FACTORS INFLUENCING WATERFOWL COUNTS ON AERIAL SURVEYS, 1961-66

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
Special Scientific Report — Wildlife No. 105

UNITED STATES DEPARTMENT OF THE INTERIOR, STEWART L. UDALL, *Secretary*
Stanley A. Cain, *Assistant Secretary for Fish and Wildlife and Parks*
Fish and Wildlife Service, Clarence F. Pautzke, *Commissioner*
Bureau of Sport Fisheries and Wildlife, John S. Gottschalk, *Director*

FACTORS INFLUENCING WATERFOWL COUNTS ON AERIAL SURVEYS, 1961-66

By

R. Kahler Martinson and Charles F. Kaczynski
Migratory Bird Populations Station
Division of Wildlife Research

Special Scientific Report--Wildlife No. 105
Washington, D.C. • June 1967

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price 45 cents

CONTENTS

ABSTRACT

Surveying of selected transects from the air and from the ground has been used since 1959 to determine the proportion of waterfowl, by species, that are observed by aerial crews. This method attempts to resolve obvious biases in aerial indexes relating to habitat differences, seasonal differences, aerial crew changes, etc. Assumptions in this method of correction are that (1) the ground crew observed substantially all waterfowl present and (2) the selected comparison transects adequately represent surrounding transects to which the correction is to be applied. This report, utilizing data of 1961 to 1966, reviews the necessity for air:ground correction and evaluates the procedure as a solution to aerial index biases; problems apparent are lack of representativeness of air:ground transects and inadequate numbers of transects. Lack of representativeness appears in population density and in species composition differences between air:ground and operational transects. The degree to which the numbers of air:ground transects are sufficient to give good estimates of air:ground ratios varies according to areas and according to species. Recommendations to improve the air:ground technique are: (1) make two daily surveys of one aerial pass each, at an interval of at least 2 hours, in the same direction and at the same time as the adjacent operational transects are surveyed; (2) make ground counts the day before or day after aerial surveys; (3) lay out all air:ground comparison transects in the same direction (west-east) as the operational transects; and (4) match new or relocated transects as nearly as possible to density and species composition of the survey stratum or area they represent.

FACTORS INFLUENCING WATERFOWL COUNTS ON AERIAL SURVEYS, 1961-66

The Bureau of Sport Fisheries and Wildlife annually surveys the major waterfowl breeding grounds in North America (Crissey, 1957). One of these surveys is an aerial census of waterfowl breeding populations conducted during May. It is generally known that the aerial observers do not see all waterfowl present on the survey transects and the procedure of allocating unidentified birds in proportion to those that are identified biases the census data by overestimating conspicuous species such as mallards at the expense of less conspicuous species such as the teals. For example, Crissey (1956), in summarizing several years of these data, noted that the proportion of mallards recorded from the air was about four times the proportion of green-winged teal. This information was based on observations by Smith (1957) who compared aerial and ground counts on his Alberta study areas and determined that aerial crews saw higher proportions of the waterfowl present (1) in grassland habitat than in aspen parklands, (2) on early morning surveys than on midday surveys, and (3) in parklands, when trees were bare than later in the season when trees had leafed out. Stoudt (1955) found that the proportion of waterfowl observed from the air on his Redvers, Saskatchewan, study area increased annually during a 3-year period 1952-54 as water levels lowered and receded from the peripheral vegetation around potholes. Diem and Lu (1960) found that other environmental factors such as wind velocity, light intensity, and temperature could also influence aerial counts of waterfowl.

Recognizing that many factors may affect the aerial census data obtained by the breeding population survey, the Bureau and the Canadian Wildlife Service initiated a study to compare aerial and ground counts of waterfowl. The purpose of the "air:ground comparison study" was to evaluate factors affecting the aerial "visibility" of waterfowl and to develop a method to correct or adjust aerial waterfowl breeding population indexes for "visibility" bias. Data were collected in Alberta and Manitoba during 1959, in Saskatchewan during 1960, and in the Tristate area of North Dakota, South Dakota, and western Minnesota during 1963. The purpose of this report is to evaluate the efficacy of the technique for correcting or adjusting bias in aerial census data from the breeding population survey. Because procedures had not been standardized during 1959 and 1960, and several discrepancies occurred during those years, only data from 1961-66 are presented.

R. G. Kinghorn, J. E. Randall, G. H. Wilson, L. C. Wills, J. A. Hague, R. J. Meyerding, R. C. Hanson, G. V. Orton, K. D. Norman, R. D. Purinton, M. M. Smith, and R. C. Droll helped by demonstrating the procedures and pointing out many problems associated with the technique. C. J. Henny, J. T. Young, A. D. Geis, and W. F. Crissey helped with either analysis or preparation of the manuscript.

TECHNIQUES

The approach used in the air:ground comparison study was to compare an aerial count (or more properly, aerial index) with a ground count of the same area of "air:ground comparison" transect. The basic assumption was that the same population of ducks was counted from the air and on the ground, and that the ground count was a complete census. The area counted was a transect one-fourth mile wide but of varied length depending on the density of water areas and ducks.

Because aerial counts and ground counts were not simultaneous and because home ranges of breeding waterfowl generally overlap the boundaries of the air:ground comparison transects (Evans and Black, 1955; Dzubin, 1955), both the aerial indexes and ground counts are subject to sampling errors (Geis, 1957). In recognition of these errors and because air:ground ratios might vary from area to area, several air:ground comparison transects were established in the various breeding population survey strata. The locations of the transects are shown in figure 1. Aerial and ground crew members who did the survey work are identified in table 1.

Aerial Procedure

To make counts comparable to those on the regular or operational breeding population survey, air:ground comparison transects were located between operational transects (fig. 2) and were surveyed by the same aerial crews during the same time period as the operational survey. Procedures for surveying were similar to those for the operational breeding population survey (BSFW, 1964). The daily period for the operational survey is generally between sunrise and noon. Each air:ground comparison transect was surveyed once in early morning and once later in the forenoon to provide counts throughout the same daily period as for the operational survey. At each count two passes were made: one in each direction along the transect (fig. 3). The two-pass or double count was designed to reduce sampling error (Geis, 1957) in the aerial index and to provide a count by both pilot and observer in both directions. The aerial index for the air:ground comparison transect was the average of the four aerial counts.

Waterfowl were recorded by species as drakes, pairs, and groups of birds of mixed sexes. Birds not identified by species were classed as "unidentified." In developing the aerial index, unidentified birds were first allocated to the categories of drakes, pairs, and groups of mixed sexes in the same proportions as the birds of known species and then were assigned the same species composition as the identified birds. Lone drakes and hens were assumed to represent pairs and were entered as such in the index.

Ground Procedure

Ground crews tried to make a complete count of ducks on the air:ground comparison transects. They walked around potholes or made "beat-outs" where necessary to reveal ducks hidden in vegetation. An effort was made to avoid flushing birds to prevent error from counting birds more than once when they were flushed from one pothole to the next. Ground counts were made within 2 or 3 days of the time that the transect was surveyed by air. Ground crews recorded ducks in the same way as aerial crews except that they identified species in all cases.

The Air:ground Ratio

With aerial indexes and ground counts for the same area(s), the proportion of waterfowl present that are recorded (air:ground ratio) can be calculated as follows:

$$\frac{\text{aerial index}}{\text{ground count}} = \text{air:ground ratio.}$$

Air:ground ratios can be compared among the various species of waterfowl, between aerial survey crews, years, habitat types, etc. Most importantly, air:ground ratios can be used to correct or adjust aerial survey indexes obtained throughout the operational breeding population survey area.

Analysis

The relationship between the density of ducks (number of birds per square mile from ground counts) and air:ground ratios was examined within survey stratum or area (Tristate area includes more than one stratum) per year in the following manner. For Canadian areas air:ground ratios for mallards were used, and in the Tristate area air:ground ratios for blue-winged teal were used, because these ratios were considered to be most reliable in their respective areas. Because there is much sampling error in air:ground ratios for individual transects, ratios for all transects in a survey stratum or area were ranked from high to low, then divided into groups of high and low ratios (basic data are in tables 19-26). If there was an even number of transects in a stratum, the "high" and "low groups" represented similar numbers of transects. If there was an odd number of transects in a stratum, or if the median ratio applied to more than one transect, the groups were separated where there was an obvious break in the series of ratios. Air:ground ratios and their corresponding duck densities were averaged for each group and provided one comparison between ratios and duck density per aerial survey stratum or area per year. Data from Saskatchewan B (strata B-W and B-E combined), 1966, are shown in table 2 as an example.

A nonparametric method, the "Sign Test" (Snedecor, 1956:114-115), was used to test the relationship between air:ground ratios and duck densities. Simple chi-square methods were used to test differences between air:ground ratios in grassland and aspen parkland habitats and differences among years.

FINDINGS

Factors Affecting Air:ground Ratios of Waterfowl

Species Composition of Waterfowl

That the species composition of waterfowl in aerial survey indexes is biased because some species are more obvious and/or more easily identified than others was confirmed by the results of the present work. When unidentified birds were allocated in proportion to the identified, the index obtained for a conspicuous species such as scaup or mallards was sometimes higher than the number actually present on the transect. Conversely, the index included only a small fraction of the number of less conspicuous species present. We found air:ground ratios that exceeded 1.000 for conspicuous species and ratios that approached zero for inconspicuous species. However, the usual range in air:ground ratios was from about 0.100 for inconspicuous to 0.600 for conspicuous species and the usual air:ground ratio for all species combined was between 0.200 and 0.400.

Tables 3 through 9 show air:ground ratios for the various species of waterfowl. Although it is difficult to completely separate any of the factors affecting the air:ground ratios of waterfowl, a year-to-year and area-by-area examination of these data shows that there are some consistent differences among ratios for the various species. If data are pooled from all areas and years, air:ground ratios for the ducks can be ranked from high to low thusly: (1) scaup, (2) canvasbacks, (3) mallards, (4) buffleheads, (5) shovelers, (6) pintails, (7) ring-necked ducks, (8) redheads, (9) gadwalls, (10) American widgeons, (11) blue-winged teal, (12) ruddy ducks, and (13) green-winged teal. The relative rank of the air:ground ratio for coots is difficult to determine since it was impractical to obtain complete ground counts of coots on the air:ground comparison transects. Coots on water areas with dense emergent vegetation are nearly impossible to count and, consequently, air:ground ratios for coots are maximal.

Although data are not adequate for all species, it is apparent that air:ground ratios for scaup, canvasbacks and mallards are high; those for shovelers and pintails are medium-high; those for redheads, gadwalls, and American widgeons, medium-low; and those for teals and ruddy ducks are low. Air:ground ratios suggest that about half the mallards and about one-eighth of the blue-winged teal present are accounted for in aerial survey indexes.

An example of the effect of species composition on air:ground ratios is as follows: about a third of all ducks present are recorded from the air in Canadian areas while less than one-fourth are recorded in the Tristate area. This disparity is due mainly to the preponderance of blue-winged teal in the Tristate area which contribute to the low air: ground ratio.

Water Areas

The proportion of existing water areas that are recorded on aerial surveys were expected to vary somewhat between regions of high and low pothole density. However, air:ground ratios showed greater variation than was expected (tables 3-9). We suspect that this was because aerial and ground crews did not all use the same criteria for selecting water areas to be counted. Although similar instructions (BSFW, 1964) were given to all survey crews, they were sometimes misinterpreted. Moreover, the separation of temporary water areas, which were not supposed to be counted, from those of the more permanent types is somewhat subjective and probably differed widely among crews.

Density of Ducks

It is evident that population density has an effect on the proportion of birds that are recorded from the air. Generally, air:ground ratios were higher where the density of ducks (number per square mile from ground counts) was lower, and vice versa. As mentioned in TECHNIQUES, we compared air:ground ratios within survey stratum per year by combining transects to form groups of high and low ratios together with their respective duck densities. Examination of these "averages" (table 10) showed that the higher air:ground ratio was associated with the lower density of ducks in 26 of 34 comparisons. The likelihood of this relation being due to chance was less than 1 in 200 (the "Sign Test": Snedecor, 1956:114-115). This suggests that, as the number of birds per unit area of aerial transect increases, the proportion recorded by survey crews decreases.

Habitat Types -- Grasslands Versus Parklands

Differences in air:ground ratios for mallards between grassland habitat and aspen parklands were tested in Alberta and Saskatchewan. Alberta stratum B is in aspen parklands and strata A and C are in grassland. Saskatchewan stratum B is in parkland and stratum A-W is in grassland. Data for Alberta suggested that the air:ground ratio for mallards was higher in the parklands than in the grasslands. However, in Saskatchewan, air:ground ratios for mallards were higher in the grasslands than in the parklands.

As mentioned earlier, Smith (1957) found that the aerial visibility of waterfowl was greater in the grasslands than in the parklands of Alberta. Data from the present work seem to disagree with Smith's findings. There are three factors which may have contributed to this disagreement. First, Smith's work was done when water levels were high and ducks could sit in flooded peripheral woody cover. Much of the present data were from a relatively dry period when ducks were more visible because peripheral vegetation was not flooded. The second factor is that Smith's findings were the result of careful work on study areas and may have been more accurate than the present data. Ground counts in parkland habitat are difficult because ducks may flush from aspen-fringed potholes without being seen by the ground crew. Thus ground counts may not yield a complete census of birds on the air:ground comparison transects. A third factor is that clearing for agriculture has modified the parkland characteristic in some of the strata which were located in that life area.

