 | 1.3 | 3.7 | 2.3 |
| 2.3 | 3.8 | | 2.4 | 1.6 | 1.6 | 7.4 | 3.6 |
| 9.9 | 11.9 | | 4.9 | 3.9 | 3.9 | 16.3 | 10.8 |
| 66.9 | 52.9 | | 85.3 | 105.4 | 52.9 | 105.4 | 74.2 |
| 19.5 | 12.8 | | 20.2 | 12.2 | 11.9 | 20.2 | 15.5 |
| 5.41 | 5.48 | | 5.86 | 5.15 | 5.15 | 5.86 | 5.36 |
| 5.38 | 5.30 | | 5.47 | 5.39 | 4.57 | 5.47 | 5.14 |
| 5.39 | 5.39 | | 5.60 | 5.29 | 4.90 | 5.60 | 5.24 |
| 0.44 | 0.43 | | 0.34 | 0.23 | 0.23 | 0.58 | 0.44 |
| 1.20 | 0.78 | | 1.24 | 0.75 | 0.73 | 1.24 | 0.95 |
| 3.4 | 0.3 | | 3.0 | 2.5 | 0.3 | 3.4 | 1.8 |
| 3.6 | 2.6 | | 7.0 | 2.8 | 1.4 | 7.0 | 3.1 |
| 26.5 | 15.7 | | 30.2 | 17.5 | 15.3 | 30.2 | 20.4 |

TABLE B–14. *Summary of breeding population and habitat statistics (Data compiled from May Breeding*

| Statistic | Year 1965 | 1966 | 1967 | 1968 |
|---|---|---|---|---|
| Mallard population estimate (thousands) | 376.6 | 479.1 | 307.5 | 205.8 |
| Mallard density (birds per square mile) | 6.6 | 8.3 | 5.4 | 3.6 |
| Density of other ducks (birds per square mile) | 12.9 | 13.3 | 13.0 | 8.9 |
| May pond estimate (thousands) | 174.6 | 153.3 | 125.1 | 90.1 |
| May pond density (ponds per square mile) | 3.0 | 2.7 | 2.2 | 1.6 |
| Mallards per May pond | 2.2 | 3.1 | 2.5 | 2.3 |
| Other ducks per May pond | 4.2 | 5.0 | 6.0 | 5.6 |
| July pond estimate (thousands) | | 97.5 | 96.9 | 78.2 |
| July pond density (ponds per square mile) | | 1.7 | 1.7 | 1.4 |
| Breeding mallards per July pond | | 5.5 | 2.9 | 2.9 |
| Other breeding ducks per July pond | | 10.9 | 8.9 | 9.3 |
| Percent of ponds remaining (May-July) | | 63.6 | 77.5 | 86.8 |
| Total brood index (all ducks) | | 46.6 | 31.8 | 31.4 |
| Average class II brood size (all ducks) | | 4.85 | 4.88 | 5.13 |
| Average class III brood size (all ducks) | | 4.62 | 4.66 | 4.40 |
| Average brood size (all ducks) | | 4.79 | 4.75 | 4.74 |
| Broods per July pond | | 0.48 | 0.33 | 0.40 |
| Broods per square mile | | 0.80 | 0.55 | 0.55 |
| Mallard late nesting index (thousands) | | 2.5 | 3.7 | 2.3 |
| Late nesting index other ducks (thousands) | | 5.6 | 5.0 | 6.5 |
| Late nesting index + broods (all ducks) | | 54.8 | 40.5 | 40.2 |

TABLE B–15. *Summary of breeding population and habitat statistics (Data compiled from May Breeding*

| Statistic | Year 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 55.4 | 27.8 | 30.5 | 26.0 | 37.5 | 33.4 | 42.7 | 25.8 |
| Mallard density (birds per square mile) | 2.8 | 1.4 | 1.5 | 1.3 | 1.9 | 1.7 | 2.1 | 1.3 |
| Density of other ducks (birds per square mile) | 4.9 | 2.5 | 6.1 | 4.2 | 8.1 | 6.7 | 5.3 | 8.1 |
| May pond estimate (thousands) | 49.4 | 25.1 | 40.0 | 14.7 | 38.2 | 75.4 | 36.2 | 74.7 |
| May pond density (ponds per square mile) | 2.5 | 1.3 | 2.0 | 0.7 | 1.9 | 3.8 | 1.8 | 3.7 |
| Mallards per May pond | 1.1 | 1.1 | 0.8 | 1.8 | 1.0 | 0.4 | 1.2 | 0.3 |
| Other ducks per May pond | 2.0 | 2.0 | 3.0 | 5.7 | 4.3 | 1.8 | 2.9 | 2.2 |
| July pond estimate (thousands) | | | | | | | | |
| July pond density (ponds per square mile) | | | | | | | | |
| Breeding mallards per July pond | | | | | | | | |
| Other breeding ducks per July pond | | | | | | | | |
| Percent of ponds remaining (May-July | | | | | | | | |
| Total brood index (all ducks) | | | | | | | | |
| Average class II brood size (all ducks) | | | | | | | | |
| Average class III brood size (all ducks) | | | | | | | | |
| Average brood size (all ducks) | | | | | | | | |
| Broods per July pond | | | | | | | | |
| Broods per square mile | | | | | | | | |
| Mallard late nesting index (thousands) | | | | | | | | |
| Late nesting index other ducks (thousands) | | | | | | | | |
| Late nesting index + broods (all ducks) | | | | | | | | |

TABLE B–16. *Summary of breeding population and habitat statistics (Data compiled from May Breeding*

| Statistic | Year 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 47.6 | 60.7 | 77.2 | 105.0 | 167.8 | 79.1 | 104.4 |
| Mallard density (birds per square mile) | 1.9 | 2.5 | 3.2 | 4.3 | 6.9 | 3.2 | 4.3 |
| Density of other ducks (birds per square mile) | 4.3 | 3.3 | 11.4 | 9.2 | 12.9 | 7.0 | 7.9 |
| May pond estimate (thousands) | 37.7 | 53.7 | 32.4 | 72.4 | 82.7 | 59.3 | 76.7 |
| May pond density (ponds per square mile) | 1.5 | 2.2 | 1.3 | 3.0 | 3.4 | 2.4 | 3.1 |
| Mallards per May pond | 1.3 | 1.1 | 2.4 | 1.5 | 2.0 | 1.3 | 1.4 |
| Other ducks per May pond | 2.8 | 1.5 | 8.6 | 3.1 | 3.8 | 2.9 | 2.5 |
| July pond estimate (thousands) | | | | | | | |
| July pond density (ponds per square mile) | | | | | | | |
| Breeding mallards per July pond | | | | | | | |
| Other breeding ducks per July pond | | | | | | | |
| Percent of ponds remaining (May-July) | | | | | | | |
| Total brood index (all ducks) | | | | | | | |
| Average class II brood size (all ducks) | | | | | | | |
| Average class III brood size (all ducks) | | | | | | | |
| Average brood size (all ducks) | | | | | | | |
| Broods per July pond | | | | | | | |
| Broods per square mile | | | | | | | |
| Mallard late nesting index (thousands) | | | | | | | |
| Late nesting index other ducks (thousands) | | | | | | | |
| Late nesting index + broods (all ducks) | | | | | | | |

