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POPULATION DYNAMICS AND DISTRIBUTION OF THE WOOD DUCK (*Aix sponsa*) IN EASTERN NORTH AMERICA

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ABSTRACT

A study of wood duck (Aix sponsa) populations in eastern North America was initiated in 1970 to improve management capabilities of this waterfowl resource. Emphasis was placed on identification of breeding populations, analysis of each population by examination of banding and harvest data, and documentation of trends in forest acreages important to wood ducks.

Sources of information were banding, recovery, and harvest-survey records collected by the U.S. Fish and Wildlife Service during the 1950 through 1968 hunting seasons. Acreage trends of six forest types judged important to wood ducks were obtained from 1963 and 1971 governmental forest surveys. Different populations (reference areas) were identified by plotting the geographic recovery locations of 143,285 banded wood ducks. Population indices were derived from (1) subjective forest-value rating schemes, (2) mathematical estimates (simultaneous equations), and (3) U.S. Fish and Wildlife Service population models.

Six summer reference areas were identified. Wood ducks native to each area differed in abundance, hunting pressure, and often survival. Banding data were insufficient for studying two wintering areas. One-half of the Eastern population (3.3 million birds) inhabited reference

areas of the Mississippi Flyway, one-third was apportioned to Atlantic Flyway areas, and the remaining were in eastern Canada. A few key states, when combined, possessed more than 50 percent of the Eastern population.

Most of the 0.5 million annually harvested wood ducks were bagged in the Mississippi Flyway (48 - 55 percent), Atlantic Flyway (26 - 40 percent), and eastern Canada (10 - 17 percent). A few key states accounted for 70 percent of each flyway harvest. The northern harvest was derived largely from native wood ducks, and the interchange between northern populations was small. Few southern banded birds were harvested in northern regions, but the southern harvest was greatly augmented by northern migrants; only 40 percent of the harvest was from native birds. Adult females and immatures of northern populations were more likely to be affected by October and November harvest regulations; whereas, adult males were influenced by late-season harvest.

The southward migration of northern banded wood ducks exposed them to hunting pressures of several states, which resulted in high recovery rates. Southern populations had significantly lower recovery rates than their northern counterparts ($p \leq 0.01$).

Adults had higher survival rates than immatures ($p \leq .01$), and adult male survival exceeded adult female

survival ($p \leq 0.05$). Survival rates for immatures did not differ ($p > 0.05$). Populations above 42° north latitude had lower survival and higher recovery rates than populations below this line ($p \leq 0.01$). Although survival differences between all populations could not be shown, differences between northern and southern populations suggested opportunities for increased hunting recreation in southern states.

Liberal hunting regulations were accompanied by increases in hunting pressure and increases in proportion of wood duck populations bagged. The total number of October hunting days and the total number of flyway hunting days were directly related to hunting pressure exerted upon northern populations.

Productivity surpassed adult mortality, and wood duck numbers slightly increased during the 1960's; however, the forest habitat base decreased. Critical habitat losses occurred in southern states where nearly 7 million acres (2.8 million hectares) of floodplain forest were destroyed by draining and channelization.

Biological basis for flyway management of wood ducks is good; however, more intensive management would be possible if population units within flyways were recognized and considered during formulation of regulation guidelines. Improvements are needed in banding programs and governmental surveys that estimate harvest and reporting rates.

Preliminary calculations indicate that 46 thousand wood ducks should be banded annually to sample Eastern population parameters reliably.

INTRODUCTION

The wood duck, *Aix sponsa*, is a prized waterfowl resource and is often judged the most beautiful of North American wildfowl. It is the only North American member of the tribe, Cairinini, that habitually uses tree cavities for nesting. The wood duck, unlike many North American dabbling ducks, is not dependent on Canadian marshlands for breeding habitat. Mallards (*Anas platyrhynchos platyrhynchos*), Northern pintails (*Anas acuta acuta*), green-winged teals (*Anas crecca carolinensis*) and most other river and pond ducks are ground nesters preferring the grasslike and prairie-land sites of Canada for nesting. The wood duck requires forests, and it is the only waterfowl species nesting in large numbers in tree cavities along wooded streams and swamps of the United States. The North American breeding range, closely paralleling the distribution of forest regions in the United States, is divided into eastern and western components (Figures 1 and 2).

Although wood ducks are now abundant, they were alarmingly scarce in the early 1900's when hunting seasons for this species were closed from 1919 to 1941. Wood ducks responded to restrictive regulations, and their current importance to hunters is demonstrated by a harvest which has grown from less than 0.5 million in the early sixties to