Annual Differences in Air:ground Ratios

Air:ground ratios for mallards varied significantly among years. Chi-square values (table 11) showed that differences in air:ground ratios among the various years were likely to be real and not merely the result of sampling error. Annual differences in air:ground ratios for all species combined were even greater than those for mallards. This was probably due to the additional effect of annual changes in species composition of the duck populations of the various areas. Annual differences can be attributed to (1) biological factors such as changes in species composition, habitat, population density and behavior, and (2) changes in aerial survey crews.

Biological Differences. Annual differences due to biological changes can be examined using air:ground ratios of mallards in survey areas where the aerial crew was the same for two or more consecutive years. These include Alberta B 1962-64, Alberta A and C 1962-64, Saskatchewan B 1964-65, Saskatchewan A-W 1964-65, Saskatchewan A-E - Manitoba A 1965-66 and Tristate 1964-65. Differences were statistically significant in Alberta during the period 1962-64 (table 12). In the other areas (all of which involved only 2 years each) differences were less marked and not statistically significant.

Annual Differences Due to Changes in Survey Crews. Because of the turn-over in aerial survey crews (Diem and Lu, 1960; table 1 in this report) it is important to understand and be able to adjust for differences in air:ground ratios that are related to differences in the techniques and/or characteristics of different crews. These relate both to the proportion of birds present that are actually seen and the ability to identify different species of waterfowl. There were four cases where complete aerial crew changes were made between years and in only one of these was there an obvious change in the air:ground ratio. This was in

Alberta between 1964 and 1965 and the change in ratios appears large enough to be attributable mainly to the change in crews. It is possible that there were differences in air:ground ratios in other cases when crews were changed but they were obscured by biological changes.

The Effect of Consecutive Aerial Passes and Direction of Flight

Since the initiation of the air:ground comparison study, aerial crew members have questioned the value of making a double pass on the transect at each daily survey period. They felt that birds were flushed and left the transect during the first of the two consecutive passes.

C. J. Henny (unpublished data, Migratory Bird Populations Station) examined this problem by summarizing aerial counts (not the calculated aerial indexes) for the years 1962-65. His findings suggested that (1) the highest counts were obtained on the first pass of a transect; (2) the difference between first and second counts was most pronounced for those transects surveyed earliest in the day; and (3) the direction of flight, in relation to the position of the rising sun, influenced the magnitude of the difference between counts made on the first and second pass.

In the present analysis, aerial indexes were calculated for each pass on air:ground comparison transects during 1966. These data were examined to find out if the count made on the second pass was biased because birds had left the transects during the first pass. The influence of flight direction on aerial counts was also considered. In table 13 aerial indexes for first and second passes are shown by time of day (before or after 9 o'clock in the morning) and by direction of flight. These data suggest that the first pass yielded the highest index and that the difference between two consecutive passes was greatest for early morning survey periods. They also suggest that flight direction influences the index. This also appears to be most pronounced during the early morning period. We conclude that the second pass on an air:ground transect yields a lower aerial index because birds are flushed from the transect during the first aerial pass; this phenomenon is most pronounced during early morning surveys when waterfowl are most active and are apt to flush and move away from the aircraft. Survey flights from east to west (away from the rising sun) yield higher indexes than those made from west to east, especially during early morning hours when the sun is at an acute angle to the earth's surface and makes censusing from west to east extremely difficult.

Use of Air:ground Ratios for Adjusting Aerial Indexes

Air:ground ratios have been used to adjust aerial indexes from the breeding population survey as follows:

$$\frac{\text{aerial index}}{\text{air:ground ratio}} = \text{adjusted aerial index.}$$

For the most part data have been adjusted by strata, but in some survey areas with few comparison transects, such as Saskatchewan B-W and B-E, and Tristate C and E, data for several strata can be combined. Air:ground comparisons are lacking for Saskatchewan C, Manitoba B, Tristate W and there is only one transect in Alberta C. For these strata, air:ground ratios from adjacent strata have been used.

The utility of the air:ground comparison technique for adjusting aerial indexes of waterfowl from breeding population surveys depends on the representativeness of the air:ground comparison transects and the adequacy with which they sample the survey area.

Air:ground comparison and operational transects in a survey stratum or area should be similar in percentage species composition of ducks because total waterfowl estimates are made on the basis of total waterfowl observed from the air divided by the air:ground ratio for total waterfowl. This estimate would be in error to the extent of differences in species composition between comparison and operational transects. Total waterfowl figures must be used for this estimate because data are not adequate for several less common and less observable species to arrive at a total waterfowl estimate by adjusting indexes species-by-species and adding them together. An additional reason for having like species composition between comparison and operational transects is the possibility that over-all species composition may influence air:ground ratios for individual species. We have no data to prove or disprove that differences may be induced in species air:ground ratios by their numerical status relative to other species present. However, the possibility of bias from this interaction is avoided when like species composition is assured between comparison and operational transects.

Air:ground comparison and operational transects should be similar in density of ducks because the proportion recorded by aerial crews appears to be inversely related to population density; i.e., high air:ground ratios are associated with low duck densities and vice versa.

Numbers of air:ground comparison transects should be sufficient to obtain a reasonably precise estimate of the mean air:ground ratio for the species and the area.

Species Composition of Ducks

Species composition of ducks on air:ground comparison and operational transects are shown in tables 14-17. In Alberta the species composition on the two transect types was quite similar in stratum B but in strata A and C the air:ground comparison transects had a lower percentage of mallards and a higher percentage of scaup than the operational transects (table 14). Comparison transects in Saskatchewan B (B-W and B-E combined) had proportionately more mallards and fewer pintails than did their corresponding operational transects (table 15). In the grasslands of

Saskatchewan (strata A-W and C) there were lower proportions of mallards and higher proportions of shovelers on comparison transects than on operational transects (table 15). In Saskatchewan stratum A-E species composition was very similar between operational and comparison transects but the latter appeared to have a lower proportion of blue-winged teal (table 16). In Manitoba A, operational transects had more scaup than comparison transects while the latter had more shovelers and pintails (table 16).

When Manitoba A and B operational transects were combined, they had more mallards and scaup and fewer blue-winged teal and shovelers than the comparison transects located in Manitoba A. In the Tristate area, operational transects had the highest percentages of mallards while comparison transects had the highest percentages of shovelers but they had similar percentages of blue-winged teals, the most abundant birds in the survey area (table 17).

These data suggest that the species composition of ducks on air:ground comparison and operational transects is approximately the same. However, in Alberta A, Saskatchewan B-W and B-E and the Tristate area, the comparison transects sample a population with a species composition somewhat different than on the operational transects.

Density of Ducks

In all survey strata where air:ground comparison transects were located it was evident that they had higher duck densities than the operational transects (table 18). This was most evident in the grassland areas of Alberta stratum C, Saskatchewan stratum A-W and the Tristate area. It was less marked in other survey strata.

Differences between air:ground comparison and operational transects in density of ducks and, in part, species composition probably are a result of the location of air:ground comparison transects. They were established in areas where there was a high density of potholes and ducks so that aerial and ground crews could obtain a satisfactory volume of data in a limited amount of time. The disparity is exaggerated because the air:ground comparison transects were set up during a period of extreme drought and were therefore located in areas of relatively permanent pothole types.

Numbers of Transects Needed

The numbers of air:ground comparison transects needed to estimate a mean air:ground ratio at a certain level of precision can be calculated with conventional statistical methods that consider variability due to real differences among the transects as well as sampling errors. For these calculations, an arcsin transformation was applied to the ratios (Snedecor, 1956:316-320). The data provide only rough approximations of

the numbers of air:ground comparison transects needed because: (1) some strata do not have transects; (2) much of the variability among air:ground ratios is real (related to time of day, for example) and reflects similar differences obtained in the data from the operational survey; (3) the "accuracy" of the air:ground ratios varies considerably among transects (numbers of birds or sample size varies); (4) the air:ground comparison transects are not representative, with regard to density of ducks, of the survey area as a whole; and (5) data were pooled and not weighted by survey strata in calculating the sample needed for the entire survey area.

Tables 19 through 34 record air:ground ratios by air:ground comparison transect for total ducks, mallards, blue-winged teal and canvasbacks. These air:ground ratios were used in calculating the number of comparison transects needed to estimate mean ratios for the various species for the strata and total survey area.

Table 35 shows the existing number of air:ground comparison transects in the various strata, crew areas, and the total survey area (fig. 1) and the numbers of transects needed to estimate the mean air:ground ratio for total ducks in each area of interest within 20 percent, 10 percent and 5 percent of the true mean ratio. These data suggest that there are enough air:ground comparison transects in most survey strata to estimate the mean air:ground ratio for total ducks within 20 percent but too few to estimate this mean within 10 percent.

Table 36 contains similar data for mallards, blue-winged teal and canvasbacks within the survey area flown by a particular aerial crew. (Remember that Saskatchewan C, Manitoba B and Tristate W have no air:ground comparison transects and Alberta C has only one). These data suggest that there are enough air:ground comparison transects to estimate the mean air:ground ratio for mallards within 20 percent of the true mean in Alberta and western Saskatchewan but not in the survey areas of Saskatchewan A-E - Manitoba A and the Tristate area. For the entire survey area there are almost enough air:ground comparison transects to estimate the mean air:ground ratio for mallards within 10 percent of the true mean. The number of transects needed to obtain an estimate of the mean air:ground ratio for blue-winged teal within 20 percent of the true mean was sufficient only in the Tristate area. It was possible to estimate the mean air:ground ratio for blue-winged teal in the survey area within 20 percent but not within 10 percent of the true mean ratio. Similar computations suggest that it was possible to estimate a reasonable mean air:ground ratio for canvasbacks. However, the arcsin transformation procedure biased downward the estimate of the number of transects needed -- air:ground ratios for canvasbacks commonly were zero or greater than 1.000 because of the small numbers of this species on most transects.

Efficacy of the Air:ground Comparison Technique for Adjusting Aerial Waterfowl Indexes

Shortcomings in the present air:ground comparison scheme for adjusting aerial waterfowl indexes are: (1) some survey strata have no air:ground comparison transects and several do not have enough transects, (2) densities of waterfowl are markedly higher on air:ground transects than on operational transects and (3) the species composition of ducks on air:ground comparison transects is not representative of that on operational breeding ground survey transects in some strata.

Differences in density of waterfowl between the air:ground comparison and operational transects, because of the inverse relationship between air:ground ratios and waterfowl density, present the most apparent problem. The obvious conclusion is that air:ground ratios obtained from the present study design are lower than "true" air:ground ratios for the operational breeding ground survey strata. Thus breeding population estimates obtained by adjusting aerial indexes with the air:ground ratios are exaggerated.

In spite of this apparent bias in their use, the air:ground ratios have produced seemingly reasonable results when used to adjust aerial breeding population indexes of ducks. Estimates of breeding populations of mallards, made with the aid of the air:ground ratios (Martinson and Henny, 1966), appeared plausible when Crissey (1957) compared them with data on productivity, kill and estimated total mortality in describing the recent population dynamics of that species. Air:ground ratios were also used to estimate the 1965 and 1966 breeding populations of blue-winged teal and, when used with productivity and kill statistics, appeared to be reasonable (Martinson, et al., 1966).

A possible explanation for this is that the aerial crews record a higher proportion of the waterfowl present on the air:ground comparison transects than on the operational survey transects despite their effort to survey both transects with equal intensity. If this is so, it could counteract the effect created by the higher density of ducks, and related lower air:ground ratio, on the air:ground comparison transects.

Breeding population survey data on mallards, at least, are most useful when they are adjusted with the air:ground ratios. Not only do the adjusted breeding population figures provide an estimate of the absolute size of the population necessary for harvest management, but, thus far, the trend depicted by the adjusted estimates has appeared to be more accurate than that from the unadjusted aerial breeding population indexes for mallards. The change in the mallard breeding population index for Alberta from 1964 to 1965 is an example. The unadjusted breeding population index decreased from 835,000 in 1964 to 335,000 in 1965, an indicated 60 percent decline in the population. However, both members of the aerial survey crew were changed in 1965 and, without the measurement

of the air:ground ratio for mallards in that area, a change of this magnitude in the mallard index would have been suspect but difficult to reject. The air:ground ratio for mallards also decreased markedly (probably because of the different characteristics of the two survey crews, p. 6) and, consequently, the adjusted breeding population indexes for 1964 (1,482,000) and 1965 (890,000) showed a lesser decrease; about 40 percent.

CONCLUSIONS AND RECOMMENDATIONS

In the foregoing sections we have discussed factors affecting the proportion of waterfowl present that are recorded in aerial survey indexes (air:ground ratios). Air:ground ratios of the different species vary and thus the species composition of ducks in a survey area will influence the proportion of all ducks recorded in aerial survey indexes. The density of ducks on a survey transect affects the proportion recorded; viz., air:ground ratios of ducks will tend to be highest in areas of low duck density and vice versa. Although not proven in this report, air:ground ratios of waterfowl are probably higher in grassland areas than in aspen parklands (Smith, 1957). Marked annual changes in air:ground ratios of ducks were found during the period 1961-66 which were attributable to both biological differences among years and changes in aerial survey crews. There was a suggestion that the direction of flight, in relation to the position of the rising sun, influenced the ability of aerial crews to census waterfowl -- flights away from the rising sun appeared to obtain higher proportions of the waterfowl present than flights into the sun.

A possible bias in the present aerial procedure of the air:ground comparison study was pointed out: making two consecutive passes on the air:ground comparison transect resulted in a lower count of ducks on the second pass because some birds left the transect during the first aerial pass.

The species composition and density of ducks on air:ground comparison and operational survey transects were compared to judge the practicality of using air:ground ratios in adjusting aerial indexes obtained on the operational transects. Numbers of air:ground comparison transects needed to obtain reasonable estimates of mean air:ground ratios for several species and areas were calculated.