*for Eastern Montana (Minor Reference Area 121), 1965–73 Ground Survey and July Production Survey.)*

| Year | | | | | Range | | Averages |
|---|---|---|---|---|---|---|---|
| 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1965–1973 |
| 295.0 | 317.1 | 279.0 | 374.2 | 277.8 | 205.8 | 479.1 | 323.6 |
| 5.1 | 5.5 | 4.9 | 6.5 | 4.8 | 3.6 | 8.4 | 5.6 |
| 13.4 | 11.9 | 8.3 | 11.7 | 10.6 | 8.3 | 13.4 | 11.6 |
| 187.9 | 202.7 | 196.4 | 212.6 | 183.9 | 90.1 | 212.6 | 169.6 |
| 3.3 | 3.5 | 3.4 | 3.7 | 3.2 | 1.6 | 3.7 | 3.0 |
| 1.6 | 1.6 | 1.4 | 1.8 | 1.5 | 1.4 | 3.1 | 2.0 |
| 4 1 | 3.4 | 2.4 | 3.2 | 3.3 | 2.4 | 6.0 | 4.1 |
| | | | | | | | 1966–73 |
| 140.1 | 107.9 | | 197.4 | 189.4 | 78.2 | 197.4 | 129.6 |
| 2.4 | 1.9 | | 3.4 | 3.3 | 1.4 | 3.4 | 2.3 |
| 2.0 | 2.8 | | 1.9 | 1.5 | 1.5 | 5.5 | 2.8 |
| 6.5 | 8.0 | | 3.4 | 3.2 | 3.2 | 10.9 | 7.2 |
| 74.6 | 53.2 | | 91.8 | 103.0 | 53.2 | 103.0 | 78.6 |
| 48.7 | 33.4 | | 48.8 | 32.9 | 31.4 | 48.8 | 39.1 |
| 4.94 | 5.50 | | 5.49 | 5.06 | 4.85 | 5.50 | 5.12 |
| 5.26 | 5.26 | | 5.48 | 5.15 | 4.40 | 5.48 | 4.98 |
| 5.16 | 5.38 | | 5.49 | 5.12 | 4.74 | 5.45 | 5.06 |
| 0.35 | 0.31 | | 0.25 | 0.17 | 0.17 | 0.48 | 0.33 |
| 0.85 | 0.58 | | 0.85 | 0.57 | 0.55 | 0.85 | 0.68 |
| 9.5 | 1.0 | | 9.9 | 9.8 | 1.0 | 9.9 | 5.5 |
| 7.1 | 7.2 | | 19.1 | 11.1 | 5.0 | 19.1 | 8.8 |
| 65.3 | 41.6 | | 77.8 | 53.8 | 40.2 | 77.8 | 53.4 |

*for Western North Dakota (Minor Reference Area 122), 1958–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1958–73 |
| 28.8 | 164.2 | 81.6 | 133.0 | 134.3 | 117.8 | 158.3 | 122.9 | 25.8 | 164.0 | 85.1 | 76.2 |
| 1.4 | 8.2 | 4.1 | 6.6 | 6.7 | 5.9 | 7.9 | 6.1 | 1.3 | 8.2 | 4.1 | 3.8 |
| 10.5 | 24.5 | 10.1 | 19.7 | 23.8 | 19.8 | 22.7 | 18.2 | 2.5 | 24.5 | 13.7 | 12.2 |
| 90.9 | 77.8 | 65.4 | 112.7 | 130.0 | 124.2 | 146.7 | 91.5 | 14.7 | 146.7 | 83.0 | 74.6 |
| 4.5 | 3.9 | 3.3 | 5.6 | 6.5 | 6.2 | 7.3 | 4.6 | 0.7 | 7.3 | 4.1 | 3.7 |
| 0.3 | 2.1 | 1.2 | 1.2 | 1.0 | 0.9 | 1.1 | 1.3 | 0.3 | 2.1 | 1.1 | 1.0 |
| 2.3 | 6.3 | 3.1 | 3.5 | 3.7 | 3.2 | 3.1 | 4.0 | 1.8 | 6.3 | 3.5 | 3.3 |
| | | | | | | | | | | 1966–73 | |
| 58.0 | 50.7 | 51.2 | 96.0 | 64.3 | 111.0 | 78.4 | 85.2 | 50.7 | 111.0 | 74.4 | |
| 2.9 | 2.5 | 2.6 | 4.8 | 3.2 | 5.6 | 3.9 | 4.3 | 2.5 | 5.6 | 3.7 | |
| 1.4 | 3.5 | 1.4 | 1.5 | 2.4 | 1.2 | 2.0 | 1.4 | 1.2 | 3.5 | 1.9 | |
| 7.7 | 12.1 | 3.9 | 5.0 | 9.9 | 3.6 | 5.8 | 4.2 | 3.6 | 12.1 | 6.5 | |
| 63.8 | 65.2 | 78.3 | 85.2 | 49.5 | 89.4 | 53.2 | 94.0 | 49.5 | 94.0 | 72.3 | |
| 9.9 | 6.9 | 6.2 | 13.3 | 11.7 | 8.2 | 13.6 | 17.0 | 6.2 | 17.0 | 10.9 | |
| 6.18 | 5.96 | 5.01 | 5.94 | 7.05 | 6.24 | 6.14 | 5.48 | 5.01 | 7.05 | 6.00 | |
| 5.13 | 4.10 | 4.80 | 5.33 | 6.03 | 5.96 | 5.76 | 4.89 | 4.10 | 6.03 | 5.25 | |
| 5.56 | 4.87 | 4.96 | 5.57 | 6.42 | 6.20 | 5.95 | 5.19 | 4.87 | 6.42 | 5.59 | |
| 0.17 | 0.14 | 0.12 | 0.14 | 0.18 | 0.07 | 0.17 | 0.20 | 0.07 | 0.20 | 0.15 | |
| 0.50 | 0.34 | 0.31 | 0.66 | 0.58 | 0.41 | 0.68 | 0.85 | 0.31 | 0.85 | 0.54 | |
| 3.9 | 5.5 | 3.5 | 4.3 | 1.9 | 2.3 | 1.3 | 3.1 | 1.3 | 5.5 | 3.2 | |
| 3.1 | 3.8 | 1.8 | 6.3 | 3.1 | 3.2 | 6.2 | 3.3 | 1.8 | 6.3 | 3.9 | |
| 16.8 | 16.2 | 11.6 | 23.8 | 16.6 | 13.7 | 21.1 | 23.4 | 11.6 | 23.8 | 17.9 | |