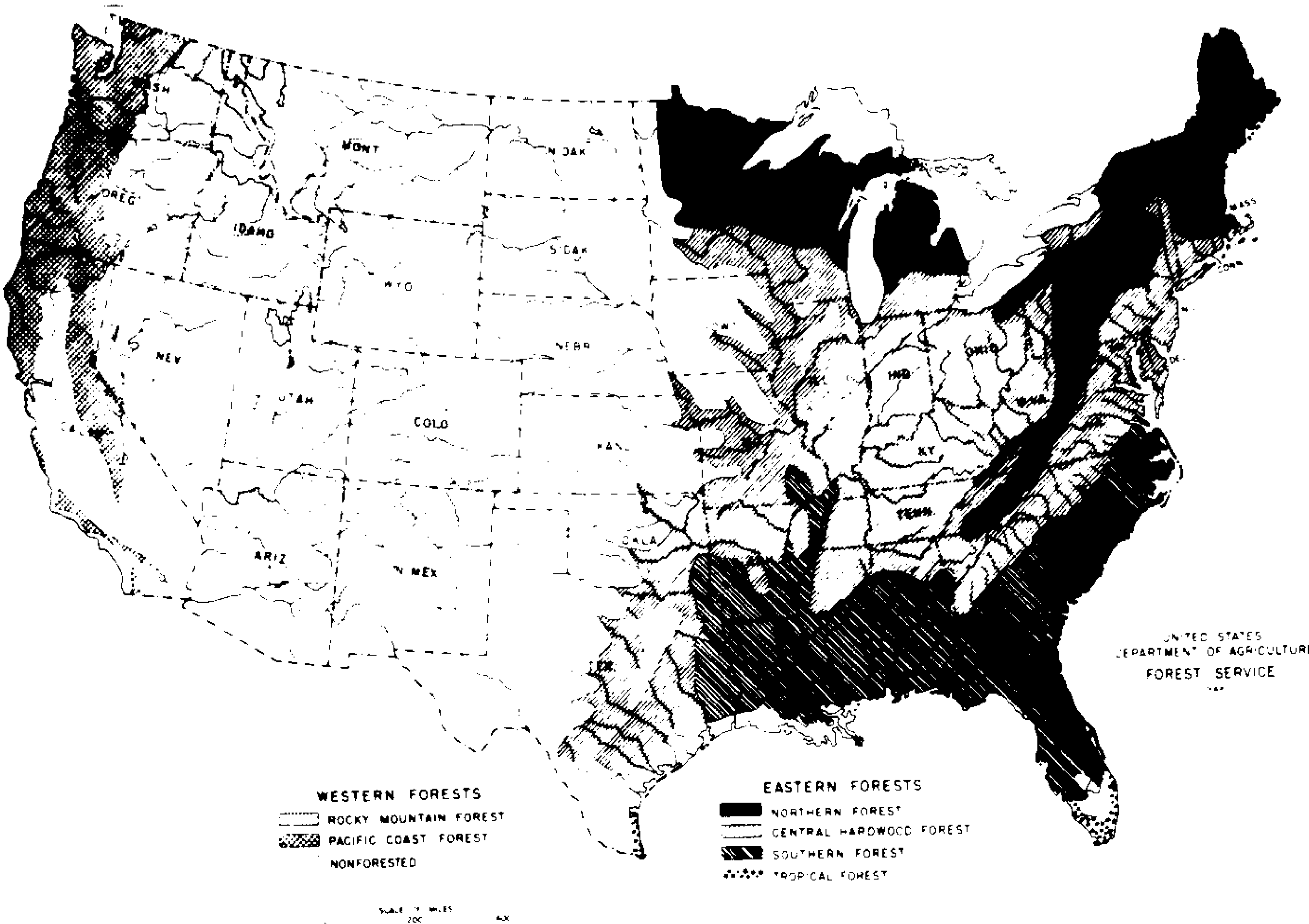


Figure 1. FOREST REGIONS OF THE UNITED STATES

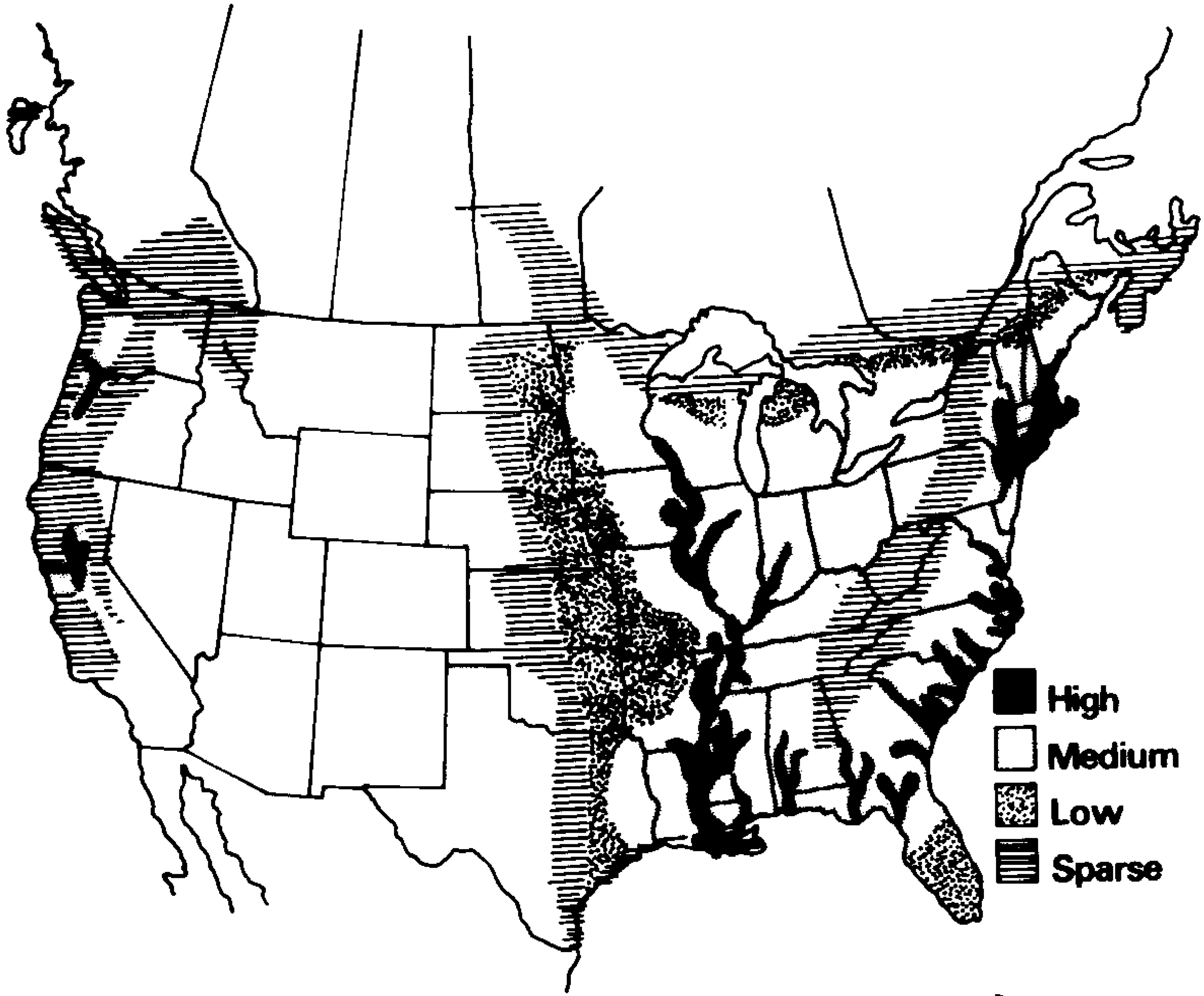


Figure 2. WOOD DUCK BREEDING RANGE (Bellrose 1976)

more than 1.0 million in 1970 (Chamberlain et al. 1972). In 1972, wood ducks ranked fourth in the total United States waterfowl harvest and second in the Atlantic and Mississippi Flyway harvests (Shroeder et al. 1974).

Previous Studies and Current Needs

Wood ducks have been the subject of much research on various aspects of their life history, but past studies have been limited to the ecology and management of local birds or segments of state-wide populations. For example, Grice and Rogers (1965) initiated a comprehensive life history study (1950 through 1956) for Massachusetts wood ducks. Information concerning migration, homing, nesting chronology, and effects of hunting was recorded. Another intensive local investigation of wood ducks was conducted by Decker (1959). His four-year study of a Pennsylvania marsh concentrated on nesting periods, brood development, and an analysis of heavy shooting pressure. Research by Leopold (1951) is another example of a valuable but restrictive examination of the nesting behavior and nest development of wood ducks. His data relate to only a small segment of the wood ducks nesting in Iowa.

Much research has been devoted to developing methods of censusing wood ducks in their forest environment by direct and indirect techniques. Hein and Haugen (1966) recorded the results of observations on 768 flight periods of 52 wood duck roosts located along a 100-mile section of

the upper Mississippi River. They concluded that direct counting of birds at given roosts held promise as an estimate for trends in wood duck numbers. Another comprehensive study concerning the feasibility of roost-flight counts as a censusing technique was conducted by Hester and Quay (1961) in North Carolina, but no concrete conclusions as to accuracy or statewide application were stated. Indirect methods to estimate wood duck levels have been explored by Kaczynski and Geis (1961). They analyzed banding and harvest survey data to obtain an estimate of 1961 population levels for the entire eastern United States. Application of this indirect technique on a regional or reference-area basis was not explored.