From these findings and analyses, and the conclusions of others (Crissey, 1956; Smith, 1957; Stoudt, 1955; Diem and Lu, 1960), we would like to recommend and re-emphasize several things necessary for the continuance of the air:ground comparison study and the use of the technique in operational surveys.

1. Make two daily aerial surveys of each air:ground comparison transect as at present but make only one pass at each time. Data from

the second consecutive pass have been biased because ducks leave the transect during the first pass. Therefore, the second pass has not been truly useful for reducing sampling error.

2. The two surveys of the air:ground comparison transect should be made at the time and in the same direction that the adjacent portions of the operational transects are surveyed (see again fig. 3). However, the two surveys should be at least two hours apart and, because of the location of some air:ground transects, this may necessitate making the second survey on another day. The postponed survey should be made in the same direction and at the same time as would have been the case if postponement was not necessary. For example, if the first survey was at 9:00 a.m., and the second would have been at 10:00 a.m., the second survey should be postponed until 10:00 a.m. the following day.

3. Make the ground count the day before or the day after the aerial survey. Both ground and aerial counts will drive birds from the transects and there is little chance for both to sample the same population if one drives birds from the transect shortly before the other is conducted.

4. All air:ground comparison transects should be laid out in an east-to-west direction as are the operational transects because of the effect of the sun on the crew's ability to observe waterfowl. The two transects that are not east to west, Kenilworth and Whiskey Gap in Alberta, should be relocated.

5. Additional air:ground comparison transects are needed and would be most valuable if located in Alberta C, A, Saskatchewan B, C, A-E and Manitoba B. Additional transects or relocation of some of the present transects are needed in the Tristate area to improve the representativeness of the species composition sampled in the air:ground comparison transects.

6. New air:ground comparison transects should be located in areas that are similar in species composition and density of ducks to the stratum in which they will be located. It may be difficult to establish workable transects which have the same density of ducks as the entire survey strata but it should be easier to match the species composition.

7. Because of the inverse relation between air:ground ratios and density of ducks, it would be logical to recommend relocation of most air:ground comparison transects into areas with lower densities of waterfowl which are more representative of the respective survey strata. However, because: (1) the air:ground ratios have thus far provided reasonable results and (2) this may be due to greater survey acuity by the aerial crews on the air:ground comparison transects than on the operational survey transects, we withhold this recommendation for further study.

8. Instructions for recording water areas should be explicit and briefing sessions should be used to minimize subjective variation among individuals in classifying water areas.

9. Although not discussed in this report, air:ground comparison studies are needed in boreal and tundra regions of the northern Prairie Provinces, the Northwest Territories and Alaska as well as in the unglaciated plains of the western Dakotas and Montana.

References

Bailey, N. T. J. 1959. Statistical methods in biology. John Wiley & Sons, Inc., New York. 200 p.

Crissey, W. F. 1956. Possible solution to the problem of measuring annual changes in the visibility bias now included in much of our aerial breeding population data. Mimeo. memorandum on file at the Migratory Bird Populations Station, Laurel, Md. 5 p.

Crissey, W. F. 1957. Forecasting waterfowl harvest by flyways. Transactions North American Wildlife Conference. 22:256-268.

Crissey, W. F. 1966. The 1966 status of waterfowl as presented to the Waterfowl Advisory Committee. U.S. Bureau of Sport Fisheries and Wildlife. 27 p. (multilith)

Diem, K. L. and K. H. Lu. 1960. Factors influencing waterfowl censuses in the parklands, Alberta, Canada. Journal of Wildlife Management 24(2):113-133.

Dzubin, A. 1955. Some evidences of home range in waterfowl. Transactions North American Wildlife Conference. 20:278-298.

Evans, C. D. and K. E. Black. 1955. Duck production studies on the prairie potholes of South Dakota. U.S. Fish and Wildlife Service, Special Scientific Report -- Wildlife No. 32.

Geis, A. D. 1957. Method proposed by Walter F. Crissey for measuring visibility biases now found in aerial breeding population transect data. Mimeo. memorandum on file at the Migratory Bird Populations Station, Laurel, Md. 5 p.

Martinson, R. K. and C. J. Henny. 1966. Trends in duck breeding populations 1955-66. Administrative Report No. 119, Migratory Bird Populations Station, Laurel, Md. 10 p.

Martinson, R. K., G. Smart and M. F. Sorensen. 1966. 1965 harvest, age ratios and kill rate of blue-winged teal compared with earlier years. Administrative Report No. 121, Migratory Bird Populations Station, Laurel, Md. 8 p.

Smith, A. G. 1957. Progress report - the 1957 aerial and ground waterfowl surveys in Alberta, Canada. U.S. Fish and Wildlife Service. 30 p. (mimeo.)

Snedecor, G. W. 1956. Statistical methods applied to experiments in agriculture and biology. 5th ed. Iowa State College Press, Ames. 534 p.

Stoudt, J. H. 1955. Progress report - Redvers waterfowl study area - Saskatchewan. U.S. Fish and Wildlife Service. 124 p. (mimeo.)

U.S. Bureau of Sport Fisheries and Wildlife. 1964. Revision of standard operating procedures. Section I, Waterfowl Air Survey Instruction for the Prairie Operations. 27 p.

Table 1.--Members of aerial and ground crews who worked air:ground comparison transects, 1961-66

Year	Alberta		Saskatchewan		Sask. A-E - Manitoba		Tristate	
	Aerial crew	Ground crew	Aerial crew	Ground crew	Aerial crew	Ground crew	Aerial crew	Ground crew
1961	G.H.Jensen F.A.Thompson	R.MacKay R.Merilee	R.C.Hanson R.D.Duncan	J.E.Chattin J.R.Norris	C.D.Evans H.W.Brown	R.J.Meyerding G.Pospichal	-- --	-- --
1962	G.H.Jensen A.E.Weinrich	J.E.Chattin J.R.Norris	H.V.Hines J.M.Matlock	R.J.Buller R.G.Kinghorn	J.D.Smith M.H.Lundy	M.M.Smith A.S.Hawkins	-- --	-- --
1963	Same	J.E.Chattin R.Spinde	R.C.Hanson D.E.Weiland	R.G.Kinghorn G.H.Wilson	J.D.Smith M.M.Smith	J.A.Hague R.J.Meyerding	G.V.Orton D.W.Fisher	R.J.Buller R.H.Wheeler
1964	Same	G.H.Wilson J.R.Norris	R.C.Hanson G.Pospichal	R.G.Kinghorn J.E.Randall	M.M.Smith K.D.Norman	Same	G.V.Orton B.D.Law	R.H.Wheeler H.T.Lovrien
1965	E.G.Wellein K.D.Norman	Same	Same	Same	M.M.Smith R.C.Droll	Same	Same	Same
1966	K.D.Norman R.D.Purinton	G.H.Wilson L.C.Wills	R.C.Hanson G.V.Orton	Same	Same	Same	G.Pospichal R.W.Slattery	Same

Table 2.--Data from Saskatchewan B (strata B-W and B-E combined), 1966, showing the method used to "group" air:ground ratios and duck densities for the analysis of their relationship

Transects	Air:ground ratio	Ducks per square mile	
Turtleford	0.706	64	"high group"
Kinistino	0.559	60	
Alticane	0.536	104	"low group"
Rose Valley	0.255	112	
Average for "high group"	0.632	62	
Average for "low group"	0.395	108	

Table 3.--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Alberta stratum B, 1961-66

	1961			1962			1963		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	642	766	0.838	567	714	0.794	470	956	0.492
Gadwall	86	170	0.506	62	200	0.310	52	228	0.228
American widgeon	127	270	0.470	73	238	0.307	102	226	0.451
Green-winged teal	43	82	0.524	8	58	0.138	8	132	0.061
Blue-winged teal	105	564	0.186	53	392	0.135	38	512	0.074
Shoveler	137	176	0.778	134	242	0.554	148	366	0.404
Pintail	205	174	1.178	161	222	0.725	174	544	0.320
Redhead	33	88	0.375	12	40	0.300	40	86	0.465
Canvasback	27	52	0.519	21	30	0.700	33	46	0.717
Scaup	168	372	0.452	175	206	0.850	200	332	0.602
Ring-necked duck	--	--	--	--	--	--	--	--	--
Bufflehead	38	56	0.678	31	54	0.574	8	16	0.500
Ruddy duck	10	36	0.278	1	4	0.250	2	24	0.083
Others	--	--	--	0	10	--	1	6	0.167
Total ducks	1,621	2,806	0.578	1,298	2,410	0.538	1,276	3,474	0.367
Coots	87	107	0.813	8	70	0.114	67	381	0.176
Water areas	469	324	1.448	598	705	0.848	929	929	1.000
Number of transects			5			6			6
Square miles			18.1875			22.9375			22.9375

Table 3.--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Alberta stratum B, 1961-66--continued

	1964			1965			1966		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	434	862	0.503	222	586	0.379	300	856	0.350
Gadwall	87	250	0.348	58	160	0.362	58	218	0.266
American widgeon	151	276	0.547	33	196	0.168	80	234	0.342
Green-winged teal	24	136	0.176	11	78	0.141	22	206	0.107
Blue-winged teal	107	701	0.153	66	372	0.177	75	368	0.204
Shoveler	173	288	0.601	59	167	0.353	80	200	0.400
Pintail	70	220	0.318	95	312	0.304	116	380	0.305
Redhead	37	88	0.420	43	138	0.312	26	122	0.213
Canvasback	41	96	0.427	28	66	0.424	18	70	0.257
Scaup	197	262	0.752	144	346	0.416	187	228	0.820
Ring-necked duck	--	--	--	3	4	0.750	3	6	0.500
Bufflehead	33	52	0.635	15	46	0.326	32	54	0.592
Ruddy duck	2	36	0.056	6	46	0.130	13	42	0.310
Others	2	18	0.111	0	4	--	1	0	--
Total ducks	1,358	3,285	0.413	783	2,521	0.310	1,011	2,984	0.339
Coots	76	224	0.339	41	259	0.158	54	244	0.221
Water areas	587	639	0.919	850	880	0.966	711	764	0.931
Number of transects			6			6			6
Square miles			22.9375			22.9375			22.9375

Table 4.--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Alberta strata A and C, 1961-66

	1961			1962			1963		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	220	410	0.536	234	596	0.393	162	256	0.633
Gadwall	77	252	0.306	41	86	0.477	27	150	0.180
American widgeon	100	380	0.263	51	174	0.293	45	134	0.336
Green-winged teal	19	91	0.209	0	36	--	0	10	--
Blue-winged teal	56	339	0.165	20	146	0.137	11	90	0.122
Shoveler	90	250	0.360	52	110	0.473	47	112	0.420
Pintail	274	434	0.631	258	600	0.430	172	374	0.460
Redhead	14	52	0.269	0	16	--	3	14	0.214
Canvasback	10	22	0.454	14	30	0.467	20	36	0.556
Scaup	136	242	0.562	188	280	0.671	180	284	0.634
Ring-necked duck	0	4	--	--	--	--	1	4	0.250
Bufflehead	2	6	0.333	2	4	0.500	--	--	--
Ruddy duck	2	16	0.125	0	8	--	0	86	--
Others	0	6	--	1	2	0.500	0	4	--
Total ducks	1,000	2,504	0.399	861	2,088	0.412	668	1,554	0.430
Coots	115	184	0.625	47	36	1.306	10	39	0.256
Water areas	318	286	1.112	191	247	0.773	170	210	0.810
Number of transects			5			4			5
Square miles			18.1875			20.625			28.0625

Table 4.--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Alberta strata A and C, 1961-66--continued

	1964			1965			1966		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	209	280	0.746	106	286	0.371	170	492	0.346
Gadwall	34	72	0.472	15	88	0.170	22	168	0.131
American widgeon	82	116	0.707	22	122	0.180	40	156	0.256
Green-winged teal	0	16	--	2	10	0.200	2	34	0.059
Blue-winged teal	23	170	0.135	9	96	0.094	55	264	0.208
Shoveler	112	166	0.675	44	134	0.328	104	342	0.304
Pintail	209	344	0.608	255	484	0.527	334	984	0.339
Redhead	5	12	0.417	3	10	0.300	2	38	0.053
Canvasback	17	20	0.850	7	6	1.167	11	16	0.688
Scaup	151	246	0.614	65	136	0.478	89	218	0.408
Ring-necked duck	0	2	--	--	--	--	3	0	--
Bufflehead	--	--	--	0	2	--	0	10	--
Ruddy duck	0	34	--	0	6	--	3	8	0.375
Others	--	--	--	0	4	--	0	6	--
Total ducks	842	1,478	0.570	528	1,384	0.382	835	2,736	0.305
Coots	91	122	0.746	6	29	0.207	48	152	0.316
Water areas	322	318	1.012	467	464	1.006	378	440	0.859
Number of transects			5			5			5
Square miles			28.0625			28.0625			28.0625

Table 5 .--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Saskatchewan stratum B, 1961-66