*for Western South Dakota (Minor Reference Area 124), 1959–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1959–73 |
| 62.8 | 155.5 | 166.6 | 234.3 | 154.2 | 166.3 | 248.4 | 145.9 | 47.6 | 248.4 | 143.7 | 131.7 |
| 2.6 | 6.3 | 6.8 | 9.6 | 6.3 | 6.8 | 10.1 | 6.0 | 1.9 | 10.1 | 5.9 | 5.4 |
| 10.5 | 13.0 | 13.3 | 12.6 | 14.1 | 13.6 | 32.5 | 17.3 | 3.3 | 32.5 | 13.5 | 12.2 |
| 89.4 | 83.7 | 68.3 | 144.8 | 139.0 | 131.4 | 183.0 | 136.5 | 32.4 | 183.0 | 100.0 | 92.7 |
| 3.6 | 3.4 | 2.8 | 5.9 | 5.7 | 5.4 | 7.5 | 5.6 | 1.3 | 7.5 | 4.1 | 3.8 |
| 0.7 | 1.9 | 2.4 | 1.6 | 1.1 | 1.3 | 1.4 | 1.1 | 0.7 | 2.4 | 1.5 | 1.5 |
| 2.9 | 3.8 | 4.8 | 2.1 | 2.5 | 2.5 | 4.3 | 3.1 | 1.5 | 8.6 | 3.6 | 3.4 |
| | | | | | | | | | | 1966–73 | |
| 60.1 | 91.2 | 53.8 | 84.8 | 71.1 | 104.0 | 126.3 | 104.4 | 53.8 | 126.3 | 87.0 | |
| 2.5 | 3.7 | 2.2 | 3.5 | 2.9 | 4.2 | 5.2 | 4.3 | 2.2 | 5.2 | 3.6 | |
| 1.3 | 1.7 | 3.3 | 3.0 | 2.6 | 2.1 | 2.0 | 1.4 | 1.3 | 3.3 | 2.2 | |
| 5.9 | 4.5 | 7.7 | 4.4 | 6.7 | 3.7 | 6.2 | 4.0 | 3.7 | 7.7 | 5.4 | |
| 67.2 | 109.0 | 78.8 | 58.6 | 51.2 | 79.1 | 69.6 | 77.2 | 51.2 | 109.0 | 73.8 | |
| 11.6 | 12.5 | 11.6 | 16.9 | 10.2 | 7.1 | 25.3 | 21.1 | 7.1 | 25.3 | 14.5 | |
| 8.00 | 4.37 | 4.47 | 5.53 | 5.06 | 6.40 | 5.24 | 4.10 | 4.10 | 8.00 | 5.40 | |
| 5.55 | 3.88 | 4.60 | 4.72 | 4.54 | 4.07 | 4.85 | 4.37 | 3.88 | 5.55 | 4.57 | |
| 7.09 | 4.26 | 4.55 | 5.01 | 4.80 | 5.54 | 5.05 | 4.25 | 4.25 | 7.09 | 5.07 | |
| 0.19 | 0.14 | 0.22 | 0.20 | 0.14 | 0.07 | 0.20 | 0.20 | 0.07 | 0.22 | 0.17 | |
| 0.48 | 0.51 | 0.47 | 0.69 | 0.41 | 0.29 | 1.03 | 0.86 | 0.29 | 1.03 | 0.59 | |
| 5.7 | 4.8 | 3.3 | 7.0 | 5.1 | 3.4 | 6.7 | 6.3 | 3.3 | 7.0 | 5.3 | |
| 6.6 | 4.5 | 3.7 | 6.4 | 7.6 | 1.6 | 11.9 | 9.7 | 1.6 | 11.9 | 6.5 | |
| 23.9 | 21.9 | 18.6 | 30.3 | 22.8 | 12.1 | 43.9 | 37.2 | 12.1 | 43.9 | 26.3 | |

TABLE B–17. *Summary of breeding population and habitat statistics (Data compiled from May Breeding*

| Statistic | Year 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 374.8 | 148.0 | 283.5 | 262.3 | 262.2 | 434.2 | 371.9 | 362.9 |
| Mallard density (birds per square mile) | 7.7 | 3.1 | 5.8 | 5.4 | 5.4 | 9.0 | 7.7 | 7.5 |
| Density of other ducks (birds per square mile) | 19.7 | 11.0 | 32.4 | 19.5 | 43.3 | 36.0 | 25.7 | 43.4 |
| May pond estimate (thousands) | 210.9 | 100.0 | 332.1 | 70.2 | 230.3 | 351.4 | 154.8 | 304.2 |
| May pond density (ponds per square mile) | 4.3 | 2.1 | 6.8 | 1.4 | 4.7 | 7.2 | 3.2 | 6.3 |
| Mallards per May pond | 1.8 | 1.5 | 0.9 | 3.7 | 1.1 | 1.2 | 2.4 | 1.2 |
| Other ducks per May pond | 4.5 | 5.3 | 4.7 | 13.4 | 9.1 | 5.0 | 8.0 | 6.9 |
| July pond estimate (thousands) | | | | | | | | |
| July pond density (ponds per square mile) | | | | | | | | |
| Breeding mallards per July pond | | | | | | | | |
| Other breeding ducks per July pond | | | | | | | | |
| Percent of ponds remaining (May-July) | | | | | | | | |
| Total brood index (all ducks) | | | | | | | | |
| Average class II brood size (all ducks) | | | | | | | | |
| Average class III brood size (all ducks) | | | | | | | | |
| Average brood size (all ducks) | | | | | | | | |
| Broods per July pond | | | | | | | | |
| Broods per square mile | | | | | | | | |
| Mallard late nesting index (thousands) | | | | | | | | |
| Late nesting index other ducks (thousands) | | | | | | | | |
| Late nesting index + broods (all ducks) | | | | | | | | |

TABLE B–18. *Summary of breeding population and habitat statistics (Data compiled from May Breeding*

| Statistic | Year 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 79.9 | 142.8 | 200.5 | 374.7 | 415.5 | 300.4 | 242.8 |
| Mallard density (birds per square mile) | 1.8 | 3.3 | 4.6 | 8.7 | 9.6 | 6.9 | 5.6 |
| Density of other ducks (birds per square mile) | 9.7 | 22.0 | 25.4 | 43.5 | 47.6 | 23.5 | 26.1 |
| May pond estimate (thousands) | 60.6 | 173.6 | 83.1 | 245.1 | 246.5 | 138.6 | 161.1 |
| May pond density (ponds per square mile) | 1.4 | 4.0 | 1.9 | 5.7 | 5.7 | 3.2 | 3.7 |
| Mallards per May pond | 1.3 | 0.8 | 2.4 | 1.5 | 1.7 | 2.2 | 1.5 |
| Other ducks per May pond | 6.9 | 5.5 | 13.2 | 7.7 | 8.3 | 7.3 | 7.0 |
| July pond estimate (thousands) | | | | | | | |
| July pond density (ponds per square mile) | | | | | | | |
| Breeding mallards per July pond | | | | | | | |
| Other breeding ducks per July pond | | | | | | | |
| Percent of ponds remaining (May-July) | | | | | | | |
| Total brood index (all ducks) | | | | | | | |
| Average class II brood size (all ducks) | | | | | | | |
| Average class III brood size (all ducks) | | | | | | | |
| Average brood size (all ducks) | | | | | | | |
| Broods per July pond | | | | | | | |
| Broods per square mile | | | | | | | |
| Mallard late nesting index (thousands) | | | | | | | |
| Late nesting index other ducks (thousands) | | | | | | | |
| Late nesting index + broods (all ducks) | | | | | | | |

TABLE B–19. *Summary of breeding population and habitat statistics (Data compiled from May Breeding*

| Statistic | Year 1958 | 1959 | 1960 | 1961 | 1962 |
|---|---|---|---|---|---|
| Mallard population estimate (thousands) | 105.1 | 124.5 | 65.0 | 99.0 | 59.2 |
| Mallard density (birds per square mile) | 2.9 | 3.4 | 1.8 | 2.7 | 1.6 |
| Density of other ducks (birds per square mile) | 4.1 | 10.3 | 8.9 | 14.4 | 15.8 |
| May pond estimate (thousands) | 154.3 | 98.4 | 118.5 | 91.8 | 143.9 |
| May pond density (ponds per square mile) | 4.2 | 2.7 | 3.2 | 2.5 | 3.9 |
| Mallards per May pond | 0.7 | 1.3 | 0.5 | 1.1 | 0.4 |
| Other ducks per May pond | 1.0 | 3.8 | 2.8 | 5.8 | 4.0 |
| July pond estimate (thousands) | 145.6 | 53.2 | 108.7 | 47.3 | 127.5 |
| July pond density (ponds per square mile) | 4.0 | 1.4 | 3.0 | 1.3 | 3.5 |
| Breeding mallards per July pond | 0.7 | 2.3 | 0.6 | 2.1 | 0.5 |
| Other breeding ducks per July pond | 1.0 | 7.1 | 3.0 | 11.2 | 4.5 |
| Percent of ponds remaining (May-July) | 94.4 | 54.1 | 91.7 | 51.5 | 88.6 |
| Total brood index (all ducks) | 11.4 | 2.6 | 16.3 | 6.5 | 5.8 |
| Average class II brood size (all ducks) | 5.31 | 4.33 | 4.50 | 4.50 | 5.00 |
| Average class III brood size (all ducks) | 5.60 | --- | 3.00 | 4.00 | 3.00 |
| Average brood size (all ducks) | 5.39 | 4.33 | 4.00 | 4.38 | 4.71 |
| Broods per July pond | 0.08 | 0.05 | 0.15 | 0.14 | 0.05 |
| Broods per square mile | 0.31 | 0.07 | 0.44 | 0.18 | 0.16 |
| Mallard late nesting index (thousands) | 0.5 | 0.9 | 0.0 | 2.7 | 6.4 |
| Late nesting index other ducks (thousands) | 7.1 | 0.0 | 13.6 | 4.3 | 5.8 |
| Late nesting index + broods (all ducks) | 19.0 | 3.5 | 29.9 | 13.5 | 18.0 |