Considerable data have also been gathered on wood duck usage of man-made nesting boxes. Bellrose et al. (1964) identified box designs most desirable to wood ducks and documented success of these structures in timbered sections of Illinois. McLaughlin and Grice (1952) investigated the effectiveness of large-scale wood duck box erection programs and concluded that they were an effective way of benefiting wood duck populations.

A recent symposium focused attention on types of research currently needed for effective wood duck management. Emphasis was placed on the necessity to evaluate the status of wood duck populations and their habitats on a broad regional or population-unit basis (Geis 1966). It was demonstrated that much of this information could be ob-

tained from banding records, together with productivity and hunter-harvest data collected annually by the U.S. Fish and Wildlife Service.

In 1951, technicians of state conservation departments and the U.S. Fish and Wildlife Service initiated a wood duck banding program throughout much of the United States. This effort and earlier bandings have resulted in approximately 350 thousand banded wood ducks. In addition, wing-collection and harvest-questionnaire surveys have been conducted by the U.S. Fish and Wildlife Service for a number of years and include large volumes of records relating to the wood duck.

There has been an important need to analyze the plethora of banding and harvest data collected for wood ducks. Their forest habitat precludes the use of conventional waterfowl survey methods for estimating population density and production; therefore, the population characteristics and status of this important species are poorly understood. Annual estimates of wood duck numbers and recruitment, as now conducted, provide information which relates only to the overall population throughout eastern North America. The status and dynamics of wood ducks in different regions and flyways are not assessed. Progressive management could be achieved if different breeding and wintering populations were defined and comparable data collected for each major population unit. A knowledge of regional differences in population size, harvest distribu-

tion and derivation, hunting pressure, and survival would make it possible to manage this species on a more intensive scale.

Objectives

The objectives of this research were to: (1) locate and characterize summer and winter populations from which banded samples of wood ducks have different harvest distributions; (2) determine the contribution of different breeding populations to the harvest occurring in various states, flyways, and other harvest areas; (3) evaluate effects of hunting regulations and assess the impact of harvest on population status; and (4) measure trends in abundance of forest types important to wood ducks.

DEFINITION OF TERMS

A list of definitions is given to aid in the understanding of research techniques utilized throughout this study. The U.S. Fish and Wildlife Service's "Bird Banding Manual", a recent publication which describes the use of waterfowl banding data (Geis 1972), and forest-trend survey booklets issued by the U.S. Forest Service (1958 and 1965) were instrumental in defining the following terms:

Adult:

A sexually mature bird in at least its second year of life.

Band recoveries:

Bands reported to the U.S. Fish and Wildlife Service from banded birds.

Crippling loss:

A loss expressed as the percent of ducks shot but not retrieved by hunters.

Direct recovery:

A band recovery occurring the first hunting season after banding.

Direct recovery rate:

The proportion of banded birds that are recovered and

reported to the U.S. Fish and Wildlife Service the first hunting season after banding. It is expressed as a percent or decimal fraction (1 percent or .01).

Forest type:

A classification of forest land based upon the species forming a plurality of live-tree stocking. Type is determined on the basis of species plurality of all live trees that contribute to stocking.

Harvest:

Number of retrieved or bagged waterfowl that are shot or found dead.

Harvest derivation:

Demonstrates what proportion of the kill in a harvest area is derived from various production areas.

Harvest distribution:

The dispersal of the hunting kill as it relates to various reference areas. Also refers to the relative size of the hunting kill in various geographic areas. Weighted direct recoveries and a mail-questionnaire survey are used to determine harvest distributions.

Harvest Index:

The proportion of a preseason population that was harvested by hunters.

Harvest rate:

The fraction of a population that is harvested. It is often estimated by dividing the direct-recovery rate by reporting rates. Harvest rates are expressed as a percent or decimal fraction.

Hunting season:

Waterfowl seasons vary from early September openings in Canada to late November or December beginnings in the southern United States. Unless otherwise noted, the hunting season in this study is defined as September 1 through January 16.

Indirect recovery:

All band recoveries occurring after the first hunting season following banding.

Kill rate:

An estimate of that segment of the population dying directly as a result of hunting. The "harvest rate" corrected for "crippling loss" yields the "kill rate." It is expressed as a percent or decimal fraction.

Preseason banding:

Defined as May 1 through August 31 for this study. A period pertaining to summer and early fall bandings.

Reference areas or population units:

Adjacent banding areas or states from which birds display similar recovery distributions.

Relative recovery rate:

The degree to which a recovery rate for one population, sex, or age surpasses that of another. It is an indication of the relative likelihood of being recovered and is signified as a percent or decimal fraction.

Reporting rate:

The proportion of banded birds taken by sportsmen that is reported to the U.S. Fish and Wildlife Service. Reporting rates are denoted as a percent or decimal fraction.

Reward band:

Special bands stating that a monetary reward will be forthcoming to those reporting and returning such a band.

Banding status:

Status codes are U.S. Fish and Wildlife Service descriptions of birds at time of banding. Four status designations are currently used: normal wild bird, hand-reared or game-farm bird, experimental bird, and dog-caught bird.

Survival rate:

The survival rate is the probability of survival of

a banded bird during a specified time period. Estimates of annual survival for this study relate to an interval from one banding period in year "i" to the time of banding in year "i+1". Average annual survival rates are obtained by averaging yearly survival estimates for "x" number of years. In all cases survival rates are described as percentages or decimal fractions.

Weighted data:

Data corrected for disproportionate banding efforts. For this study it was determined by dividing each state population-density estimate by number of wood ducks banded in the state to obtain a weight per recovery. These weighting factors were applied to band recoveries to adjust for the varying number of birds that a recovery represented.

Winter banding:

Defined as December 1 through March 31 for this research.

INFORMATION SOURCES AND METHODS

The major sources of information were banding and recovery data, harvest surveys, and wing-collection surveys conducted annually by the U.S. Fish and Wildlife Service, plus forest inventory data provided by forestry agencies in the United States and Canada. Emphasis was placed on recovery records of normal, wild wood ducks banded in eastern North America during the summer and recovered (shot or found dead) during the 1950 through 1968 hunting seasons.

Bands and Recoveries

Banding and recovery data filed on magnetic tapes at the Migratory Bird and Habitat Research Laboratory, U.S. Fish and Wildlife Service, Laurel, Maryland, were utilized throughout the study. More than 31 thousand recovery records of wood ducks banded during 1914 through 1968 were available for examination. The volume of banding during the 1914 through 1949 preseason period was small; therefore, data obtained during the 1950's and 1960's were stressed. Banding and recovery records were also restricted by the status of wood ducks at time of capture as well as by yearly and monthly time periods of banding and recovery. Only bandings pertaining to wild wood ducks caught, banded, and released in a normal manner during the preseason and winter periods were used. Wood ducks experimentally

handled were not included. These restrictive criteria left a maximum of 20 thousand recoveries for analysis.