	1961			1962			1963		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	229	470	0.487	176	342	0.515	145	322	0.450
Gadwall	4	48	0.083	6	50	0.120	11	28	0.393
American widgeon	15	136	0.110	10	120	0.083	17	128	0.133
Green-winged teal	0	38	--	2	30	0.067	0	22	--
Blue-winged teal	7	178	0.039	2	52	0.038	12	48	0.250
Shoveler	16	86	0.186	2	54	0.037	19	42	0.452
Pintail	50	144	0.347	46	108	0.426	32	108	0.296
Redhead	4	24	0.167	1	16	0.062	5	10	0.500
Canvasback	5	8	0.625	1	12	0.083	11	14	0.786
Scaup	18	68	0.265	37	50	0.740	16	56	0.286
Ring-necked duck	--	--	--	0	2	--	--	--	--
Bufflehead	--	--	--	0	6	--	0	5	--
Ruddy duck	0	2	--	2	14	0.143	--	--	--
Others	--	--	--	0	2	--	--	--	--
Total ducks	348	1,202	0.290	285	860	0.331	268	783	0.342
Coots	2	44	0.045	18	47	0.383	5	65	0.077
Water areas	182	309	0.589	464	466	0.996	205	204	1.005
Number of transects			4			4			4
Square miles			10.25			10.25			10.25

Table 5 .--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Saskatchewan stratum B, 1961-66--continued

	1964			1965			1966		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	103	172	0.599	87	186	0.468	132	286	0.462
Gadwall	16	32	0.500	10	28	0.357	12	24	0.500
American widgeon	12	62	0.194	13	90	0.144	14	112	0.125
Green-winged teal	3	32	0.094	4	28	0.143	3	54	0.056
Blue-winged teal	14	76	0.184	13	72	0.180	17	120	0.142
Shoveler	44	48	0.917	19	36	0.528	17	48	0.354
Pintail	20	90	0.222	38	86	0.442	50	152	0.329
Redhead	6	10	0.600	2	36	0.056	2	16	0.125
Canvasback	2	4	0.500	14	22	0.636	12	14	0.857
Scaup	20	28	0.714	21	30	0.700	46	44	1.045
Ring-necked duck	2	0	--	2	4	0.500	--	--	--
Bufflehead	0	6	--	0	6	--	1	0	--
Ruddy duck	--	--	--	0	4	--	0	18	--
Others	--	--	--	1	2	0.500	4	4	1.000
Total ducks	242	560	0.432	224	630	0.356	310	892	0.348
Coots	2	14	0.143	8	30	0.267	10	101	0.099
Water areas	124	290	0.428	310	441	0.703	315	621	0.507
Number of transects			4			4			4
Square miles			10.25			10.25			10.25

Table 6.--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Saskatchewan stratum A-W, 1961-66

	1961			1962			1963		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	389	558	0.697	198	272	0.728	162	326	0.497
Gadwall	18	278	0.065	13	240	0.054	60	200	0.300
American widgeon	18	170	0.106	2	72	0.028	18	88	0.204
Green-winged teal	4	104	0.038	0	26	--	0	30	--
Blue-winged teal	12	415	0.029	0	72	--	20	170	0.118
Shoveler	93	258	0.360	6	88	0.068	89	164	0.543
Pintail	117	450	0.260	68	172	0.395	125	424	0.295
Redhead	0	2	--	7	32	0.219	3	10	0.300
Canvasback	5	46	0.109	10	56	0.178	32	76	0.421
Scaup	110	206	0.534	11	38	0.289	17	48	0.354
Ring-necked duck	14	0	--	--	--	--	--	--	--
Bufflehead	2	0	--	--	--	--	--	--	--
Ruddy duck	0	42	--	0	16	--	7	32	0.219
Others	--	--	--	--	--	--	--	--	--
Total ducks	782	2,529	0.309	315	1,084	0.290	533	1,568	0.340
Coots	94	52	1.808	0	32	--	22	64	0.344
Water areas	222	287	0.774	411	386	1.065	315	317	0.994
Number of transects			5			5			5
Square miles			16.75			16.75			16.75

Table 6 .--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Saskatchewan stratum A-W, 1961-66--continued

	1964			1965			1966		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	222	426	0.521	167	342	0.488	226	512	0.441
Gadwall	117	214	0.547	44	164	0.268	51	288	0.177
American widgeon	22	140	0.157	10	130	0.077	16	140	0.114
Green-winged teal	2	58	0.034	2	28	0.071	3	62	0.048
Blue-winged teal	102	498	0.205	50	256	0.195	58	462	0.126
Shoveler	159	336	0.473	75	184	0.408	110	322	0.342
Pintail	108	368	0.293	153	376	0.407	212	602	0.352
Redhead	14	28	0.500	12	24	0.500	18	74	0.243
Canvasback	17	24	0.708	12	20	0.600	46	56	0.821
Scaup	20	108	0.185	30	70	0.428	17	84	0.202
Ring-necked duck	2	2	1.000	2	0	--	1	0	--
Bufflehead	1	0	--	1	0	--	--	--	--
Ruddy duck	2	16	0.125	7	6	1.167	3	52	0.058
Others	--	--	--	--	--	--	--	--	--
Total ducks	788	2,218	0.355	565	1,600	0.353	761	2,654	0.287
Coots	22	110	0.200	27	148	0.182	90	437	0.206
Water areas	333	462	0.721	611	786	0.777	610	757	0.806
Number of transects			5			6			6
Square miles			20.75			20.75			20.75

Table 7.--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Saskatchewan stratum A-E, 1961-66

	1961			1962			1963		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	171	229	0.747	112	214	0.523	83	131	0.634
Gadwall	12	48	0.250	4	14	0.286	6	4	1.500
American widgeon	16	64	0.250	5	54	0.092	5	44	0.114
Green-winged teal	5	18	0.278	0	10	--	--	--	--
Blue-winged teal	42	220	0.191	4	96	0.042	7	42	0.167
Shoveler	34	136	0.250	7	26	0.269	4	10	0.400
Pintail	13	32	0.406	24	108	0.222	17	50	0.340
Redhead	0	12	--	0	2	--	6	6	1.000
Canvasback	5	18	0.278	1	6	0.167	2	6	0.333
Scaup	16	34	0.470	0	24	--	2	0	--
Ring-necked duck	0	18	--	0	2	--	--	--	--
Bufflehead	--	--	--	0	2	--	--	--	--
Ruddy duck	0	6	--	--	--	--	--	--	--
Others	--	--	--	--	--	--	--	--	--
Total ducks	314	835	0.376	157	558	0.281	132	293	0.450
Coots	0	22	--	1	1	1.000	4	3	1.333
Water areas	82	126	0.651	424	502	0.845	329	279	1.179
Number of transects			6			5			6
Square miles			11.75			10.00			10.3125

Table 7 .--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Saskatchewan stratum A-E, 1961-66--continued

	1964			1965			1966		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	74	218	0.339	99	232	0.427	109	216	0.505
Gadwall	10	44	0.227	3	24	0.125	5	34	0.147
American widgeon	14	40	0.350	12	38	0.316	10	74	0.135
Green-winged teal	0	24	--	2	8	0.250	1	26	0.038
Blue-winged teal	18	352	0.051	8	186	0.043	8	194	0.041
Shoveler	21	86	0.244	11	38	0.289	12	48	0.250
Pintail	58	134	0.433	25	56	0.446	20	92	0.217
Redhead	8	2	4.000	8	10	0.800	8	14	0.571
Canvasback	4	2	2.000	14	10	1.400	45	52	0.865
Scaup	16	26	0.615	15	20	0.750	55	46	1.196
Ring-necked duck	0	4	--	--	--	--	--	--	--
Bufflehead	--	--	--	0	6	--	--	--	--
Ruddy duck	0	4	--	2	4	0.500	1	16	0.062
Others	--	--	--	--	--	--	0	2	--
Total ducks	223	936	0.238	199	632	0.315	274	814	0.337
Coots	38	154	0.247	34	127	0.268	25	96	0.260
Water areas	832	1,031	0.807	717	1,004	0.714	993	1,085	0.915
Number of transects			6			6			6
Square miles			11.75			11.75			11.75

Table 8 .--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Manitoba stratum A, 1961-66

	1961			1962			1963		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	148	194	0.763	85	152	0.559	118	172	0.686
Gadwall	18	46	0.391	10	46	0.217	16	61	0.262
American widgeon	14	30	0.467	4	34	0.118	5	48	0.104
Green-winged teal	4	58	0.069	0	40	--	0	39	--
Blue-winged teal	75	448	0.167	73	229	0.319	51	225	0.227
Shoveler	55	132	0.417	21	36	0.583	18	56	0.321
Pintail	63	104	0.606	35	84	0.417	36	82	0.439
Redhead	7	38	0.184	5	50	0.100	34	78	0.436
Canvasback	54	20	2.700	16	30	0.533	26	66	0.394
Scaup	11	24	0.458	38	40	0.950	18	31	0.581
Ring-necked duck	5	20	0.250	0	6	--	--	--	--
Bufflehead	--	--	--	--	--	--	--	--	--
Ruddy duck	0	8	--	0	6	--	3	16	0.188
Others	--	--	--	--	--	--	--	--	--
Total ducks	454	1,122	0.405	287	753	0.381	325	874	0.372
Coots	35	103	0.340	19	43	0.442	86	213	0.404
Water areas	310	483	0.642	328	428	0.766	552	596	0.926
Number of transects			4			4			4
Square miles			9.625			9.625			9.625

Table 8 .--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in southern Manitoba stratum A, 1961-66--continued

	1964			1965			1966		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	52	158	0.329	59	124	0.476	76	136	0.559
Gadwall	9	50	0.180	6	40	0.150	4	50	0.080
American widgeon	10	38	0.263	17	28	0.607	8	32	0.250
Green-winged teal	0	32	--	5	20	0.250	1	36	0.028
Blue-winged teal	31	436	0.071	15	220	0.068	14	218	0.064
Shoveler	48	108	0.444	19	62	0.306	16	50	0.320
Pintail	38	108	0.352	54	108	0.500	32	66	0.485
Redhead	27	68	0.397	24	38	0.632	18	24	0.750
Canvasback	38	58	0.655	24	66	0.364	27	22	1.227
Scaup	28	44	0.636	15	22	0.682	18	22	0.818
Ring-necked duck	3	6	0.500	--	--	--	0	4	--
Bufflehead	--	--	--	1	8	0.125	--	--	--
Ruddy duck	1	26	0.038	--	--	--	4	8	0.500
Others	--	--	--	--	--	--	--	--	--
Total ducks	285	1,132	0.252	239	736	0.325	218	668	0.326
Coots	116	342	0.339	82	366	0.224	67	134	0.500
Water areas	633	708	0.894	1,278	1,669	0.766	550	729	0.754
Number of transects			4			4			4
Square miles			9.625			9.625			9.625

Table 9.--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in the Tristate area, 1963-66

	1963			1964		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	202	378	0.534	109	242	0.450
Gadwall	104	372	0.280	15	236	0.064
American widgeon	8	36	0.222	0	16	--
Green-winged teal	0	18	--	0	18	--
Blue-winged teal	233	1,843	0.126	171	902	0.190
Shoveler	129	314	0.411	82	174	0.471
Pintail	146	366	0.399	47	248	0.190
Redhead	30	148	0.203	32	100	0.320
Canvasback	0	12	--	0	30	--
Scaup	9	10	0.900	0	12	--
Ring-necked duck	0	10	--	0	6	--
Bufflehead	--	--	--	--	--	--
Ruddy duck	16	52	0.308	1	46	0.022
Others	0	2	--	--	--	--
Total ducks	877	3,561	0.246	457	2,030	0.225
Coots	179	419	0.427	32	327	0.098
Water areas	479	700	0.684	285	332	0.858
Number of transects			8			8
Square miles			18.875			18.875

Table 9.--Aerial indexes, ground counts and air:ground ratios for combined air:ground comparison transects in the Tristate area, 1963-66--continued

	1965			1966		
	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Mallard	94	234	0.402	70	156	0.449
Gadwall	54	230	0.235	63	106	0.594
American widgeon	1	8	0.125	0	2	--
Green-winged teal	0	14	--	1	6	0.167
Blue-winged teal	165	1,026	0.161	43	550	0.078
Shoveler	49	218	0.225	22	82	0.268
Pintail	93	302	0.308	27	166	0.163
Redhead	23	122	0.188	16	84	0.190
Canvasback	11	14	0.786	8	8	1.000
Scaup	12	18	0.667	1	16	0.062
Ring-necked duck	0	2	--	1	2	0.500
Bufflehead	--	--	--	0	0	--
Ruddy duck	4	80	0.050	4	24	0.167
Others	--	--	--	--	--	--
Total ducks	506	2,268	0.223	256	1,202	0.213
Coots	132	458	0.288	111	175	0.634
Water areas	509	528	0.964	269	364	0.739
Number of transects			9			7
Square miles			22.875			15.375

Table 10.--The results of comparing groups of high and low air:ground ratios per survey stratum or area per year with their respective duck densities

	Years	Higher air:ground ratio associated with lower density of ducks			Total comparisons
		Yes	No	No difference	
Alberta B	1961-66	6	0	0	6
Alberta A and C	1961-66	5	0	1	6
Saskatchewan B	1961-66	3	3	0	6
Saskatchewan A-W	1961-66	4	1	1	6
Saskatchewan A-E and Manitoba A	1961-66	5	1	0	6
Tristate	1963-66	3	1	0	4
Totals		26	6	2	34

Table 11.--Chi-square values for tests of the differences in air:ground ratios of mallards among years

Survey area	Years	X^2	Degrees of freedom	Probability of difference being due to chance
Alberta B	1961-66	172.26	5	Less than .01
Alberta A and C	1961-66	58.93	5	Less than .01
Saskatchewan B	1961-66	4.44	5	Between .50 and .25
Saskatchewan A-W	1961-66	32.24	5	Less than .01
Saskatchewan A-E and Manitoba A	1961-66	51.14	5	Less than .01
Tristate	1963-66	5.63	3	Between .50 and .25

Table 12.--Chi-square values for tests of the differences in air:ground ratios of mallards among years in which the aerial survey crew was the same -- differences are presumed to reflect biological changes among years.