*for Eastern North Dakota (Minor Reference Area 131), 1958–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1958–73 |
| 413.2 | 416.8 | 374.2 | 359.1 | 585.7 | 609.3 | 501.9 | 437.7 | 148.0 | 609.3 | 414.7 | 387.4 |
| 8.5 | 8.6 | 7.7 | 7.4 | 12.1 | 12.6 | 10.3 | 9.0 | 3.1 | 12.6 | 8.6 | 8.0 |
| 57.3 | 47.2 | 33.2 | 53.2 | 52.4 | 50.5 | 42.4 | 29.7 | 11.0 | 57.3 | 41.1 | 37.3 |
| 456.1 | 483.4 | 262.9 | 503.1 | 593.2 | 420.9 | 492.6 | 223.3 | 70.2 | 593.2 | 349.7 | 324.3 |
| 9.4 | 10.0 | 5.4 | 10.4 | 12.2 | 8.7 | 10.2 | 4.6 | 1.4 | 12.2 | 7.2 | 6.7 |
| 0.9 | 0.9 | 1.4 | 0.7 | 1.0 | 1.4 | 1.0 | 2.0 | 0.7 | 3.7 | 1.5 | 1.4 |
| 6.1 | 4.7 | 6.1 | 5.1 | 4.3 | 5.8 | 4.2 | 6.5 | 4.2 | 13.4 | 6.6 | 6.2 |
| | | | | | | | | | | 1966–73 | |
| 207.0 | 235.7 | 234.0 | 433.3 | 347.1 | 296.7 | 233.5 | 149.3 | 149.3 | 433.3 | 267.1 | |
| 4.3 | 4.9 | 4.8 | 8.9 | 7.2 | 6.1 | 4.8 | 3.1 | 3.1 | 8.9 | 5.5 | |
| 2.2 | 2.1 | 1.0 | 0.9 | 2.1 | 1.8 | 2.2 | 2.9 | 0.9 | 2.9 | 1.9 | |
| 13.2 | 11.0 | 6.1 | 6.7 | 10.5 | 7.2 | 8.8 | 9.6 | 6.1 | 13.2 | 9.1 | |
| 45.4 | 48.8 | 89.0 | 86.1 | 58.5 | 70.5 | 47.3 | 67.3 | 45.4 | 89.0 | 64.1 | |
| 40.5 | 42.0 | 20.4 | 36.1 | 44.3 | 29.3 | 38.3 | 18.1 | 18.1 | 44.3 | 33.6 | |
| 6.88 | 5.88 | 6.04 | 6.56 | 6.88 | 6.00 | 6.30 | 5.67 | 5.67 | 6.88 | 6.28 | |
| 5.77 | 4.79 | 5.21 | 6.17 | 5.97 | 4.26 | 4.62 | 4.48 | 4.26 | 6.17 | 5.16 | |
| 6.50 | 5.48 | 5.84 | 6.43 | 6.55 | 5.53 | 5.46 | 5.31 | 5.31 | 6.55 | 5.89 | |
| 0.20 | 0.18 | 0.09 | 0.08 | 0.13 | 0.10 | 0.16 | 0.12 | 0.08 | 0.20 | 0.13 | |
| 0.84 | 0.86 | 0.42 | 0.74 | 0.91 | 0.60 | 0.79 | 0.37 | 0.37 | 0.86 | 0.69 | |
| 13.9 | 18.2 | 9.5 | 9.6 | 16.8 | 12.1 | 12.3 | 7.3 | 7.3 | 18.2 | 12.5 | |
| 21.4 | 40.5 | 11.5 | 41.3 | 33.9 | 19.1 | 35.4 | 10.9 | 10.9 | 41.3 | 26.8 | |
| 75.9 | 100.7 | 41.4 | 86.9 | 95.0 | 60.4 | 86.0 | 36.3 | 36.3 | 100.7 | 72.8 | |

*for Eastern South Dakota (Minor Reference Area 132), 1959–73 Ground Survey and July Production Survey.)*

| Year | | | | | | | | Range | | Averages | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | Low | High | 1961–73 | 1959–73 |
| 172.0 | 144.9 | 337.1 | 287.2 | 310.4 | 287.7 | 326.7 | 331.7 | 79.9 | 415.5 | 287.0 | 263.6 |
| 4.0 | 3.4 | 7.8 | 6.6 | 7.2 | 6.7 | 7.6 | 7.7 | 1.8 | 9.6 | 6.6 | 6.1 |
| 31.3 | 12.7 | 21.3 | 37.4 | 38.8 | 27.2 | 43.1 | 30.9 | 9.7 | 47.6 | 31.4 | 29.4 |
| 228.3 | 205.5 | 210.7 | 387.0 | 264.5 | 233.1 | 394.6 | 225.6 | 60.6 | 394.6 | 232.6 | 217.2 |
| 5.3 | 4.8 | 4.9 | 9.0 | 6.1 | 5.4 | 9.1 | 5.2 | 1.4 | 9.0 | 5.4 | 5.0 |
| 0.8 | 0.7 | 1.6 | 0.7 | 1.2 | 1.2 | 0.8 | 1.5 | 0.7 | 2.4 | 1.4 | 1.3 |
| 5.9 | 2.7 | 4.4 | 4.2 | 6.3 | 5.0 | 4.7 | 5.9 | 2.7 | 13.2 | 6.4 | 6.3 |
| | | | | | | | | | | 1966–73 | |
| 119.2 | 206.6 | 141.8 | 272.5 | 157.4 | 199.3 | 207.7 | 145.8 | 119.2 | 272.5 | 181.3 | |
| 2.8 | 4.8 | 3.3 | 6.3 | 3.6 | 4.6 | 4.8 | 3.4 | 2.8 | 6.3 | 4.2 | |
| 1.7 | 0.8 | 1.7 | 1.1 | 2.3 | 1.4 | 1.6 | 2.3 | 0.8 | 2.3 | 1.6 | |
| 10.9 | 3.2 | 6.1 | 6.5 | 13.8 | 5.4 | 9.0 | 9.1 | 3.2 | 13.8 | 8.0 | |
| 52.2 | 100.5 | 67.3 | 70.4 | 59.5 | 85.5 | 52.5 | 65.1 | 52.2 | 100.5 | 69.1 | |
| 17.3 | 10.2 | 11.7 | 24.6 | 28.6 | 19.2 | 33.5 | 21.2 | 10.2 | 33.5 | 20.8 | |
| 7.44 | 5.28 | 5.53 | 6.19 | 6.12 | 6.19 | 6.04 | 4.80 | 4.80 | 7.44 | 5.95 | |
| 6.32 | 4.51 | 5.14 | 5.00 | 5.26 | 4.18 | 5.23 | 4.38 | 4.18 | 6.32 | 5.00 | |
| 7.04 | 5.02 | 5.44 | 5.75 | 5.99 | 5.53 | 5.71 | 4.70 | 4.70 | 7.04 | 5.65 | |
| 0.14 | 0.05 | 0.08 | 0.09 | 0.18 | 0.10 | 0.16 | 0.15 | 0.05 | 0.18 | 0.12 | |
| 0.40 | 0.24 | 0.27 | 0.57 | 0.66 | 0.44 | 0.78 | 0.49 | 0.24 | 0.78 | 0.48 | |
| 7.3 | 13.3 | 6.5 | 10.1 | 12.6 | 9.6 | 13.4 | 7.8 | 6.5 | 13.4 | 10.1 | |
| 7.5 | 20.9 | 4.7 | 26.4 | 20.4 | 17.3 | 25.3 | 13.6 | 4.7 | 26.4 | 17.0 | |
| 32.2 | 44.4 | 22.9 | 61.1 | 61.6 | 46.1 | 72.2 | 42.6 | 22.9 | 72.2 | 47.9 | |