Source of Harvest Data

Waterfowl harvest survey information is annually obtained by the U.S. Fish and Wildlife Service from randomly selected post offices throughout each state (Carney et al. 1975). Names and addresses of a sample of waterfowl hunters are secured by these selected post offices when each hunter buys an annually required Federal Migratory Bird Hunting Stamp. The stamp buyer completes a "Hunter Contact Card" and sends his name and address to the U.S. Fish and Wildlife Service. A portion of the card is retained by the purchaser and used throughout the waterfowl season to keep a personal record of waterfowl shot. After the hunting season, the hunter receives a questionnaire asking about his waterfowl success. The questionnaire is completed by referring to the personal waterfowl record card and then returned to the U.S. Fish and Wildlife Service for coding and recording. Harvest questionnaire data received by the U.S. Fish and Wildlife Service during the 1962 through 1968 hunting seasons were utilized for this study. During the 1962 through 1968 period, approximately 87 thousand waterfowl hunters were contacted and 55 thousand questionnaires were completed each year (Geis et al. 1971).

A sample of duck wings thought to be representative

of the total duck harvest is also collected by the U.S. Fish and Wildlife Service during each hunting season (Carney et al. 1975). Every hunter to be sampled receives 10 to 20 postage-paid envelopes prior to the waterfowl season and is asked to enclose one wing from each duck shot. The wings received are aged and sexed according to species, and this information along with other data are recorded on computer tapes by the U.S. Fish and Wildlife Service. Sampled hunters are selected largely from Mail Questionnaire Survey respondents of the previous year, who bagged at least one duck and are over 15 years old. Other hunter samples are derived from lists of respondents to previous wing surveys and occasionally from hunters who report shooting a banded bird. Wing survey data used throughout this study pertain to 1962 through 1968 hunting seasons when the annual number of contacted United States hunters was 30 to 40 thousand returning approximately 43 thousand wings from all species of ducks (Geis et al. 1971).

Information pertaining to wood duck harvest in Canada from 1967 through 1969 was obtained through personal correspondence with Dr. Frederick G. Cooch, Staff Specialist with the Canadian Wildlife Service.

Forest Trend Sources

Over the past several decades the Forest Service of the U.S. Department of Agriculture has periodically reviewed the timber supply, timber demand, and outlook for

the United States. These studies include statistical data on the current area and condition of the nation's forest land, inventories of standing timber, and reports of timber growth and removal for individual states. Information is also included on recent trends for forest lands and timber availability. Forest statistics for the years 1963 and 1970 were reviewed for segments of this research (U.S. Forest Service 1965 and 1973a). Canadian forest data (1963 and 1971) were obtained from the Canada Department of Lands and Forests, Toronto, Ontario (Dixon 1963, Manning and Grinnell 1971).

Plotting Recoveries

All recoveries (direct and indirect) of wood ducks banded during the 1950 through 1968 preseason and winter periods and later shot or found dead during the 1950 through 1968 hunting seasons were hand plotted on maps. Recoveries from different banding sites were color coded and plotted by 1-degree blocks of latitude and longitude to show differences in distribution patterns. Banding sites and states demonstrating a similar geographic recovery-distribution pattern were combined into reference areas as described by Geis et al. (1971). For example, the recovery distributions of wood ducks banded in Michigan, Ohio, and Indiana were similar; most wood ducks recovered outside the area of banding were harvested in southern states of the Mississippi Flyway (26 to 35 percent) and

Atlantic Flyway (12 to 18 percent). Although wood ducks banded in in Minnesota, Wisconsin, and Iowa were also recovered in southern states of the Mississippi Flyway (29 to 46 percent), few were harvested in southern regions of the Atlantic Flyway (2 to 4 percent); thus two different reference areas began to materialize.

Population Indices

Three approaches (forest values, FHMUP, and simultaneous equations) were used to estimate population density values for states and provinces within each summer reference area.

Forest Values

A wood duck population index for each state within a reference area was estimated from the state acreages of six forest types (Oak-Gum-Cypress, Elm-Ash-Cottonwood, Maple-Beech-Birch, Aspen-Birch, Oak-Hickory, and Spruce Fir). State acreages and definitions for each timber type were obtained from publications on timber trends (U.S. Forest Service 1965 and 1973a). Each forest type was subjectively given an importance value ranging from a minimum of 0.5 to a maximum of 10.0 based upon wood duck habitat requirements indicated in the literature, together with silvical characteristics of each forest type and the general physiography of the state being considered. For example, the Oak-Gum-Cypress type received a maximum rating of 10.0 in all states, because species associated

with this type provide cavities for nesting and it occurs in wet sites that provide brood-rearing habitat and available food. A wood duck density-index was obtained by summing the products of acreage and importance value for forest types within a state. This procedure is graphically illustrated in Appendix Tables 42 and 43.

Comparable data for Canadian forests could not be obtained, but information provided by Dixon (1963) suggested that the Great Lakes and St. Lawrence Forest Types of southern Ontario and Quebec, and especially the Deciduous Forest Type of Ontario, contained tree species and habitats beneficial to wood ducks. The wood duck index for the approximate 63 million acres (25 million hectares) of these Canadian forest types was estimated as 126 thousand; a value equivalent to 13 percent of the wood duck values of all six Eastern forest types (Appendix Table 43).

<u>Fish and Wildlife Service Model (FHMUP)</u>

Sutherland (1971), in cooperation with federal and state waterfowl biologists, developed a profile model (Flyway Habitat Management Unit Project or FHMUP) to estimate waterfowl species densities and distributions throughout the North American Continent for each of 10 months during 1965. The procedure was to first estimate the total number of breeding wood ducks within North America by utilizing data and techniques discussed by Kaczynski (1968). This estimated breeding density was considered a May 1965

population of breeding wood ducks (Sutherland 1971). The May population was then multiplied by an estimated production ratio to obtain a fall flight (August 1965) estimate of wood ducks. Next, an estimate of the total mortality rate occurring from August 1965 to May 1966 was made. When May populations, August populations, and total mortality from August through May had been determined for flyways and northern (Canadian) birds, estimates of the average monthly populations in each flyway, from September through August, were obtained by distributing total mortality by 30-day intervals. The monthly mortality (loss of birds) was subtracted from each previous monthly population number, beginning with the month of August (Sutherland 1971). The end result was a monthly estimate of wood duck numbers for each flyway. These flyway densities were then allocated to flyway states according to the subjective judgment and consensus of those men most familiar with the wood duck situation in each state (Sutherland 1971).

May wood duck populations calculated by Sutherland (1971) for each flyway state were used as one estimate of the adult breeding populations for my study. Differences between Sutherland's May and August population numbers were also used as one estimate of immature densities.

Those wood duck populations described in the FHMUP report as northern birds were considered to be Canadian populations and were increased by approximately 36 percent to account for differences in FHMUP population estimates

and Canadian population estimates shown by Cringan (1971) for the years 1967 through 1969.

Simultaneous Equations

This technique required computer solutions for a set of simultaneous linear equations. Data pertaining to harvest rates and size of harvest for 32 states and 2 provinces were used in the calculations. Chapman and Junge (1956) and Overton and Davis (1969) gave descriptions of this general method of population estimation, and Geis (1972) provided an example of the processes involved. The general procedures are illustrated in Example 1 of Appendix A.