Survey area	Years	X^2	Degrees of freedom	Probability of difference being due to chance
Alberta B	1962-64	45.60	2	Less than .01
Alberta A and C	1962-64	32.47	2	Less than .01
Saskatchewan B	1964-65	2.06	1	Between .25 and .10
Saskatchewan A-W	1964-65	0.25	1	Between .75 and .50
Saskatchewan A-E and Manitoba A	1965-66	1.73	1	Between .25 and .10
Tristate	1964-65	0.45	1	.50

Table 13.--The difference between aerial indexes of ducks from first and second consecutive aerial passes on air:ground comparison transects in relation to time of day and direction of flight, 1966

Time and direction of first aerial pass	First aerial pass			Second aerial pass			Percent difference between means of first & second passes	"t" of difference (Bailey, 1959:173)	Number of transects for which aerial indexes on the first pass were --			X^2 of relation
	$\bar{X}$	N	S_X	$\bar{X}$	N	S_X			Higher	Lower	Same	
Before 9:00 A.M.												
East-to-west	65.1	14	30.5	43.8	14	25.8	-33	1.99	12	2	0	5.78
West-to-east	160.4	11	101.7	147.2	11	105.2	- 8	0.30	8	3	0	1.45
Total[1/]	116.6	28	85.9	98.2	28	87.8	-16	0.79	23	5	0	10.32
After 9:00 A.M.												
East-to-west	80.0	9	69.1	73.3	9	67.1	- 8	0.21	6	2	1	0.44
West-to-east	71.9	15	47.3	72.1	15	63.3	--	0.01	8	7	0	0
Total[2/]	79.1	25	58.9	75.2	25	64.7	- 5	0.22	15	9	1	0.64

[1/] Three transect coverages in north-south direction.

[2/] One transect coverage in north-south direction.

Table 14.--A comparison of the duck species in aerial indexes for operational and air:ground comparison transects in southern Alberta, 1961-66

Species	B		A		C		A and C combined	
	Operational transects	Air:ground comparison transects	Operational transects	Air:ground comparison transects	Operational transects	Air:ground comparison transects	Operational transects	Air:ground comparison transects
Mallard	37.9	35.9	33.0	23.2	29.3	23.4	33.3	23.2
Gadwall	5.5	5.5	4.5	4.4	2.8	5.0	3.9	4.6
Am. Widgeon	7.8	7.7	7.4	7.3	6.6	6.7	7.0	7.2
GW Teal	1.8	1.6	1.0	0.6	0.5	0.2	0.9	0.5
BW Teal	5.9	6.0	5.1	3.8	3.1	3.4	4.4	3.7
Shoveler	8.1	10.0	10.1	10.4	7.7	6.7	9.2	9.5
Pintail	9.4	11.2	27.8	31.9	36.2	31.4	29.7	31.8
Redhead	2.5	2.5	1.1	0.7	0.9	0.2	1.0	0.6
Canvasback	3.0	2.3	1.2	1.9	0.4	0.8	0.9	1.6
Scaup	13.2	14.6	8.2	15.5	11.0	21.9	8.9	17.1
Ruddy duck	0.8	0.5	0.2	0.1	1.4	0.1	0.6	0.1
Others	4.1	2.2	0.2	0.2	0.1	0.2	0.3	0.2
Total	100.0	100.0	99.8	100.0	100.0	100.0	100.1	100.1

Table 15.--A comparison of the duck species in aerial indexes for operational and air:ground comparison transects in southern Saskatchewan, 1961-66

Species	B-W		B-E		B-W and B-E combined		A-W		A-W and C combined
	Operational transects	Air:ground comparison transects	Operational transects	Air:ground comparison transects	Operational transects	Air:ground comparison transects	Operational transects	Air:ground comparison transects	Operational transects
Mallard	40.6	56.5	51.3	48.0	47.0	55.2	41.4	36.4	37.4
Gadwall	5.4	2.0	3.5	4.8	4.3	3.7	8.7	8.1	8.1
Am. Widgeon	5.5	6.3	4.0	3.7	4.6	5.2	4.4	2.3	3.0
GW Teal	1.0	0.9	0.3	0.4	0.6	0.7	0.7	0.3	0.4
BW Teal	4.4	5.0	3.8	3.0	4.1	4.2	6.3	6.5	6.1
Shoveler	7.1	4.0	6.2	9.5	6.5	7.4	7.2	14.2	13.2
Pintail	13.0	10.6	14.4	17.0	13.8	8.6	23.0	20.9	21.8
Redhead	2.6	0.8	2.0	1.7	2.3	1.3	1.4	1.4	1.1
Canvasback	5.7	1.8	4.3	3.4	4.8	2.8	2.4	3.3	2.5
Scaup	10.5	11.0	7.1	8.0	8.5	10.0	3.5	5.4	5.3
Ruddy duck	1.2	0.1	0.7	0.1	0.9	0.1	0.5	0.5	0.6
Others	2.9	0.9	2.4	0.2	2.7	0.6	0.4	0.6	0.5
Total	99.9	99.9	100.0	99.8	100.1	99.8	99.9	99.9	100.0

Table 16.--A comparison of the duck species in aerial indexes for operational and air:ground comparison transects in southern Saskatchewan stratum A-E and southern Manitoba, 1961-66

Species	Sask. A-E		Man. A		Man. A & B combined
	Operational transects	Air:ground comparison transects	Operational transects	Air:ground comparison transects	Operational transects
Mallard	51.5	49.9	30.9	28.1	35.6
Gadwall	3.4	3.1	2.9	3.3	2.3
Am. Widgeon	4.6	4.8	4.5	3.0	3.9
GW Teal	0.5	0.6	0.5	0.5	0.6
BW Teal	10.6	6.7	12.0	13.6	9.0
Shoveler	5.8	6.8	6.9	14.5	6.5
Pintail	11.7	12.1	9.9	13.5	9.6
Redhead	1.3	2.3	4.9	6.0	6.1
Canvasback	3.4	5.5	7.8	9.7	6.7
Scaup	6.2	8.0	15.0	6.7	14.3
Ruddy Duck	0.1	0.2	3.3	0.4	2.8
Others	0.6	--	1.5	0.5	2.6
Total	99.7	100.0	100.1	99.8	100.0

Table 17.--A comparison of the duck species in aerial indexes for operational and air:ground comparison transects in the Tristate area, 1963-66

Species	C		E		C and E combined		E, C and W combined
	Operational transects	Air:ground comparison transects	Operational transects	Air:ground comparison transects	Operational transects	Air:ground comparison transects	Operational transects
Mallard	28.6	20.0	32.8	28.6	30.1	20.7	32.5
Gadwall	13.9	12.2	8.2	7.1	11.9	11.7	11.8
Am. Widgeon	0.3	0.4	0.4	--	0.3	0.4	0.4
GW Teal	0.4	0.2	0.1	--	0.3	0.2	0.3
BW Teal	25.6	25.5	26.7	31.3	26.0	26.3	25.1
Shoveler	9.7	20.7	9.0	4.1	9.4	18.8	8.9
Pintail	11.3	13.6	9.1	15.0	10.5	13.8	10.6
Redhead	4.6	4.0	4.7	11.6	4.6	4.9	4.2
Canvasback	2.6	1.0	3.0	--	2.7	0.8	2.4
Scaup	2.2	1.3	4.7	--	3.1	1.1	3.0
Ruddy Duck	0.7	1.0	0.8	2.4	0.8	1.2	0.4
Others	0.1	0.1	0.6	--	0.3	0.1	0.3
Total	100.0	100.0	100.1	100.1	100.0	100.0	99.9

Table 18.--A comparison of breeding ducks (all species combined) per square mile from aerial indexes on operational and air:ground comparison transects in breeding ground survey strata, 1961-66

Province or State	Stratum	Ducks per square mile	
		Operational transects	Air:ground comparison transects
Alberta	B	44.3	53.4
	A	21.9	25.4
	C	14.2	46.5
	A & C combined	18.6	28.7
Saskatchewan	B-W	18.4	28.9
	B-E	15.4	26.0
	B-W & B-E combined	16.5	27.3
	A-W	13.9	34.5
	C	10.6	--
	A-W & C combined	13.1	--
Sask. A-E and Manitoba[1/]	Sask. A-E	15.9	19.9
	Man. A	26.9	39.6
	Man. B	9.9	--
	A & B combined	14.4	--
Tristate	W	3.4	--
	C	10.1	23.4
	E	6.3	12.2
	C & E combined	8.4	20.9
	W, C & E combined	7.3	--

1/ 1962 not included.

Table 19.--Aerial indexes, ground counts and air:ground ratios for ducks (all species combined) on air:ground comparison transects in southern Alberta, 1961-66

Length of transect (miles)	Stratum	Transect	1961			1962			1963		
			Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
17.00	C	Whiskey Gap	234	408	0.574	247	472	0.523	108	236	0.458
39.50	A	Stavely	--[1]	390	--	239	498	0.480	96	180	0.533
14.00	A	Mossleigh	300	720	0.417	88	450	0.196	72	98	0.735
29.00	A	Strathmore	251	1,026	0.245	287	668	0.430	277	872	0.318
12.75	A	Farrell Lake	215	350	0.614	--	--	--	114	168	0.678
16.00	B	Bashaw	477	902	0.529	352	504	0.698	245	618	0.396
19.00	B	Camrose	--[1]	64	--	171	222	0.770	296	780	0.379
10.75	B	Viking	354	590	0.600	291	436	0.667	257	596	0.431
18.50	B	Kenilworth	208	178	1.168	215	314	0.685	180	486	0.370
17.50	B	Leduc	238	526	0.452	156	408	0.382	148	444	0.333
10.00	B	Royal Park	345	610	0.566	112	496	0.226	150	550	0.273

[1] No aerial data

Table 19.--Aerial indexes, ground counts and air:ground ratios for ducks (all species combined) on air:ground comparison transects in southern Alberta, 1961-66--continued

Length of transect (miles)	Stratum	Transect	1964			1965			1966		
			Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
17.00	C	Whiskey Gap	255	424	0.601	159	424	0.375	183	766	0.239
39.50	A	Stavely	132	202	0.653	44	168	0.262	101	270	0.374
14.00	A	Mossleigh	86	108	0.796	93	216	0.430	179	440	0.407
29.00	A	Strathmore	283	620	0.456	147	406	0.362	276	970	0.284
12.75	A	Farrell Lake	85	124	0.685	82	170	0.482	96	290	0.331
16.00	B	Bashaw	362	788	0.459	181	526	0.344	260	808	0.322
19.00	B	Camrose	164	498	0.329	86	353	0.244	115	394	0.292
10.75	B	Viking	247	636	0.388	187	594	0.315	167	532	0.314
18.50	B	Kenilworth	209	535	0.391	130	498	0.261	174	512	0.340
17.50	B	Leduc	167	348	0.480	93	308	0.302	164	370	0.443
10.00	B	Royal Park	210	480	0.438	104	242	0.430	130	368	0.353

Table 20.--Aerial indexes, ground counts and air:ground ratios for ducks (all species combined) on air:ground comparison transects in southern Saskatchewan, 1961-66

Length of transect (miles)	Stratum	Transect	1961			1962			1963		
			Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
17.00	A-W	Lake Alma	131	594	0.220	42	338	0.124	108	406	0.266
16.00	A-W	Wheatstone	161	613	0.263	56	178	0.315	60	228	0.263
11.00	A-W	Shamrock	43	110	0.391	62	118	0.525	139	314	0.443
10.00	A-W	Gouldtown	199	590	0.337	78	300	0.260	140	426	0.329
13.00	A-W	Kenaston	247	622	0.397	76	150	0.507	86	194	0.443
16.00	A-W	Valley Center[1/]	--	--	--	--	--	--	--	--	--
11.00	B-W	Alticane	119	322	0.370	48	136	0.353	78	152	0.513
7.00	B-W	Turtleford	63	304	0.207	59	204	0.289	45	220	0.204
11.00	B-E	Rose Valley	91	276	0.330	104	310	0.335	115	274	0.420
12.00	B-E	Kinistino	76	300	0.253	72	210	0.343	30	136	0.220

[1/] Established in 1965.

Table 20.--Aerial indexes, ground counts and air:ground ratios for ducks (all species combined) on air:ground comparison transects in southern Saskatchewan, 1961-66--continued

Length of transect (miles)	Stratum	Transect	1964			1965			1966		
			Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
17.00	A-W	Lake Alma	233	754	0.309	134	334	0.401	177	578	0.306
16.00	A-W	Wheatstone	125	326	0.383	122	330	0.370	105	424	0.248
11.00	A-W	Shamrock	85	234	0.363	90	208	0.433	114	256	0.445
10.00	A-W	Gouldtown	178	510	0.349	87	324	0.268	183	804	0.228
13.00	A-W	Kenaston	164	394	0.416	89	224	0.397	108	344	0.314
16.00	A-W	Valley Center[1/]	--	--	--	42	180	0.233	73	248	0.294
11.00	B-W	Alticane	50	126	0.397	71	168	0.423	98	288	0.340
7.00	B-W	Turtleford	61	166	0.367	37	138	0.268	53	112	0.473
11.00	B-E	Rose Valley	105	178	0.590	88	214	0.411	85	312	0.272
12.00	B-E	Kinistino	26	90	0.289	30	104	0.288	75	180	0.417

[1/] Established in 1965.