*for Western Minnesota (Minor Reference Area 133), 1958–67 Ground Survey and July Production Survey.)*

| Year | | | | | Range | | Averages |
|---|---|---|---|---|---|---|---|
| 1963 | 1964 | 1965 | 1966 | 1967 | Low | High | 1958–1967 |
| 72.2 | 115.9 | 179.1 | 119.6 | 155.2 | 59.2 | 179.1 | 109.5 |
| 2.0 | 3.2 | 4.9 | 3.3 | 4.2 | 1.6 | 4.9 | 3.0 |
| 11.9 | 10.9 | 13.7 | 8.0 | 9.3 | 4.1 | 15.8 | 10.7 |
| | | | | | | | 1958–1966 |
| 163.6 | 88.6 | 124.4 | 156.6 | | 88.6 | 156.6 | 126.7 |
| 4.5 | 2.4 | 3.4 | 4.3 | | 2.4 | 4.5 | 3.5 |
| 0.4 | 1.3 | 1.4 | 0.8 | | 0.4 | 1.4 | 0.9 |
| 2.7 | 4.5 | 4.1 | 1.9 | | 1.0 | 5.8 | 3.4 |
| 123.9 | 69.5 | 93.4 | 114.6 | | 47.3 | 145.6 | 98.2 |
| 3.4 | 1.9 | 2.5 | 3.1 | | 1.3 | 4.0 | 2.7 |
| 0.6 | 1.7 | 1.9 | 1.0 | | 0.5 | 2.3 | 1.3 |
| 3.5 | 5.8 | 5.4 | 2.6 | | 1.0 | 11.2 | 4.9 |
| 75.7 | 78.4 | 75.1 | 73.2 | | 51.5 | 94.4 | 75.9 |
| 12.5 | 6.0 | 6.5 | 10.9 | | 2.6 | 16.3 | 8.7 |
| 6.20 | 6.33 | 5.00 | 7.00 | | 4.33 | 7.00 | 5.60 |
| 4.67 | 4.00 | 3.67 | 8.25 | | 3.00 | 8.25 | 5.20 |
| 5.62 | 5.75 | 4.56 | 7.29 | | 4.00 | 7.29 | 5.49 |
| 0.10 | 0.09 | 0.07 | 0.10 | | 0.05 | 0.15 | 0.09 |
| 0.34 | 0.16 | 0.18 | 0.30 | | 0.07 | 0.44 | 0.24 |
| 3.8 | 0.0 | 7.6 | 1.6 | | 0.0 | 7.6 | 2.6 |
| 4.9 | 4.9 | 5.4 | 4.3 | | 0.0 | 13.6 | 5.6 |
| 21.2 | 10.9 | 19.5 | 16.8 | | 3.5 | 29.9 | 16.9 |

TABLE B-20. *Mallard breeding population estimates in those areas not included in standardized Breeding Ground Surveys. In all cases these data are used as long-term averages*

| Minor reference area | Area code | Source [1] | Breeding population estimate (thousands) |
|---|---|---|---|
| British Columbia | 013 | 1 | 250.0 |
| E Ontario-W Quebec | 081 | 2 | 300.0 |
| W Washington | 091 | 1 | 10.5 |
| E Washington | 092 | 1 | 59.5 |
| W Oregon | 093 | 1 | 7.5 |
| E Oregon | 094 | 1 | 42.5 |
| N California | 101 | 3 | 13.5 |
| Central California | 102 | 3 | 105.8 |
| Idaho | 111 | 1 | 40.0 |
| Nevada | 113 | 1 | 15.0 |
| Utah | 114 | 1 | 20.0 |
| W Wyoming | 115 | 4 | 34.0 |
| W Colorado | 116 | 4 | 3.9 |
| E Wyoming | 123 | 4 | 102.0 |
| W Nebraska | 125 | 4 | 37.0 |
| E Colorado | 126 | 4 | 22.4 |
| S Central Colorado | 127 | 4 | 17.7 |
| E Nebraska | 134 | 4 | 20.0 |
| W Iowa | 135 | 4 | 9.6 |
| E Minnesota-E Iowa | 141 | 4 | 60.1 |
| Wisconsin-N Illinois | 142 | 5 | 135.0 |
| Michigan-N Ohio-N Indiana | 143 | 5 | 93.0 |
| W Mid-Atlantic | 151 | 5 | 32.2 |
| Chesapeake Bay Region | 152 | 5 | 7.4 |
| NE United States | 161 | 5 | 23.6 |

[1] 1. Estimate provided in May, 1972 by John Chattin, Migratory Bird Coordinator, Bureau of Sport Fisheries and Wildlife, Portland, Oregon.
2. Information for areas in Ontario north of 40°N latitude was obtained from BSFW surveys conducted 1962–64 and 1966–68, adjusted for visibility. Estimates in southern Ontario were derived from experimental surveys conducted by D. G. Dennis, Canadian Wildlife Service, in 1970 and 1971. The mallard breeding population in western Quebec was estimated to be 40,000.
3. Estimate derived from average of State survey results published in Pacific Flyway Reports and adjusted for visibility.
4. Long-term average of special State survey.
5. Estimate provided by State waterfowl biologists from State survey or breeding waterfowl estimate.

# APPENDIX C

## Weighting Factors for Mallards 1955–73

Appendix Table C-1 shows annual population estimates of mallards in each of the 44 minor reference areas based on information presented in Appendix B. Long-term averages were used to supplement incomplete data sets, and constant values were used for those minor reference areas presented in Table B-20. In six minor reference areas, additional mallards were added (a constant value each year) to the population estimate to account for breeding birds inside the minor reference area but outside the boundary of standard aerial surveys. The number of birds added were as follows:

| Minor reference area | Mallards added (thousands) |
|---|---|
| 012 | 10.3 |
| 031 | 4.0 |
| 061 | 21.5 |
| 071 | 5.0 |
| 072 | 19.2 |
| 112 | 32.0 |

Appendix Table C-2 presents the proportionate distribution of the data presented in Table C-1.