Harvest rates and harvest estimates for adult and immature wood ducks banded in 32 states and 2 Canadian provinces were summarized in matrix form; however, population estimates determined from these original harvest and recovery matrices did not yield realistic results. Numerous state estimates were obviously too high or too low. The major sources of error were believed to be inaccurate harvest estimates and a lack of banding and recovery data for numerous states; therefore, adjusted harvest and adjusted recovery rates were used to construct other matrices (Appendix Tables 44 through 47). I assumed that harvest distributions obtained from the FHMUP model and forest values were more accurate than distributions determined via wing surveys. Therefore, original harvest data (obtained from

weighted wing data provided by the U.S. Fish and Wildlife Service) for each state were systematically adjusted by a comparison of the original harvest distribution and harvest distributions determined from band recoveries that were weighted by FHMUP and forest indices (Appendix Table 44). The percentage difference of the comparisons dictated an increase or decrease in the original harvest estimate. For example, if the original U.S. Fish and Wildlife Service harvest survey revealed that Iowa accounted for 3.70 percent of the total wood duck harvest as opposed to an average of 2.75 percent derived from weighted direct recoveries, the Iowa harvest estimate was adjusted downward by 25.70 percent [(3.70 - 2.75)/3.70].

Adjusted band recovery rates were necessary for states banding numbers insufficient for meaningful direct recovery rate estimates (Appendix Table 45). These rates were prorated from adjacent states by use of procedures similar to those described by Chan (1972). For example, if the state of Georgia exhibited an insufficient number of first-year recoveries (less than 10 for adults and 15 for immatures), I assumed the recovery distribution of Georgia birds would be similar to the average distribution of wood ducks banded in South Carolina and Alabama.

Weighting Data

Since the number of wood ducks banded in each state varied in relation to actual numbers present, it was not

possible to compare the relative importance of recoveries between two areas until a "weighting factor" had been calculated. Indices of abundance were provided by forest, FHMUP, and simultaneous equation estimates. Weighting factors were then obtained for each state or province by dividing the number of preseason banded wood ducks into each estimated population-density index. As described by Geis (1972), this gives an estimate of the relative number of wood ducks represented by each duck in the banded sample.

Reporting Rates

Reporting rates were determined from 1965 through 1969 band recovery data supplied by the U.S. Fish and Wildlife Service. The number of bands reported for all duck species was divided by the estimated total number of bands taken by hunters (as determined from the Harvest Questionnaire Surveys) to yield a reporting rate for each state (Geis and Atwood 1961). It was assumed that the reporting rates for Ontario and Quebec were equivalent to those of Ohio.

Harvest

State harvest estimates by age and sex were computed using 1962 through 1968 harvest-survey and wing-collection data obtained from the files of the U.S. Fish and Wildlife Service and 1967 through 1969 data from the Canadian Wildlife Service. Procedures were similar to those described by Carney et al. (1975). First, the U.S. Fish and Wildlife

Service divided each state into several duck-stamp sales zones (groups of counties). The total number of stamps sold in each zone was multiplied by the average number of ducks killed per hunter (as determined from Hunter Questionnaire Survey) to obtain the total bag of all ducks for a state zone. This total was then divided by wings received from that zone to estimate the ducks bagged per wing received (a weighted value). This value was applied to each wood duck wing associated with a given stamp sales zone; thus, the total state harvest of wood ducks could be estimated by summing the products of wings and weighted values for every zone within a state.

Harvests occurring in the unknown age and sex categories were prorated as adult males, adult females, immature males, immature females according to the existing proportionate relationships among known age-sex categories.

The harvest distribution was determined from weighted direct recoveries and weighted wing-collection surveys. Harvest derivations were calculated exclusively from weighted direct recoveries of wood ducks banded May through September 1950 through 1968. Geis (1972) and Stewart et al. (1958) gave an in-depth explanation of these procedures. Briefly, they involve a study of the distribution of weighted direct recoveries from breeding reference areas to show the proportion of birds recovered in a harvest area that came from each reference area (Example 2 of Appendix A).

Chronology of harvest was determined from weighted wing-collection data (1962 through 1968) and weighted direct recoveries of wood ducks banded May through September 1950 through 1968 that were later recovered at monthly intervals throughout the hunting season.

Survival Rates

Survival rate estimates were computed according to the technique developed by Seber (1970 and 1972) and adapted for computer application by Anderson et al. (1974). Unedited preseason bandings and hunting-season recoveries were used in annual survival calculations. I established a criterion of at least 10 recoveries for each banding period before data were coded for survival estimates. Because survival of immatures is normally less than adult survival, data coding procedures for adults and immatures differed due to Seber's assumption that survival is independent of age at the time of banding. Examples of coding procedures are given in Appendix B.

Survival rates for each summer reference area were estimated by weighting (based on population density) and averaging annual survival rates from component states or by calculating annual survival rates from the composite of all banding and recovery data related to a reference area.

Banding Requirements

A FORTRAN program (unpublished, mimeographed handout, "Estimation of Survival Rates from Banding and Recovery

Data," U.S. Fish and Wildlife Service), which is incorporated in Seber's (1970) survival estimation technique, was used to estimate the approximate number of wood ducks that should be banded within a reference area to reduce variance estimates of the survival statistic. The procedure was to first create numerous sets of data by utilizing constant survival rates and fixed direct recovery rates, and then varying the numbers banded. These deterministic sets of data were repeatedly submitted to the computer program until a change in the numbers-banded variable produced the predetermined survival estimate with an associated coefficient of variation between 10 and 20 percent. Examples 5 and 6 (Appendix B) demonstrate the technique.

Statistical Analyses

Chi-square Test for Recovery Data

Chi-square tests (Siegel 1956, p. 104-111) were conducted to determine if the "proportion" of wood ducks banded before the hunting season and later recovered by hunters differed (1) by flyways and reference areas of banding, (2) during time intervals of the hunting season, and (3) by latitudinal zones of banding.

Age and Sex Differences in Recovery

A least squares analysis of variance (Snedecor and Cochran 1967, p. 299-307) was performed to evaluate direct recovery rate differences among age-sex classes for selected

states. After differences among groups were found to be significant, specific age and sex differences were discerned via orthogonal comparisons (Li 1964, p. 255-265).

Survival Comparisons

The student's "t" test (Li 1964, p. 100-117) was used to determine mean survival differences for wood ducks banded above and below 42° north latitude and to judge differences in mean survival for wood ducks banded during divergent time periods.

A paired "t" test (Li 1964, p. 100-117) was useful in examining mean survival discrepancies between age-sex groups of wood ducks banded in various flyway states.

Sign Test for Nonparametric Data

The sign test (Siegel 1956, p. 68-75) was helpful in deciding if a change in hunting regulations from strict to liberal was followed by a change in direction of recovery and survival rates (an increase + or decrease -). This test was also used to determine what directional change survival rates would take when comparisons were made with the extreme low and high recovery rates of various states.