Table 21.--Aerial indexes, ground counts and air:ground ratios for ducks (all species combined) on air:ground comparison transects in southern Saskatchewan and southern Manitoba, 1961-66

Length of transect (miles)	Stratum	Transect	1961			1962			1963		
			Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
7.00	Sask. A-E	Fertile	15	62	0.242	--	--	--	24	44	0.545
5.75	Sask. A-E	Moose Valley	39	233	0.167	6	94	0.064	--	--	--
13.00	Sask. A-E	Kipling	126	286	0.440	54	98	0.551	29	78	0.372
6.75	Sask. A-E	Grayson	34	56	0.607	26	72	0.361	26	38	0.684
5.50	Sask. A-E	Jasmin	89	166	0.536	34	124	0.274	36	93	0.387
9.00	Sask. A-E	Springside	10	32	0.312	40	170	0.235	16	40	0.400
8.50	Man. A	Boissevain	154	304	0.506	156	307	0.508	120	400	0.300
9.00	Man. A	Griswold	120	394	0.304	38	152	0.250	57	142	0.401
10.00	Man. A	Buelah-Decker	62	128	0.484	40	120	0.333	57	108	0.528
11.00	Man. A	Oakburn	116	296	0.392	53	174	0.304	92	224	0.411

Table 21.--Aerial indexes, ground counts and air:ground ratios for ducks (all species combined) on air:ground comparison transects in southern Saskatchewan and southern Manitoba, 1961-66--continued

Length of transect (miles)	Stratum	Transect	1964			1965			1966		
			Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
7.00	Sask. A-E	Fertile	22	150	0.147	22	62	0.355	24	66	0.364
5.75	Sask. A-E	Moose Valley	37	150	0.247	49	170	0.288	66	242	0.273
13.00	Sask. A-E	Kipling	49	240	0.204	30	144	0.208	55	170	0.324
6.75	Sask. A-E	Grayson	73	286	0.255	48	162	0.296	78	178	0.438
5.50	Sask. A-E	Jasmin	21	36	0.583	18	54	0.333	27	62	0.435
9.00	Sask. A-E	Springside	23	76	0.303	30	40	0.750	22	96	0.229
8.50	Man. A	Boissevain	76	364	0.209	46	142	0.324	46	154	0.299
9.00	Man. A	Griswold	44	172	0.256	64	180	0.356	44	172	0.256
10.00	Man. A	Buelah-Decker	57	174	0.328	57	222	0.257	34	152	0.224
11.00	Man. A	Oakburn	108	422	0.256	72	192	0.375	96	190	0.505

Table 22.--Aerial indexes, ground counts and air:ground ratios for ducks (all species combined) on air:ground comparison transects in the Tristate area, 1963-66

Length of transect (miles)	State and stratum	Transect	1963			1964		
			Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
10.00	N. Dak. C	Max	139	348	0.399	76	244	0.311
8.00	N. Dak. C	Sharon[1/]	--	--	--	--	--	--
10.50	N. Dak. C	Woodworth	162	695	0.233	56	340	0.165
12.00	N. Dak. C	Jud	129	356	0.362	13	56	0.232
13.00	S. Dak. C	Hosmer[1/]	--	--	--	--	--	--
14.00	S. Dak. C	Waubay	130	622	0.209	111	538	0.206
19.00	S. Dak. C	Hayti	79	316	0.250	48	224	0.214
10.00	S. Dak. C	Mitchell	125	814	0.154	96	280	0.343
5.00	Minn. E	Hitterdal	49	156	0.314	24	106	0.226
19.00	Minn. E	Clinton	65	256	0.254	33	242	0.136

[1/] Established in 1965.

Table 22.--Aerial indexes, ground counts and air:ground ratios for ducks (all species combined) on air:ground comparison transects in the Tristate area, 1963-66--continued

Length of transect (miles)	State and stratum	Transect	1965 Aerial index	1965 Ground count	1965 Air:ground ratio	1966 Aerial index	1966 Ground count	1966 Air:ground ratio
10.00	N. Dak. C	Max	33	202	0.163	32	202	0.158
8.00	N. Dak. C	Sharon[1/]	25	138	0.181	--	--	--[2/]
10.50	N. Dak. C	Woodworth	84	376	0.223	67	278	0.241
12.00	N. Dak. C	Jud	71	324	0.219	71	326	0.218
13.00	S. Dak. C	Hosmer[1/]	129	534	0.242	--	--	--[2/]
14.00	S. Dak. C	Waubay	95	394	0.241	--	--	--[2/]
19.00	S. Dak. C	Hayti	26	136	0.191	27	136	0.198
10.00	S. Dak. C	Mitchell	12	32	0.375	19	42	0.452
5.00	Minn. E	Hitterdal	--	--	--[2/]	22	72	0.306
19.00	Minn. E	Clinton	30	132	0.227	18	148	0.122

[1/] Established in 1965.

[2/] Not presented because of procedural discrepancy.

Table 23.--Aerial indexes, ground counts and air:ground ratios for mallards on air:ground comparison transects in southern Alberta, 1961-66

Stratum	Transect	1961			1962			1963		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
C	Whiskey Gap	49	82	0.598	73	242	0.302	18	42	0.428
A	Stavely	--[1]	54	--	86	164	0.524	25	26	0.962
A	Mossleigh	39	82	0.476	22	54	0.407	6	14	0.428
A	Strathmore	50	144	0.347	53	136	0.390	55	108	0.509
A	Farrell Lake	81	102	0.794	--	--	--[1]	58	66	0.879
B	Bashaw	182	256	0.711	151	188	0.803	96	196	0.490
B	Camrose	--[1]	42	--	94	52	1.808	132	216	0.611
B	Viking	136	176	0.773	124	146	0.849	73	172	0.424
B	Kenilworth	110	54	2.037	112	106	1.057	70	126	0.556
B	Leduc	83	142	0.584	48	74	0.649	49	104	0.471
B	Royal Park	131	138	0.949	38	148	0.257	50	142	0.352

[1] Not counted.

Table 23.--Aerial indexes, ground counts and air:ground ratios for mallards on air:ground comparison transects in southern Alberta, 1961-66--continued

Stratum	Transect	1964			1965			1966		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
C	Whiskey Gap	63	88	0.716	32	100	0.320	42	176	0.239
A	Stavely	36	40	0.900	13	48	0.271	31	64	0.484
A	Mossleigh	19	20	0.950	10	32	0.312	29	66	0.439
A	Strathmore	58	96	0.604	27	46	0.587	42	106	0.396
A	Farrell Lake	32	36	0.889	24	60	0.400	26	80	0.325
B	Bashaw	93	156	0.596	36	108	0.333	64	236	0.271
B	Camrose	71	174	0.408	41	102	0.402	57	126	0.452
B	Viking	55	194	0.284	53	140	0.378	51	174	0.293
B	Kenilworth	80	126	0.635	36	102	0.353	58	114	0.509
B	Leduc	66	98	0.673	27	68	0.397	38	114	0.333
B	Royal Park	68	114	0.596	29	66	0.439	31	92	0.337

Table 24.--Aerial indexes, ground counts and air:ground ratios for mallards on air:ground comparison transects in southern Saskatchewan, 1961-66

Stratum	Transect	1961			1962			1963		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
A-W	Lake Alma	60	110	0.545	39	38	1.026	38	66	0.576
A-W	Wheatstone	64	100	0.640	33	54	0.611	14	50	0.280
A-W	Shamrock	34	32	1.062	38	48	0.792	35	76	0.460
A-W	Gouldtown	75	102	0.735	35	72	0.486	29	56	0.518
A-W	Kenaston	156	214	0.729	53	60	0.883	46	78	0.590
A-W	Valley Center[1/]	--	--	--	--	--	--	--	--	--
B-W	Alticane	78	138	0.565	38	68	0.559	60	78	0.769
B-W	Turtleford	35	84	0.417	38	104	0.365	30	76	0.395
B-E	Rose Valley	66	108	0.611	54	66	0.818	37	98	0.378
B-E	Kinistino	50	140	0.357	47	104	0.452	18	70	0.257

1/Established in 1965.

Table 24.--Aerial indexes, ground counts and air:ground ratios for mallards on air:ground comparison transects in southern Saskatchewan, 1961-66--continued

Stratum	Transect	1964			1965			1966		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
A-W	Lake Alma	58	102	0.569	48	66	0.727	75	68	1.103
A-W	Wheatstone	52	58	0.896	38	80	0.475	30	82	0.366
A-W	Shamrock	29	76	0.382	29	40	0.725	27	62	0.435
A-W	Gouldtown	22	84	0.262	9	54	0.167	32	138	0.232
A-W	Kenaston	60	106	0.566	28	58	0.483	41	98	0.418
A-W	Valley Center[1/]	--	--	--	15	44	0.341	20	64	0.312
B-W	Alticane	20	50	0.400	23	[illegible]	0.523	44	82	0.536
B-W	Turtleford	35	38	0.921	18	42	0.428	24	34	0.706
B-E	Rose Valley	36	48	0.750	28	48	0.583	26	102	0.255
B-E	Kinistino	13	36	0.361	18	52	0.346	38	68	0.559

1/ Established in 1965.

Table 25.--Aerial indexes, ground counts and air:ground ratios for mallards on air:ground comparison transects in southern Saskatchewan and southern Manitoba, 1961-66

Stratum	Transect	1961			1962			1963		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Sask. A-E	Fertile	8	22	0.364	--	--	--[1]	13	10	1.300
Sask. A-E	Moose Valley	10	37	0.270	6	26	0.231	--	--	--[1]
Sask. A-E	Kipling	67	70	0.957	42	46	0.913	13	34	0.382
Sask. A-E	Grayson	27	38	0.710	20	48	0.417	22	32	0.688
Sask. A-E	Jasmin	54	46	1.174	24	42	0.571	27	45	0.600
Sask. A-E	Springside	4	16	0.250	21	52	0.404	8	10	0.800
Man. A	Boissevain	58	24	2.417	29	26	1.115	15	36	0.417
Man. A	Griswold	25	56	0.446	8	30	0.267	19	48	0.396
Man. A	Buelah-Decker	40	58	0.690	27	50	0.540	26	34	0.765
Man. A	Oakburn	25	56	0.446	21	46	0.456	58	54	1.074

[1] Not counted.

Table 25.--Aerial indexes, ground counts and air:ground ratios for mallards on air:ground comparison transects in southern Saskatchewan and southern Manitoba, 1961-66--continued

Stratum	Transect	1964			1965			1966		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Sask. A-E	Fertile	5	30	0.167	10	18	0.556	17	18	0.944
Sask. A-E	Moose Valley	8	24	0.333	24	52	0.462	20	48	0.417
Sask. A-E	Kipling	19	60	0.317	14	56	0.250	28	60	0.467
Sask. A-E	Grayson	18	72	0.250	18	52	0.346	18	40	0.450
Sask. A-E	Jasmin	9	10	0.900	14	38	0.368	14	24	0.583
Sask. A-E	Springside	15	22	0.682	19	16	1.188	12	26	0.462
Man. A	Boissevain	6	46	0.130	12	14	0.857	7	24	0.292
Man. A	Griswold	9	24	0.375	12	24	0.500	12	26	0.462
Man. A	Buelah-Decker	15	34	0.441	14	52	0.269	18	42	0.428
Man. A	Oakburn	22	54	0.407	22	34	0.647	39	44	0.886

Table 26.--Aerial indexes, ground counts and air:ground ratios for mallards on air:ground comparison transects in the Tristate area, 1963-66

State and stratum	Transect	1963 Aerial index	1963 Ground count	1963 Air:ground ratio	1964 Aerial index	1964 Ground count	1964 Air:ground ratio
N. Dak. C	Max	20	40	0.500	21	20	1.050
N. Dak. C	Sharon[1/]	--	--	--	--	--	--
N. Dak. C	Woodworth	39	46	0.848	6	38	0.158
N. Dak. C	Jud	34	56	0.607	4	8	0.500
S. Dak. C	Hosmer[1/]	--	--	--	--	--	--
S. Dak. C	Waubay	36	66	0.545	41	66	0.621
S. Dak. C	Hayti	14	30	0.467	8	26	0.308
S. Dak. C	Mitchell	25	70	0.357	11	24	0.458
Minn. E	Hitterdal	19	36	0.528	6	22	0.273
Minn. E	Clinton	15	34	0.441	13	38	0.342

[1/] Established in 1965.

Table 26.--Aerial indexes, ground counts and air:ground ratios for mallards on air:ground comparison transects in the Tristate area, 1963-66--continued

State and stratum	Transect	1965 Aerial index	1965 Ground count	1965 Air:ground ratio	1966 Aerial index	1966 Ground count	1966 Air:ground ratio
N. Dak. C	Max	8	32	0.250	12	26	0.462
N. Dak. C	Sharon[1/]	6	10	0.600	--	--	--[2/]
N. Dak. C	Woodworth	18	42	0.428	14	30	0.467
N. Dak. C	Jud	11	38	0.289	18	38	0.474
S. Dak. C	Hosmer[1/]	19	40	0.475	--	--	--[2/]
S. Dak. C	Waubay	12	36	0.333	--	--	--[2/]
S. Dak. C	Hayti	7	16	0.438	7	20	0.350
S. Dak. C	Mitchell	6	6	1.000	4	2	2.000
Minn. E	Hitterdal	--	--	--[2/]	7	24	0.292
Minn. E	Clinton	6	14	0.428	6	16	0.375

[1/] Established in 1965.

[2/] Not presented because of procedural discrepancy.