TABLE C–1. *Annual population estimates*

| Minor Reference area code | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|---|
| 011 | 154.6 | 154.6 | 112.0 | 140.7 | 174.4 | 131.1 | 218.8 | 136.7 | 180.8 |
| 012 | 120.5 | 108.5 | 66.8 | 84.9 | 283.6 | 128.7 | 250.9 | 138.9 | 192.5 |
| 013 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 |
| Subtotal | 525.1 | 513.1 | 428.8 | 475.6 | 708.0 | 509.8 | 719.7 | 525.6 | 623.3 |
| 021 | 384.6 | 310.1 | 311.6 | 509.8 | 1,057.3 | 206.8 | 598.8 | 348.9 | 384.0 |
| 022 | 439.4 | 200.1 | 394.5 | 784.9 | 1,137.5 | 282.0 | 871.8 | 407.9 | 432.0 |
| 023 | 701.6 | 567.7 | 750.0 | 1,030.0 | 1,294.7 | 506.1 | 1,236.9 | 723.7 | 652.9 |
| Subtotal | 1,525.6 | 1,077.9 | 1,456.1 | 2,324.7 | 3,489.5 | 994.9 | 2,707.5 | 1,480.5 | 1,468.9 |
| 031 | 1,302.1 | 1,173.2 | 1,225.3 | 1,329.6 | 1,081.2 | 898.9 | 786.5 | 571.1 | 679.1 |
| 041 | 2,729.5 | 3,228.4 | 2,581.3 | 2,366.0 | 1,473.1 | 1,684.9 | 1,402.8 | 919.3 | 1,311.8 |
| 051 | 1,968.8 | 2,664.5 | 2,565.0 | 3,238.7 | 1,275.0 | 1,963.6 | 768.1 | 576.9 | 713.6 |
| 061 | 532.6 | 697.0 | 646.0 | 870.5 | 764.6 | 487.1 | 347.3 | 224.7 | 349.8 |
| 071 | 410.1 | 486.1 | 371.8 | 630.1 | 640.5 | 319.7 | 277.8 | 268.3 | 354.4 |
| 072 | 216.7 | 285.4 | 204.2 | 429.9 | 245.1 | 172.2 | 222.9 | 226.7 | 188.8 |
| 073 | 35.5 | 158.3 | 59.8 | 124.1 | 109.7 | 169.7 | 141.0 | 312.0 | 160.0 |
| Subtotal | 662.3 | 929.8 | 635.8 | 1,184.1 | 995.3 | 661.6 | 641.7 | 807.0 | 703.2 |
| 081 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 |
| 091 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 |
| 092 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 |
| 093 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| 094 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 |
| Subtotal | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 |
| 101 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 |
| 102 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 |
| Subtotal | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 |
| 111 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| 112 | 118.3 | 118.3 | 118.3 | 118.3 | 118.3 | 118.3 | 118.3 | 118.3 | 118.3 |
| 113 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| 114 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| 115 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 |
| 116 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 |
| Subtotal | 231.2 | 231.2 | 231.2 | 231.2 | 231.2 | 231.2 | 231.2 | 231.2 | 231.2 |
| 121 | 323.6 | 323.6 | 323.6 | 323.6 | 323.6 | 323.6 | 323.6 | 323.6 | 323.6 |
| 122 | 76.2 | 76.2 | 76.2 | 55.4 | 27.8 | 30.5 | 26.0 | 37.5 | 33.4 |
| 123 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 |
| 124 | 131.7 | 131.7 | 131.7 | 131.7 | 47.6 | 60.7 | 77.2 | 105.0 | 167.8 |
| 125 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 |
| 126 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 |
| 127 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 |
| Subtotal | 710.6 | 710.6 | 710.6 | 689.8 | 578.1 | 593.9 | 605.9 | 645.2 | 703.9 |
| 131 | 387.4 | 387.4 | 387.4 | 374.8 | 148.0 | 283.5 | 262.3 | 262.2 | 434.2 |
| 132 | 263.6 | 263.6 | 263.6 | 263.6 | 79.9 | 142.8 | 200.5 | 374.7 | 415.5 |
| 133 | 109.5 | 109.5 | 109.5 | 105.1 | 124.5 | 65.0 | 99.0 | 59.2 | 72.2 |
| 134 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| 135 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 |
| Subtotal | 790.1 | 790.1 | 790.1 | 773.1 | 382.0 | 520.9 | 591.4 | 725.7 | 951.5 |
| 141 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 |
| 142 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 |
| 143 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 |
| Subtotal | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 |
| 151 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 |
| 152 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 |
| Subtotal | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 |
| 161 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 |
| Total | 11,868.5 | 12,906.4 | 12,160.8 | 14,373.9 | 11,868.6 | 9,437.4 | 9,692.7 | 7,597.8 | 8,626.9 |

*of mallards in preseason reference areas*

| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|---|---|---|
| 82.0 | 144.7 | 89.5 | 183.8 | 170.4 | 113.7 | 211.2 | 118.1 | 241.2 | 179.7 |
| 87.8 | 134.1 | 86.4 | 72.9 | 91.8 | 78.5 | 130.6 | 107.5 | 66.4 | 59.0 |
| 250.0 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 | 250.0 |
| 419.8 | 528.8 | 425.9 | 506.7 | 512.2 | 442.2 | 591.8 | 475.6 | 557.6 | 488.7 |
| 410.9 | 152.5 | 305.7 | 263.2 | 201.6 | 169.9 | 360.4 | 405.6 | 593.3 | 333.2 |
| 515.9 | 281.9 | 312.5 | 222.6 | 272.5 | 244.8 | 292.9 | 311.5 | 535.2 | 408.8 |
| 746.6 | 521.6 | 559.2 | 434.2 | 452.7 | 464.9 | 569.5 | 653.1 | 779.8 | 684.6 |
| 1,673.4 | 956.0 | 1,177.4 | 920.0 | 926.8 | 879.6 | 1,222.8 | 1,370.2 | 1,908.3 | 1,426.6 |
| 676.2 | 531.7 | 964.0 | 1,004.5 | 582.6 | 752.3 | 997.1 | 1,127.9 | 1,120.0 | 1,088.7 |
| 1,047.3 | 853.8 | 1,700.8 | 1,611.9 | 1,755.1 | 1,683.5 | 2,325.4 | 2,872.3 | 2,027.0 | 2,048.0 |
| 728.2 | 544.2 | 780.0 | 769.1 | 757.6 | 861.7 | 1,218.5 | 1,235.9 | 1,240.7 | 954.4 |
| 422.3 | 282.7 | 323.1 | 325.3 | 276.0 | 364.3 | 493.6 | 326.6 | 385.5 | 275.2 |
| 584.7 | 461.1 | 386.8 | 755.8 | 553.8 | 656.3 | 889.6 | 525.7 | 419.8 | 427.8 |
| 164.1 | 301.7 | 139.1 | 480.2 | 534.1 | 575.2 | 819.4 | 348.8 | 271.9 | 355.3 |
| 189.6 | 46.1 | 133.4 | 147.6 | 105.3 | 117.7 | 134.2 | 139.0 | 163.0 | 195.8 |
| 938.4 | 808.9 | 659.3 | 1,383.6 | 1,193.2 | 1,349.2 | 1,843.2 | 1,013.5 | 854.7 | 978.9 |
| 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 |
| 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 |
| 59.5 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 | 59.5 |
| 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 | 42.5 |
| 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 | 120.0 |
| 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 | 13.5 |
| 105.8 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 | 105.8 |
| 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 |
| 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| 118.3 | 124.4 | 195.7 | 134.9 | 67.9 | 106.6 | 112.4 | 98.6 | 141.8 | 82.4 |
| 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 |
| 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 | 3.9 |
| 231.2 | 237.3 | 308.6 | 247.8 | 180.8 | 219.5 | 225.3 | 211.5 | 254.7 | 195.3 |
| 323.6 | 376.6 | 479.1 | 307.5 | 205.8 | 295.0 | 317.1 | 279.0 | 374.2 | 277.8 |
| 42.7 | 25.8 | 28.8 | 164.2 | 81.6 | 133.0 | 134.3 | 117.8 | 158.3 | 122.9 |
| 102.0 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 | 102.0 |
| 79.1 | 104.4 | 62.8 | 155.5 | 166.6 | 234.3 | 154.2 | 166.3 | 248.4 | 145.9 |
| 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 |
| 22.4 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 | 22.4 |
| 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 | 17.7 |
| 624.5 | 685.9 | 749.8 | 806.3 | 633.1 | 841.4 | 784.8 | 742.2 | 960.0 | 725.7 |
| 371.9 | 362.9 | 413.2 | 416.8 | 374.2 | 359.1 | 585.7 | 609.3 | 501.9 | 437.7 |
| 300.4 | 242.8 | 172.0 | 144.9 | 337.1 | 287.2 | 310.4 | 287.7 | 326.7 | 331.7 |
| 115.9 | 179.1 | 119.6 | 155.2 | 109.5 | 109.5 | 109.5 | 109.5 | 109.5 | 109.5 |
| 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 |
| 817.8 | 814.4 | 734.4 | 746.5 | 850.4 | 785.4 | 1,035.2 | 1,036.1 | 967.7 | 908.5 |
| 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 | 60.1 |
| 135.0 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 | 135.0 |
| 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 | 93.0 |
| 288.1 | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 | 288.1 |
| 32.2 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 | 32.2 |
| 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 |
| 39.6 | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 | 39.6 |
| 23.6 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 | 23.6 |
| 8,469.7 | 7,134.3 | 8,713.9 | 9,212.3 | 8,558.4 | 9,069.7 | 11,628.2 | 11,302,4 | 11,166.8 | 9,980.6 |