Regression Analysis

Stepwise regression procedures were used to identify relationships between the dependent variable (direct recovery rate) and the following hunting regulation variables: average total hunting days in reference area of

banding, total hunting days in parent flyway, total October hunting days, and average duck bag-limit for states in a parent flyway. A maximum R^2 improvement technique developed by Barr and Goodnight (1972) was the actual procedure followed for regression analysis. This technique does not settle on a best single model to explain what independent variables account for the greatest variation of the dependent variable but looks for a best one-variable model, a best two-variable model, and so forth.

RESULTS

Reference Areas

Based upon consistencies and differences in the geographic distribution of 13,200 recoveries of 132,300 preseason banded wood ducks and 730 recoveries of 10,985 winter bandings, six summer (breeding) and two winter reference areas were identified. The Atlantic Flyway is composed of two summer reference areas (Northeastern and Southeastern), there are three divisions for the Mississippi Flyway (North Central, Lake States, and Southern), and one unit in Canada (New York-Eastern Canada). Winter reference areas were defined as the Atlantic Coast and Gulf Coast regions. The component states and provinces of each reference area are shown in Figures 3 and 4, and the state by state recovery distributions of wood ducks banded in each summer reference area are demonstrated in Figures 5 through 16.

Bandings and Recoveries

More than 31 thousand recoveries from 350 thousand wood ducks banded from 1914 through 1968 were available for study. Numbers banded and recovered in relation to restraints on age and sex, banding and recovery periods, banding locations, and status of trapped wood ducks are summarized in Appendix Tables 54 through 58.