Table 27.--Aerial indexes, ground counts and air:ground ratios for blue-winged teal on air:ground comparison transects in southern Alberta, 1961-66

Stratum	Transect	1961			1962			1963		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
C	Whiskey Gap	21	83	0.253	8	30	0.267	0	20	--
A	Stavely	--[1]	70	--	3	4	0.750	4	0	--
A	Mossleigh	9	54	0.167	0	38	--	1	2	0.500
A	Strathmore	8	158	0.051	9	74	0.122	3	46	0.065
A	Farrell Lake	18	44	0.409	--	--	--[1]	4	22	0.182
B	Bashaw	22	190	0.116	22	54	0.407	7	52	0.135
B	Camrose	--[1]	2	--	4	98	0.041	8	108	0.074
B	Viking	31	42	0.738	9	28	0.321	8	80	0.100
B	Kenilworth	6	40	0.150	3	28	0.107	8	96	0.083
B	Leduc	24	112	0.214	11	100	0.110	4	72	0.056
B	Royal Park	21	180	0.117	4	84	0.048	4	104	0.038

[1] Not counted.

Table 27.--Aerial indexes, ground counts and air:ground ratios for blue-winged teal on air:ground comparison transects in southern Alberta, 1961-66--continued

Stratum	Transect	1964			1965			1966		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
C	Whiskey Gap	4	48	0.083	0	30	--	8	66	0.121
A	Stavely	3	14	0.214	0	0	--	6	14	0.428
A	Mossleigh	1	6	0.167	2	6	0.333	10	28	0.357
A	Strathmore	12	82	0.146	1	24	0.042	22	104	0.212
A	Farrell Lake	2	20	0.100	6	36	0.167	8	52	0.154
B	Bashaw	32	214	0.150	22	86	0.256	16	116	0.138
B	Camrose	16	92	0.174	4	46	0.087	6	42	0.143
B	Viking	15	116	0.129	6	60	0.100	6	46	0.130
B	Kenilworth	16	129	0.124	14	110	0.127	9	66	0.136
B	Leduc	10	24	0.417	9	30	0.300	13	38	0.342
B	Royal Park	16	126	0.127	11	40	0.275	24	60	0.400

Table 28.--Aerial indexes, ground counts and air:ground ratios for blue-winged teal on air:ground comparison transects in southern Saskatchewan, 1961-66

Stratum	Transect	1961			1962			1963		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
A-W	Lake Alma	0	166	--	0	28	--	8	74	0.108
A-W	Wheatstone	5	115	0.043	0	28	--	0	28	--
A-W	Shamrock	0	2	--	0	2	--	5	24	0.208
A-W	Gouldtown	2	48	0.042	0	6	--	5	20	0.250
A-W	Kenaston	5	84	0.060	0	8	--	2	24	0.083
A-W	Valley Center[1/]	--	--	--	--	--	--	--	--	--
B-W	Alticane	4	36	0.111	0	2	--	6	10	0.600
B-W	Turtleford	2	60	0.033	0	16	--	3	16	0.188
B-E	Rose Valley	0	46	--	2	32	0.062	3	22	0.136
B-E	Kinistino	2	36	0.056	0	2	--	0	0	--

[1/] Established in 1965.

Table 28.--Aerial indexes, ground counts and air:ground ratios for blue-winged teal on air:ground comparison transects in southern Saskatchewan, 1961-66--continued

Stratum	Transect	1964			1965			1966		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
A-W	Lake Alma	70	254	0.276	14	68	0.206	11	180	0.061
A-W	Wheatstone	3	44	0.068	10	62	0.161	12	76	0.158
A-W	Shamrock	13	30	0.433	6	28	0.214	7	26	0.269
A-W	Gouldtown	4	56	0.071	8	28	0.286	16	106	0.151
A-W	Kenaston	12	114	0.105	10	60	0.167	11	58	0.190
A-W	Valley Center[1/]	--	--	--	2	10	0.200	1	16	0.062
B-W	Alticane	7	18	0.389	2	36	0.056	5	46	0.109
B-W	Turtleford	1	30	0.033	2	18	0.111	8	16	0.500
B-E	Rose Valley	7	26	0.269	7	16	0.438	2	38	0.053
B-E	Kinistino	0	2	--	2	2	1.000	3	20	0.150

[1/] Established in 1965.

Table 29.--Aerial indexes, ground counts and air:ground ratios for blue-winged teal on air:ground comparison transects in southern Saskatchewan and southern Manitoba, 1961-66

Stratum	Transect	1961			1962			1963		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Sask. A-E	Fertile	4	32	0.125	--	--	--[1]	2	14	0.143
Sask. A-E	Moose Valley	10	80	0.125	0	26	--	--	--	--[1]
Sask. A-E	Kipling	15	48	0.312	2	26	0.077	4	16	0.250
Sask. A-E	Grayson	1	4	0.250	2	6	0.333	0	0	--
Sask. A-E	Jasmin	8	44	0.182	0	8	--	1	6	0.167
Sask. A-E	Springside	2	12	0.167	0	30	--	0	6	--
Man. A	Boissevain	8	140	0.057	42	113	0.372	25	114	0.219
Man. A	Griswold	36	176	0.204	20	60	0.333	18	43	0.419
Man. A	Buelah-Decker	15	32	0.469	2	20	0.100	5	30	0.167
Man. A	Oakburn	16	100	0.160	8	36	0.222	4	38	0.105

[1] Not counted.

Table 29.--Aerial indexes, ground counts and air:ground ratios for blue-winged teal on air:ground comparison transects in southern Saskatchewan and southern Manitoba, 1961-66--continued

Stratum	Transect	1964			1965			1966		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Sask. A-E	Fertile	4	86	0.046	3	34	0.088	2	34	0.059
Sask. A-E	Moose Valley	5	72	0.069	4	62	0.064	1	78	0.013
Sask. A-E	Kipling	5	82	0.061	0	32	--	1	24	0.042
Sask. A-E	Grayson	2	82	0.024	0	54	--	2	26	0.077
Sask. A-E	Jasmin	1	4	0.250	0	2	--	2	14	0.143
Sask. A-E	Springside	1	26	0.038	1	2	0.500	0	18	--
Man. A	Boissevain	17	130	0.131	3	48	0.062	7	48	0.146
Man. A	Griswold	5	110	0.045	8	72	0.111	1	80	0.012
Man. A	Buelah-Decker	5	68	0.074	4	66	0.061	3	46	0.065
Man. A	Oakburn	4	128	0.031	1	34	0.029	4	44	0.091

Table 30.--Aerial indexes, ground counts and air:ground ratios for blue-winged teal on air:ground comparison transects in the Tristate area, 1963-66

State and stratum	Transect	1963 Aerial index	1963 Ground count	1963 Air:ground ratio	1964 Aerial index	1964 Ground count	1964 Air:ground ratio
N. Dak. C	Max	18	112	0.161	33	60	0.550
N. Dak. C	Sharon[1/]	--	--	--	--	--	--
N. Dak. C	Woodworth	24	313	0.077	8	132	0.061
N. Dak. C	Jud	20	132	0.152	3	20	0.150
S. Dak. C	Hosmer[1/]	--	--	--	--	--	--
S. Dak. C	Waubay	36	336	0.107	29	220	0.132
S. Dak. C	Hayti	40	208	0.192	32	142	0.225
S. Dak. C	Mitchell	61	516	0.118	45	154	0.292
Minn. E	Hitterdal	11	80	0.138	8	54	0.148
Minn. E	Clinton	23	146	0.158	13	120	0.108

[1/] Established in 1965.

Table 30.--Aerial indexes, ground counts and air:ground ratios for blue-winged teal on air:ground comparison transects in the Tristate area, 1963-66--continued

State and stratum	Transect	1965 Aerial index	1965 Ground count	1965 Air:ground ratio	1966 Aerial index	1966 Ground count	1966 Air:ground ratio
N. Dak. C	Max	4	66	0.061	1	62	0.016
N. Dak. C	Sharon[1/]	8	64	0.125	--	--	--[2/]
N. Dak. C	Woodworth	15	156	0.096	12	134	0.090
N. Dak. C	Jud	12	118	0.102	10	150	0.067
S. Dak. C	Hosmer[1/]	46	228	0.202	--	--	--[2/]
S. Dak. C	Waubay	49	222	0.221	--	--	--[2/]
S. Dak. C	Hayti	9	82	0.110	4	76	0.053
S. Dak. C	Mitchell	4	22	0.182	8	16	0.500
Minn. E	Hitterdal	--	--	--[2/]	6	34	0.176
Minn. E	Clinton	18	68	0.265	2	78	0.026

[1/] Established in 1965.

[2/] Not presented because of procedural discrepancy.

Table 31.--Aerial indexes, ground counts and air:ground ratios for canvasbacks on air:ground comparison transects in southern Alberta, 1961-66

Stratum	Transect	1961			1962			1963		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
C	Whiskey Gap	2	2	1.000	0	0	--	3	2	1.500
A	Stavely	--[1]	2	--	0	12	--	0	0	--
A	Mossleigh	0	0	--	0	0	--	0	0	--
A	Strathmore	5	20	0.250	14	18	0.778	15	32	0.469
A	Farrell Lake	2	0	--	--	--	--[1]	2	2	1.000
B	Bashaw	15	32	0.469	10	6	1.667	12	14	0.857
B	Camrose	--[1]	0	--	0	0	--	0	6	--
B	Viking	2	4	0.500	2	4	0.500	3	10	0.300
B	Kenilworth	0	2	--	0	8	--	2	4	0.500
B	Leduc	7	10	0.700	9	6	1.500	2	2	1.000
B	Royal Park	2	4	0.500	0	6	--	14	10	1.400

[1] Not counted.

Table 31 .--Aerial indexes, ground counts and air:ground ratios for canvasbacks on air:ground comparison transects in southern Alberta, 1961-66--continued

Stratum	Transect	1964			1965			1966		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
C	Whiskey Gap	2	0	--	2	0	--	0	0	--
A	Stavely	0	4	--	0	0	--	0	2	--
A	Mossleigh	0	0	--	0	0	--	0	0	--
A	Strathmore	15	16	0.938	5	4	1.250	11	14	0.786
A	Farrell Lake	0	0	--	0	2	--	0	0	--
B	Bashaw	16	50	0.320	8	18	0.444	9	26	0.346
B	Camrose	4	12	0.333	0	4	--	1	14	0.071
B	Viking	10	6	1.667	12	14	0.857	3	16	0.188
B	Kenilworth	2	4	0.500	3	6	0.500	3	4	0.750
B	Leduc	4	22	0.182	4	18	0.222	0	6	--
B	Royal Park	5	2	2.500	1	6	0.167	2	4	0.500

Table 32.--Aerial indexes, ground counts and air:ground ratios for canvasbacks on air:ground comparison transects in southern Saskatchewan, 1961-66

Stratum	Transect	1961			1962			1963		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
A-W	Lake Alma	0	2	--	1	36	0.028	0	6	--
A-W	Wheatstone	5	2	2.500	1	0	--	2	20	0.100
A-W	Shamrock	0	0	--	0	0	--	0	0	--
A-W	Gouldtown	0	26	--	4	16	0.250	30	46	0.652
A-W	Kenaston	0	16	--	3	4	0.750	0	4	--
A-W	Valley Center[1/]	--	--	--	--	--	--	--	--	--
B-W	Alticane	0	0	--	1	0	--	0	4	--
B-W	Turtleford	1	6	0.167	0	4	--	0	6	--
B-E	Rose Valley	4	2	2.000	0	8	--	11	4	2.750
B-E	Kinistino	0	0	--	0	0	--	0	0	--

[1/] Established in 1965.

Table 32.--Aerial indexes, ground counts and air:ground ratios for canvasbacks on air:ground comparison transects in southern Saskatchewan, 1961-66--continued

Stratum	Transect	1964			1965			1966		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
A-W	Lake Alma	2	2	1.000	3	0	--	2	10	0.200
A-W	Wheatstone	6	18	0.333	6	14	0.428	3	20	0.150
A-W	Shamrock	0	0	--	0	0	--	0	0	--
A-W	Gouldtown	8	2	4.000	0	2	--	18	12	1.500
A-W	Kenaston	1	2	0.500	3	2	1.500	15	6	2.500
A-W	Valley Center[1/]	--	--	--	0	2	--	8	8	1.000
B-W	Alticane	0	0	--	4	2	2.000	7	8	0.875
B-W	Turtleford	0	0	--	1	0	--	0	0	--
B-E	Rose Valley	2	4	0.500	8	20	0.400	5	6	0.833
B-E	Kinistino	0	0	--	1	0	--	0	0	--

[1/]Established in 1965.

Table 33.--Aerial indexes, ground counts and air:ground ratios for canvasbacks on air:ground comparison transects in southern Saskatchewan and southern Manitoba, 1961-66

Stratum	Transect	1961			1962			1963		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Sask. A-E	Fertile	0	0	--	--	--	--[1]	2	6	0.333
Sask. A-E	Moose Valley	1	6	0.167	0	0	--	--	--	--[1]
Sask. A-E	Kipling	4	12	0.333	0	0	--	0	0	--
Sask. A-E	Grayson	0	0	--	0	0	--	0	0	--
Sask. A-E	Jasmin	0	0	--	0	2	--	0	0	--
Sask. A-E	Springside	0	0	--	1	4	0.250	0	0	--
Man. A	Boissevain	30	8	3.750	12	12	1.000	12	40	0.300
Man. A	Griswold	10	4	2.500	2	8	0.250	4	0	--
Man. A	Buelah-Decker	0	2	--	1	4	0.250	9	6	1.500
Man. A	Oakburn	13	6	2.167	2	6	0.333	2	20	0.100

[1] Not counted.