TABLE C–2. *Weighting factors for adult*

| Minor reference area code | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 |
|---|---|---|---|---|---|---|---|---|---|
| 011 | .01303 | .01198 | .00921 | .00979 | .01469 | .01389 | .02257 | .01799 | .02096 |
| 012 | .01015 | .00841 | .00549 | .00591 | .02389 | .01364 | .02589 | .01828 | .02231 |
| 013 | .02106 | .01937 | .02056 | .01739 | .02106 | .02649 | .02579 | .03290 | .02898 |
| Subtotal | .04424 | .03976 | .03526 | .03309 | .05965 | .05402 | .07425 | .06918 | .07225 |
| 021 | .03241 | .02403 | .02562 | .03547 | .08908 | .02191 | .06178 | .04592 | .04451 |
| 022 | .03702 | .01550 | .03244 | .05461 | .09584 | .02988 | .08994 | .05369 | .05008 |
| 023 | .05911 | .04399 | .06167 | .07166 | .10909 | .05363 | .12761 | .09525 | .07568 |
| Subtotal | .12854 | .08352 | .11974 | .16173 | .29401 | .10542 | .27933 | .19486 | .17027 |
| 031 | .10971 | .09090 | .10076 | .09250 | .09110 | .09525 | .08114 | .07517 | .07872 |
| 041 | .22998 | .25014 | .21226 | .16460 | .12412 | .17853 | .14473 | .12100 | .15206 |
| 051 | .16588 | .20645 | .21092 | .22532 | .10743 | .20807 | .07925 | .07593 | .08272 |
| 061 | .04488 | .05400 | .05312 | .06056 | .06442 | .05161 | .03583 | .02957 | .04055 |
| 071 | .03455 | .03766 | .03057 | .04384 | .05397 | .03388 | .02866 | .03531 | .04108 |
| 072 | .01826 | .02211 | .01679 | .02991 | .02065 | .01825 | .02300 | .02984 | .02189 |
| 073 | .00299 | .01227 | .00492 | .00863 | .00924 | .01798 | .01455 | .04106 | .01855 |
| Subtotal | .05580 | .07204 | .05228 | .08238 | .08386 | .07010 | .06620 | .10621 | .08151 |
| 081 | .02528 | .02324 | .02467 | .02087 | .02528 | .03179 | .03095 | .03949 | .03477 |
| 091 | .00088 | .00081 | 00086 | .00073 | .00088 | .00111 | .00108 | .00138 | .00122 |
| 092 | .00501 | .00461 | .00489 | .00414 | .00501 | .00630 | .00614 | .00783 | .00690 |
| 093 | .00063 | .00058 | .00612 | .00052 | .00063 | .00079 | .00077 | .00099 | .00087 |
| 094 | .00358 | .00329 | .00349 | .00296 | .00358 | .00450 | .00438 | .00559 | .00493 |
| Subtotal | .01011 | .00930 | .00987 | .00835 | .01011 | .01272 | .01238 | .01579 | .01391 |
| 101 | .00114 | .00105 | .00111 | .00094 | .00114 | .00143 | .00139 | .00178 | .00156 |
| 102 | .00891 | .00820 | .00870 | .00736 | .00891 | .01121 | .01092 | .01393 | .01226 |
| Subtotal | .01005 | .00924 | .00981 | .00830 | .01005 | .01264 | .01231 | .01570 | .01383 |
| 111 | .00337 | .00310 | .00329 | .00278 | .00337 | .00424 | .00413 | .00526 | .00464 |
| 112 | .00997 | .00917 | .00973 | .00823 | .00997 | .01254 | .01221 | .01557 | .01371 |
| 113 | .00126 | .00116 | .00123 | .00104 | .00126 | .00159 | .00155 | .00197 | .00174 |
| 114 | .00169 | .00155 | .00164 | .00139 | .00169 | .00212 | .00206 | .00263 | .00232 |
| 115 | .00286 | .00263 | .00280 | .00237 | .00286 | .00360 | .00351 | .00447 | .00394 |
| 116 | .00033 | .00030 | .00032 | .00027 | .00033 | .00041 | .00040 | .00051 | .00045 |
| Subtotal | .01948 | .01791 | .01901 | .01608 | .01948 | .02450 | .02385 | .03043 | .02680 |
| 121 | .02727 | .02507 | .02661 | .02251 | .02727 | .03429 | .03339 | .04259 | .03751 |
| 122 | .00642 | .00590 | .00627 | .00385 | .00234 | .00323 | .00268 | .00494 | .00387 |
| 123 | .00859 | .00790 | .00839 | .00710 | .00859 | .01081 | .01052 | .01342 | .01182 |
| 124 | .01110 | .01020 | .01083 | .00916 | .00401 | .00643 | .00796 | .01382 | .01945 |
| 125 | .00312 | .00287 | .00304 | .00257 | .00312 | .00392 | .00382 | .00487 | .00429 |
| 126 | .00189 | .00174 | .00184 | .00156 | .00189 | .00237 | .00231 | .00295 | .00260 |
| 127 | .00149 | .00137 | .00146 | .00123 | .00149 | .00188 | .00183 | .00233 | .00205 |
| Subtotal | .05987 | .05506 | .05843 | .04799 | .04871 | .06293 | .06251 | .08492 | .08159 |
| 131 | .03264 | .03002 | .03186 | .02608 | .01247 | .03004 | .02706 | .03451 | .05033 |
| 132 | .02221 | .02042 | .02168 | .01834 | .00673 | .01513 | .02069 | .04932 | .04816 |
| 133 | .00923 | .00848 | .00900 | .00731 | .01049 | .00689 | .01021 | .00779 | .00837 |
| 134 | .00169 | .00155 | .00164 | .00139 | .00169 | .00212 | .00206 | .00263 | .00232 |
| 135 | .00081 | .00074 | .00079 | .00067 | .00081 | .00102 | .00099 | .00126 | .00111 |
| Subtotal | .06657 | .06122 | .06497 | .05378 | .03219 | .05520 | .06101 | .09551 | .11029 |
| 141 | .00506 | .00466 | .00494 | .00418 | .00506 | .00637 | .00620 | .00791 | .00697 |
| 142 | .01137 | .01046 | .01110 | .00939 | .01137 | .01430 | .01393 | .01777 | .01565 |
| 143 | .00784 | .00721 | .00765 | .00647 | .00784 | .00985 | .00959 | .01224 | .01078 |
| Subtotal | .02427 | .02232 | .02369 | .02004 | .02427 | .03053 | .02972 | .03792 | .03340 |
| 151 | .00271 | .00249 | .00265 | .00224 | .00271 | .00341 | .00332 | .00424 | .00373 |
| 152 | .00062 | .00057 | .00061 | .00051 | .00062 | .00078 | .00076 | .00097 | .00086 |
| Subtotal | .00334 | .00307 | .00326 | .00275 | .00334 | .00420 | .00409 | .00521 | .00459 |
| 161 | .00199 | .00183 | .00194 | .00164 | .00199 | .00250 | .00243 | .00311 | .00274 |
| Total | .99999 | 1.00000 | .99999 | .99998 | 1.00001 | 1.00001 | .99998 | 1.00000 | 1.00000 |