Normal, wild wood ducks were banded in a regular

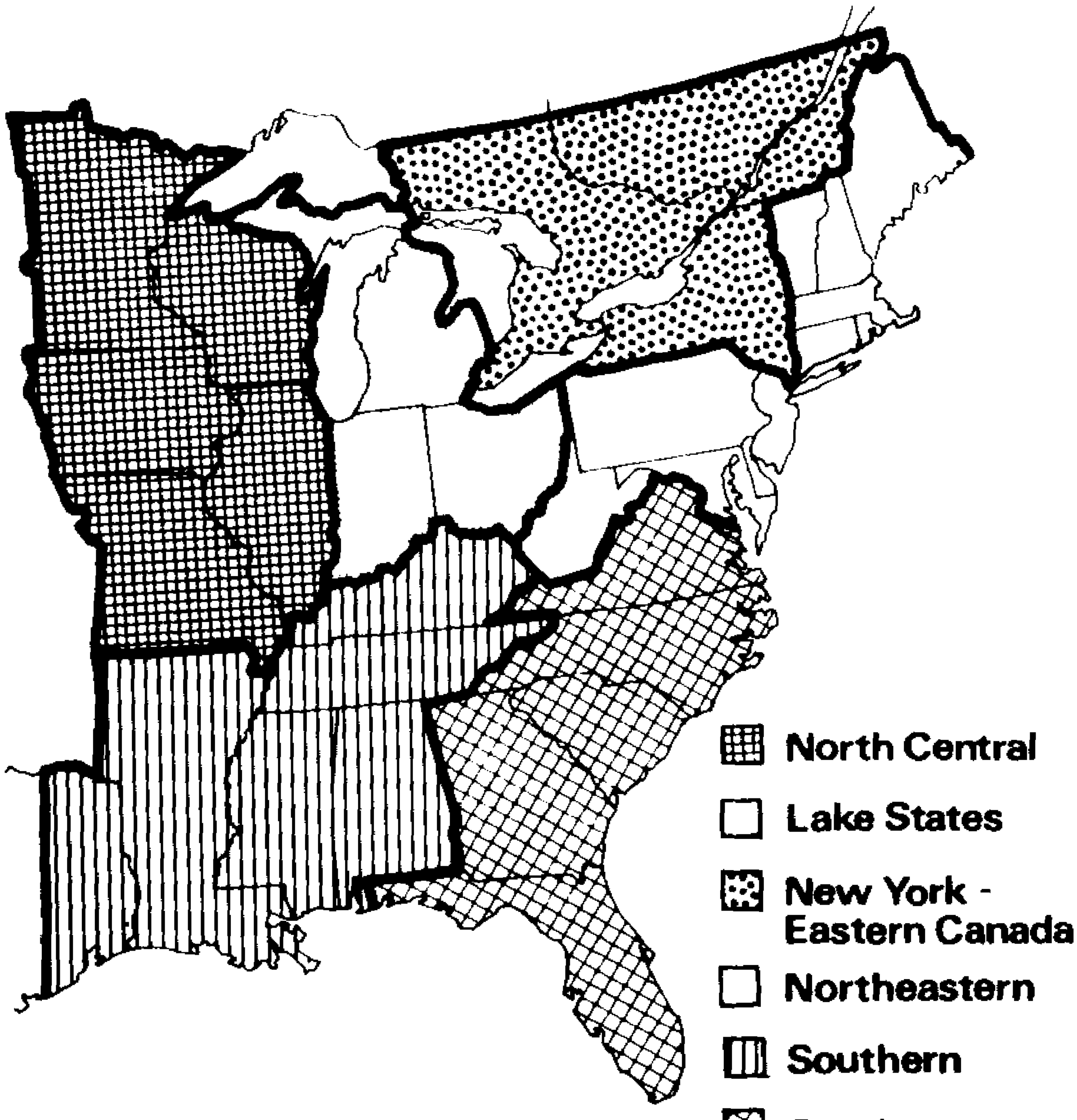


Figure 3.
WOOD DUCK BREEDING REFERENCE AREAS

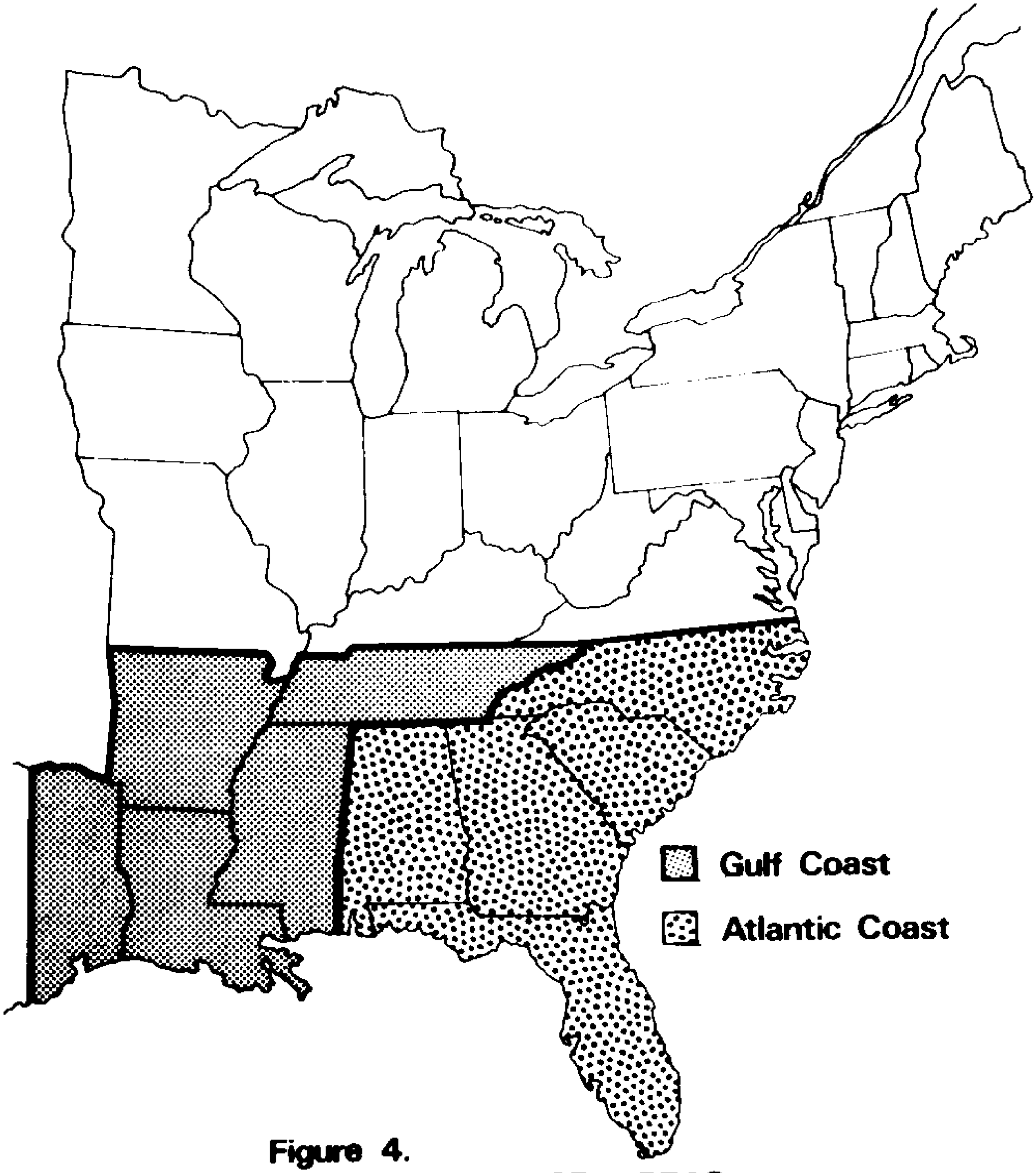


Figure 4.
WOOD DUCK WINTER REFERENCE AREAS

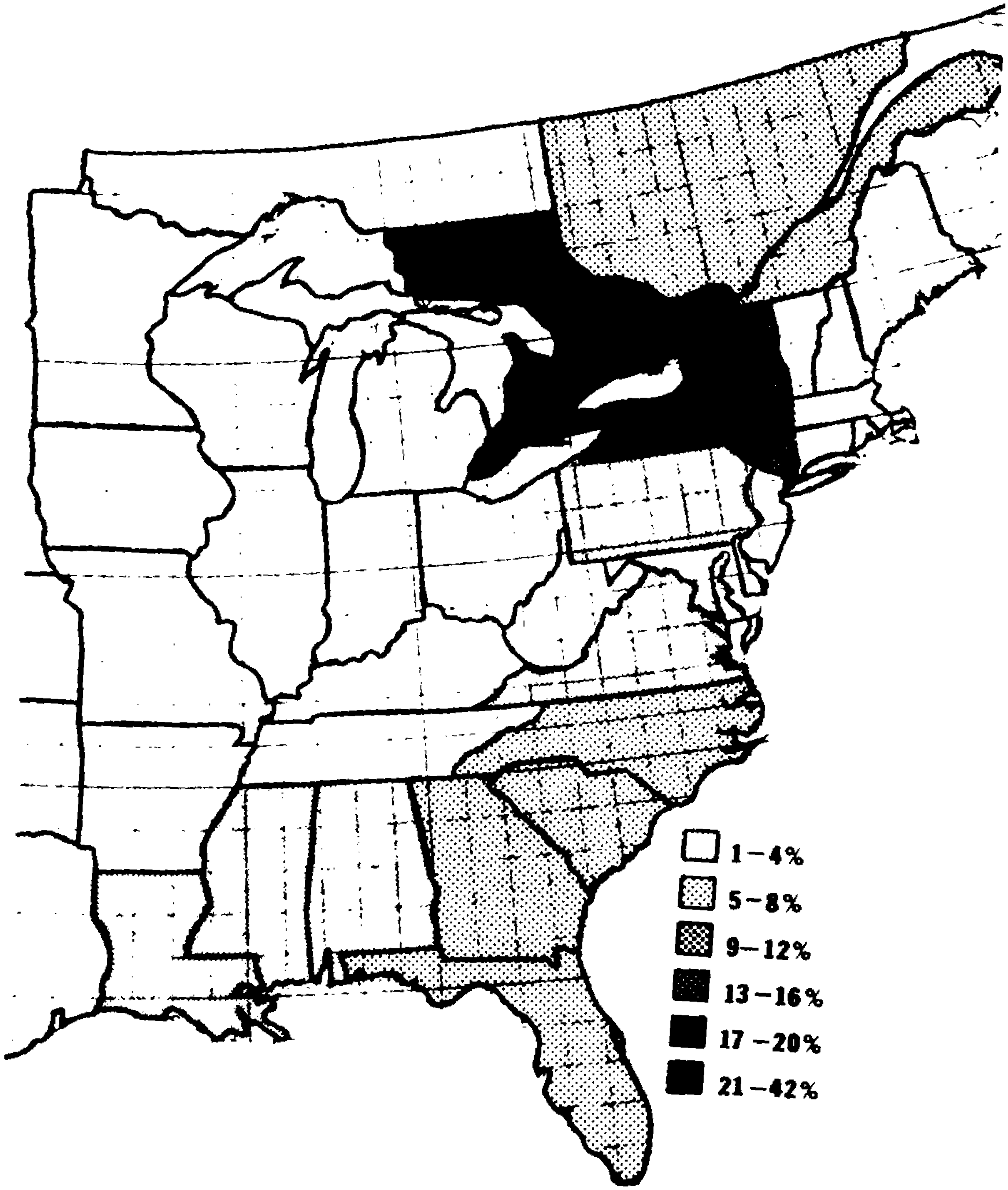


FIGURE 5. HARVEST DISTRIBUTION OF ADULT WOOD DUCKS BANDED IN THE NEW YORK-EASTERN CANADA REGION.