Table 33.--Aerial indexes, ground counts and air:ground ratios for canvasbacks on air:ground comparison transects in southern Saskatchewan and southern Manitoba, 1961-66--continued

Stratum	Transect	1964			1965			1966		
		Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio	Aerial index	Ground count	Air:ground ratio
Sask. A-E	Fertile	0	2	--	0	0	--	0	0	--
Sask. A-E	Moose Valley	0	0	--	2	6	0.333	8	10	0.800
Sask. A-E	Kipling	2	0	--	0	0	--	0	0	--
Sask. A-E	Grayson	3	0	--	11	4	2.750	0	2	--
Sask. A-E	Jasmin	0	0	--	0	0	--	0	0	--
Sask. A-E	Springside	0	0	--	1	0	--	1	2	0.500
Man. A	Boissevain	7	22	0.318	6	34	0.176	10	14	0.714
Man. A	Griswold	15	2	7.500	1	2	0.500	2	0	--
Man. A	Buelah-Decker	2	6	0.333	9	22	0.409	0	2	--
Man. A	Oakburn	14	28	0.500	6	8	0.750	15	6	2.500

Table 34.--Aerial indexes, ground counts and air:ground ratios for canvasbacks on air:ground comparison transects in the Tristate area, 1963-66

State and stratum	Transect	1963 Aerial index	1963 Ground count	1963 Air:ground ratio	1964 Aerial index	1964 Ground count	1964 Air:ground ratio
N. Dak. C	Max	1	0	--	0	0	--
N. Dak. C	Sharon[1/]	--	--	--	--	--	--
N. Dak. C	Woodworth	0	0	--	0	0	--
N. Dak. C	Jud	0	0	--	0	0	--
S. Dak. C	Hosmer[1/]	--	--	--	--	--	--
S. Dak. C	Waubay	0	4	--	0	28	--
S. Dak. C	Hayti	0	0	--	0	0	--
S. Dak. C	Mitchell	0	0	--	0	0	--
Minn. E	Hitterdal	0	6	--	0	0	--
Minn. E	Clinton	0	2	--	0	0	--

[1/] Established in 1965.

Table 34.--Aerial indexes, ground counts and air:ground ratios for canvasbacks on air:ground comparison transects in the Tristate area, 1963-66--continued

State and stratum	Transect	1965 Aerial index	1965 Ground count	1965 Air:ground ratio	1966 Aerial index	1966 Ground count	1966 Air:ground ratio
N. Dak. C	Max	0	0	--	2	4	0.500
N. Dak. C	Sharon[1]	0	0	--	--	--	--[2]
N. Dak. C	Woodworth	6	8	0.750	5	4	1.250
N. Dak. C	Jud	3	2	1.500	2	0	--
S. Dak. C	Hosmer[1]	2	4	0.500	--	--	--[2]
S. Dak. C	Waubay	0	0	--	--	--	--[2]
S. Dak. C	Hayti	0	0	--	0	0	--
S. Dak. C	Mitchell	0	0	--	0	0	--
Minn. E	Hitterdal	--	--	--[2]	0	0	--
Minn. E	Clinton	0	0	--	0	0	--

[1] Established in 1965.

[2] Not presented because of procedural discrepancy.

Table 35.--Numbers of transects needed to estimate mean air:ground ratios for ducks (all species combined) with various degrees of precision; data from 1961-66

	Present number of air:ground comparison transects	Number of transects needed to estimate mean air:ground ratio within --					
		20 percent		10 percent		5 percent	
		Average number	Range among years	Average number	Range among years	Average number	Range among years
Alberta B	6	6	1-19	22	4-75	--	--
Alberta A	4	11	2-23	--	--	--	--
Total crew area[1/]	11	6	1-13	22	4-52	--	--
Saskatchewan B	4	5	1-13	21	2-53	--	--
Saskatchewan A-W	6	5	1-14	18	3-57	--	--
Total crew area	10	3	2-6	13	8-23	--	--
Saskatchewan A-E	6	11	3-22	--	--	--	--
Manitoba A	4	4	2-9	18	6-38	--	--
Total crew area	10	6	3-10	23	13-39	--	--
Tristate C[2/]	8	4	3-9	20	11-37	--	--
Total crew area[3/]	10	4	2-8	17	9-31	--	--
All areas[2/]	41	5	3-7	18	11-27	72	45-110

[1/] One transect in C.
[2/] 1963-65 only.
[3/] Two transects in E.

Table 36.--Numbers of transects needed to estimate mean air:ground ratios for mallards, blue-winged teal and canvasbacks with various degrees of precision; data from 1961-66

	Present number of air:ground comparison transects	Species	Number of transects needed to estimate mean air:ground ratio within --			
			20 percent		10 percent	
			Average number	Range among years	Average number	Range among years
Alberta B, A and C	11	Mallards	8	2-18	31	8-72
		BW Teal	38	9-105	--	--
		Canvasbacks	64	33-100	--	--
Saskatchewan B and A-W	10	Mallards	10	6-18	41	24-71
		BW Teal	68	19-203	--	--
		Canvasbacks	118	27-264	--	--
Sask. A-E and Man. A	10	Mallards	16	10-20	--	--
		BW Teal	42	11-95	--	--
		Canvasbacks	62	29-88	--	--
Tristate C and E[1/]	10	Mallards	18	4-26	--	--
		BW Teal	12	3-21	--	--
		Canvasbacks	--	--	--	--
All areas[1/]	41	Mallards	10	8-12	42	34-49
		BW Teal	32	21-43	130	84-172
		Canvasbacks	51	36-76	--	--

[1/] 1963-65 only.

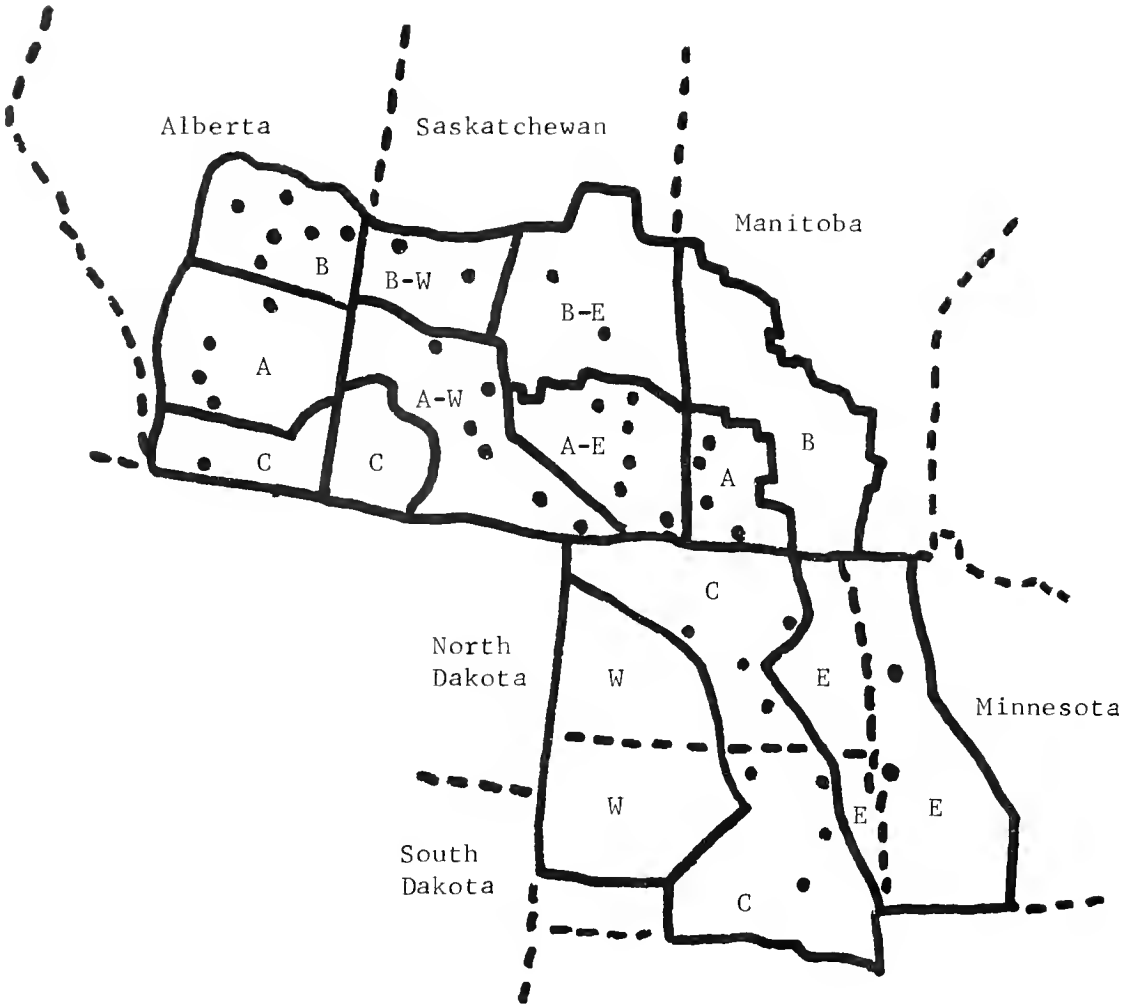

Figure 1.--Breeding ground survey strata in the Prairie Provinces and Tristate area and locations of air:ground comparison transects

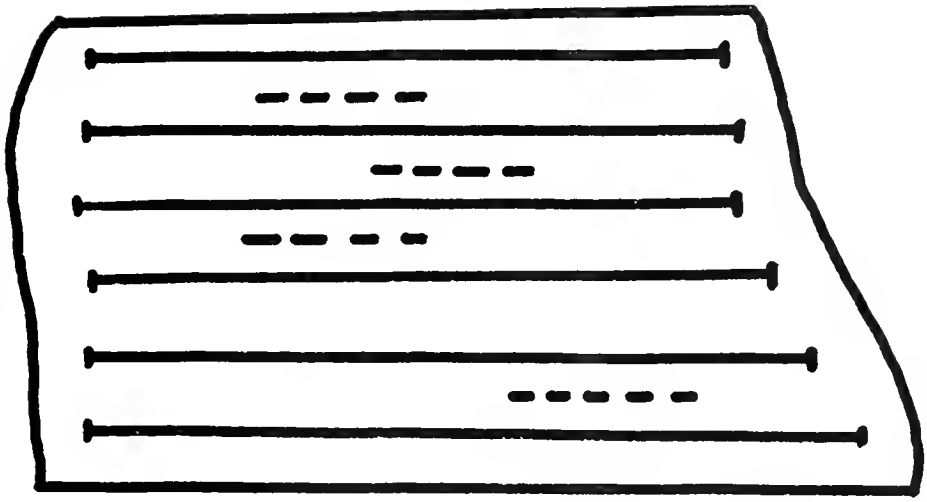

Figure 2.

Location of air:ground comparison transects (- - - -) and operational survey transects (———) in a stratum

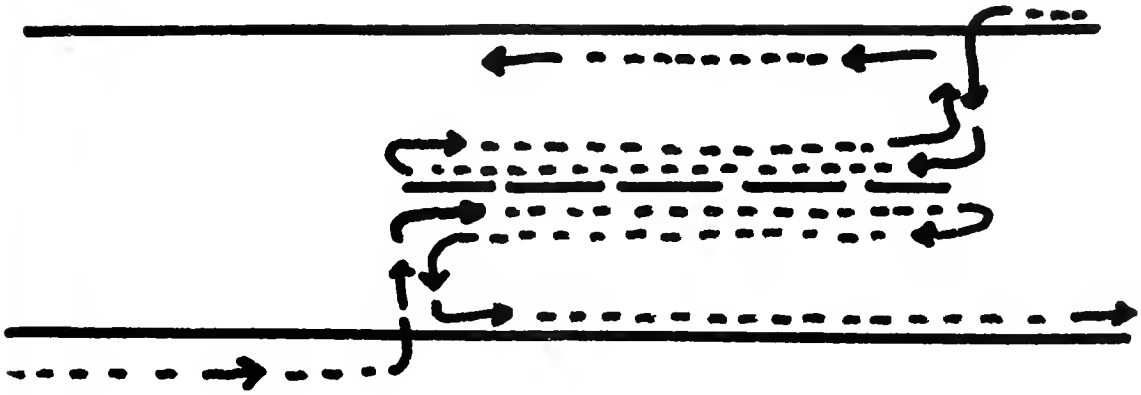

Figure 3.

Path of airplane while surveying air:ground comparison transects during the operational breeding population survey

Appendix A

Common and Scientific Names of Waterfowl Mentioned in this Report

Mallard (*Anas platyrhynchos*)
Black Duck (*Anas rubripes*)
Gadwall (*Anas strepera*)
American Widgeon (*Mareca americana*)
Green-winged Teal (*Anas carolinensis*)
Blue-winged Teal (*Anas discors*)
Cinnamon Teal (*Anas cyanoptera*)
Shoveler (*Spatula clypeata*)
Pintail (*Anas acuta*)
Redhead (*Aythya americana*)
Canvasback (*Aythya valisineria*)
Lesser Scaup (*Aythya affinis*)
Ring-necked Duck (*Aythya collaris*)
Common Goldeneye (*Bucephala clangula*)
Bufflehead (*Bucephala albeola*)
White-winged Scoter (*Melanitta deglandi*)
American Coot (*Fulica americana*)

☆ U. S. GOVERNMENT PRINTING OFFICE 1967 O - 268-793

The Department of the Interior, created in 1849, is a Department of Conservation, concerned with management, conservation, and development of the Nation's water, wildlife, fish, mineral, forest, and park and recreational resources. It has major responsibilities also for Indian and Territorial affairs.

As America's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States, now and in the future.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
WASHINGTON, D. C. 20240