*mallards during the preseason banding period*

| 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|---|---|---|
| .00968 | .02028 | .01027 | .01995 | .01991 | .01254 | .01816 | .01045 | .02160 | .01800 |
| .01037 | .01880 | .00992 | .00791 | .01073 | .00866 | .01123 | .00951 | .00595 | .00591 |
| .02952 | .03504 | .02869 | .02714 | .02921 | .02756 | .02150 | .02212 | .02239 | .02505 |
| .04956 | .07412 | .04888 | .05500 | .05985 | .04876 | .05089 | .04208 | .04993 | .04896 |
| .04851 | .02138 | .03508 | .02857 | .02356 | .01873 | .03099 | .03589 | .05313 | .03338 |
| .06091 | .03951 | .03586 | .02416 | .03184 | .02699 | .02519 | .02756 | .04793 | .04096 |
| .08815 | .07311 | .06417 | .04713 | .05290 | .05126 | .04898 | .05778 | .06983 | .06859 |
| .19757 | .13400 | .13512 | .09987 | .10829 | .09698 | .10516 | .12123 | .17089 | .14294 |
| .07984 | .07453 | .11063 | .10904 | .06807 | .08295 | .08575 | .09979 | .10030 | .10908 |
| .12365 | .11968 | .19518 | .17497 | .20507 | .18562 | .19998 | .25413 | .18152 | .20520 |
| .08598 | .07628 | .08951 | .08349 | .08852 | .09501 | .10479 | .10935 | .11111 | .09563 |
| .04986 | .03963 | .03708 | .03531 | .03225 | .04017 | .04245 | .02890 | .03452 | .02757 |
| .06903 | .06463 | .04439 | .08204 | .06471 | .07236 | .07650 | .04651 | .03759 | .04286 |
| .01937 | .04229 | .01596 | .05213 | .06241 | .06342 | .07047 | .03086 | .02435 | .03560 |
| .02239 | .00646 | .01531 | .01602 | .01230 | .01298 | .01154 | .01230 | .01460 | .01962 |
| .11079 | .11338 | .07566 | .15019 | .13942 | .14876 | .15851 | .08967 | .07654 | .09808 |
| .03542 | .04205 | .03443 | .03257 | .03505 | .03308 | .02580 | .02654 | .02687 | .03006 |
| .00124 | .00147 | .00120 | .00114 | .00123 | .00116 | .00090 | .00093 | .00094 | .00105 |
| .00703 | .00834 | .00683 | .00646 | .00695 | .00656 | .00512 | .00526 | .00533 | .00596 |
| .00089 | .00105 | .00086 | .00081 | .00088 | .00083 | .00064 | .00066 | .00067 | .00075 |
| .00502 | .00596 | .00488 | .00461 | .00497 | .00469 | .00365 | .00376 | .00381 | .00426 |
| .01417 | .01682 | .01377 | .01303 | .01402 | .01323 | .01032 | .01062 | .01075 | .01202 |
| .00159 | .00189 | .00155 | .00147 | .00158 | .00149 | .00116 | .00119 | .00121 | .00135 |
| .01249 | .01483 | .01214 | .01148 | .01236 | .01167 | .00910 | .00936 | .00947 | .01060 |
| .01409 | .01672 | .01369 | .01295 | .01394 | .01315 | .01026 | .01056 | .01068 | .01195 |
| .00472 | .00561 | .00459 | .00434 | .00467 | .00441 | .00344 | .00354 | .00358 | .00401 |
| .01397 | .01744 | .02246 | .01464 | .00793 | .01175 | .00967 | .00872 | .01270 | .00826 |
| .00177 | .00210 | .00172 | .00163 | .00175 | .00165 | .00129 | .00133 | .00134 | .00150 |
| .00236 | .00280 | .00230 | .00217 | .00234 | .00221 | .00172 | .00177 | .00179 | .00200 |
| .00401 | .00477 | .00390 | .00369 | .00397 | .00375 | .00292 | .00301 | .00304 | .00341 |
| .00046 | .00055 | .00045 | .00042 | .00046 | .00043 | .00034 | .00034 | .00035 | .00039 |
| .02730 | .03326 | .03541 | .02690 | .02113 | .02420 | .01938 | .01871 | .02281 | .01957 |
| .03821 | .05279 | .05498 | .03338 | .02405 | .03253 | .02727 | .02468 | .03351 | .02783 |
| .00504 | .00362 | .00331 | .01782 | .00953 | .01466 | .01155 | .01042 | .01418 | .01231 |
| .01204 | .01430 | .01171 | .01107 | .01192 | .01125 | .00877 | .00902 | .00913 | .01022 |
| .00934 | .01463 | .00721 | .01688 | .01947 | .02583 | .01326 | .01471 | .02224 | .01462 |
| .00437 | .00519 | .00425 | .00402 | .00432 | .00408 | .00318 | .00327 | .00331 | .00371 |
| .00264 | .00314 | .00257 | .00243 | .00262 | .00247 | .00193 | .00198 | .00201 | .00224 |
| .00209 | .00248 | .00203 | .00192 | .00207 | .00195 | .00152 | .00157 | .00159 | .00177 |
| .07373 | .09614 | .08605 | .08752 | .07397 | .09277 | .06748 | .06567 | .08597 | .07271 |
| .04391 | .05087 | .04742 | .04524 | .04372 | .03959 | .05037 | .05391 | .04495 | .04386 |
| .03547 | .03403 | .01974 | .01573 | .03939 | .03167 | .02669 | .02545 | .02926 | .03323 |
| .01368 | .02510 | .01373 | .01685 | .01279 | .01207 | .00942 | .00969 | .00981 | .01097 |
| .00236 | .00280 | .00230 | .00217 | .00234 | .00221 | .00172 | .00177 | .00179 | .00200 |
| .00113 | .00135 | .00110 | .00104 | .00112 | .00106 | .00083 | .00085 | .00086 | .00096 |
| .09656 | .11415 | .08428 | .08103 | .09936 | .08660 | .08902 | .09167 | .08666 | .09103 |
| .00710 | .00842 | .00690 | .00652 | .00702 | .00663 | .00517 | .00532 | .00538 | .00602 |
| .01594 | .01892 | .01549 | .01465 | .01577 | .01488 | .01161 | .01194 | .01209 | .01353 |
| .01098 | .01304 | .01067 | .01010 | .01087 | .01025 | .00800 | .00823 | .00833 | .00932 |
| .03402 | .04038 | .03306 | .03127 | .03366 | .03177 | .02478 | .02549 | .02580 | .02887 |
| .00380 | .00451 | .00370 | .00350 | .00376 | .00355 | .00277 | .00285 | .00288 | .00323 |
| .00087 | .00104 | .00085 | .00080 | .00086 | .00082 | .00064 | .00065 | .00066 | .00074 |
| .00468 | .00555 | .00454 | .00430 | .00463 | .00437 | .00341 | .00350 | .00355 | .00397 |
| .00279 | .00331 | .00271 | .00256 | .00276 | .00260 | .00203 | .00209 | .00211 | .00236 |
| 1.00001 | 1.00000 | 1.00000 | 1.00000 | .99999 | 1.00002 | 1.00001 | 1.00000 | 1.00001 | 1.00000 |

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DEPARTMENT OF THE INTERIOR
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BUREAU OF SPORT FISHERIES AND WILDLIFE
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