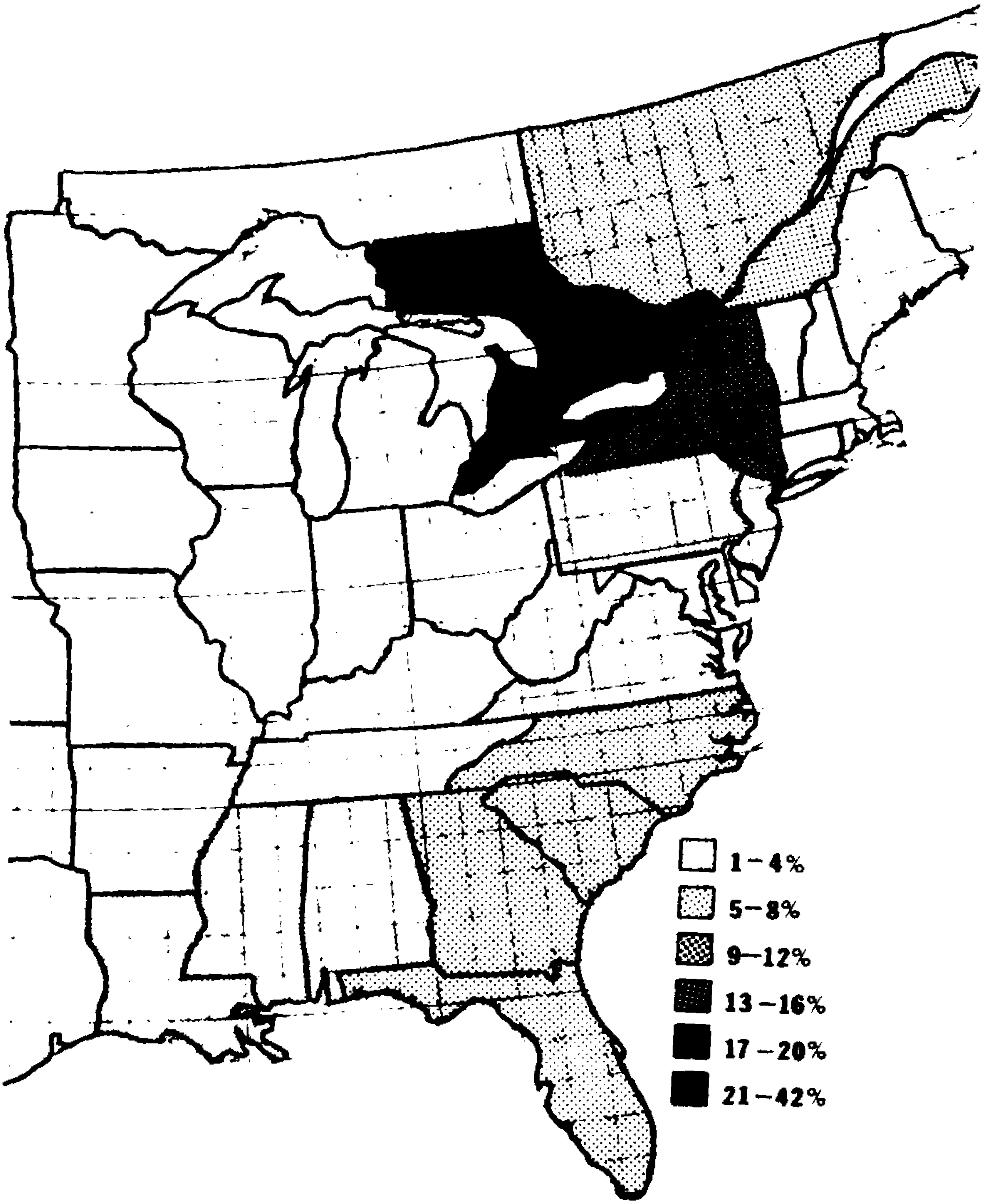


FIGURE 6. HARVEST DISTRIBUTION OF IMMATURE WOOD DUCKS BANDED IN THE NEW YORK-EASTERN CANADA REGION.

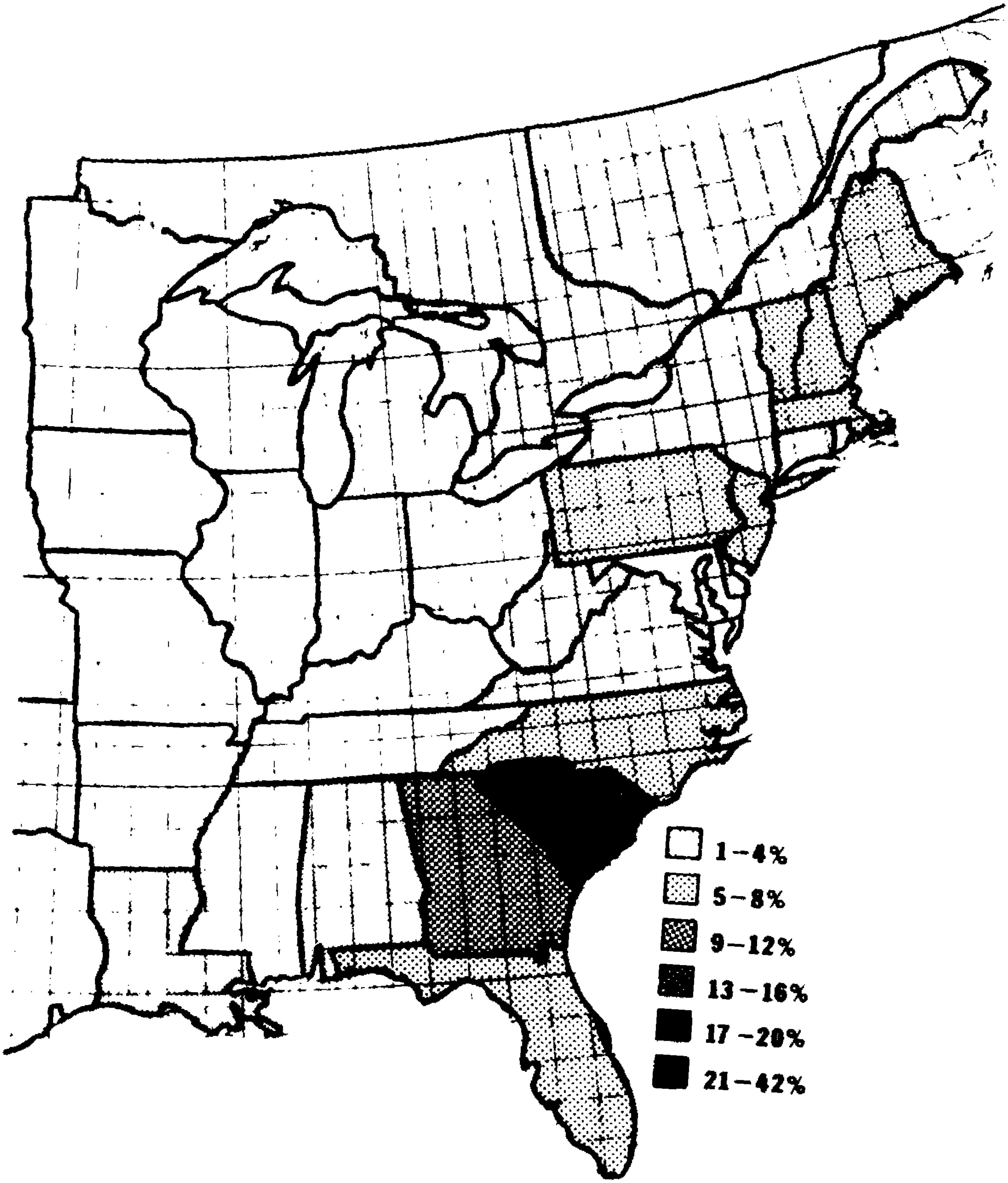


FIGURE 7. HARVEST DISTRIBUTION OF ADULT WOOD DUCKS BANDED IN THE NORTHEASTERN REGION.

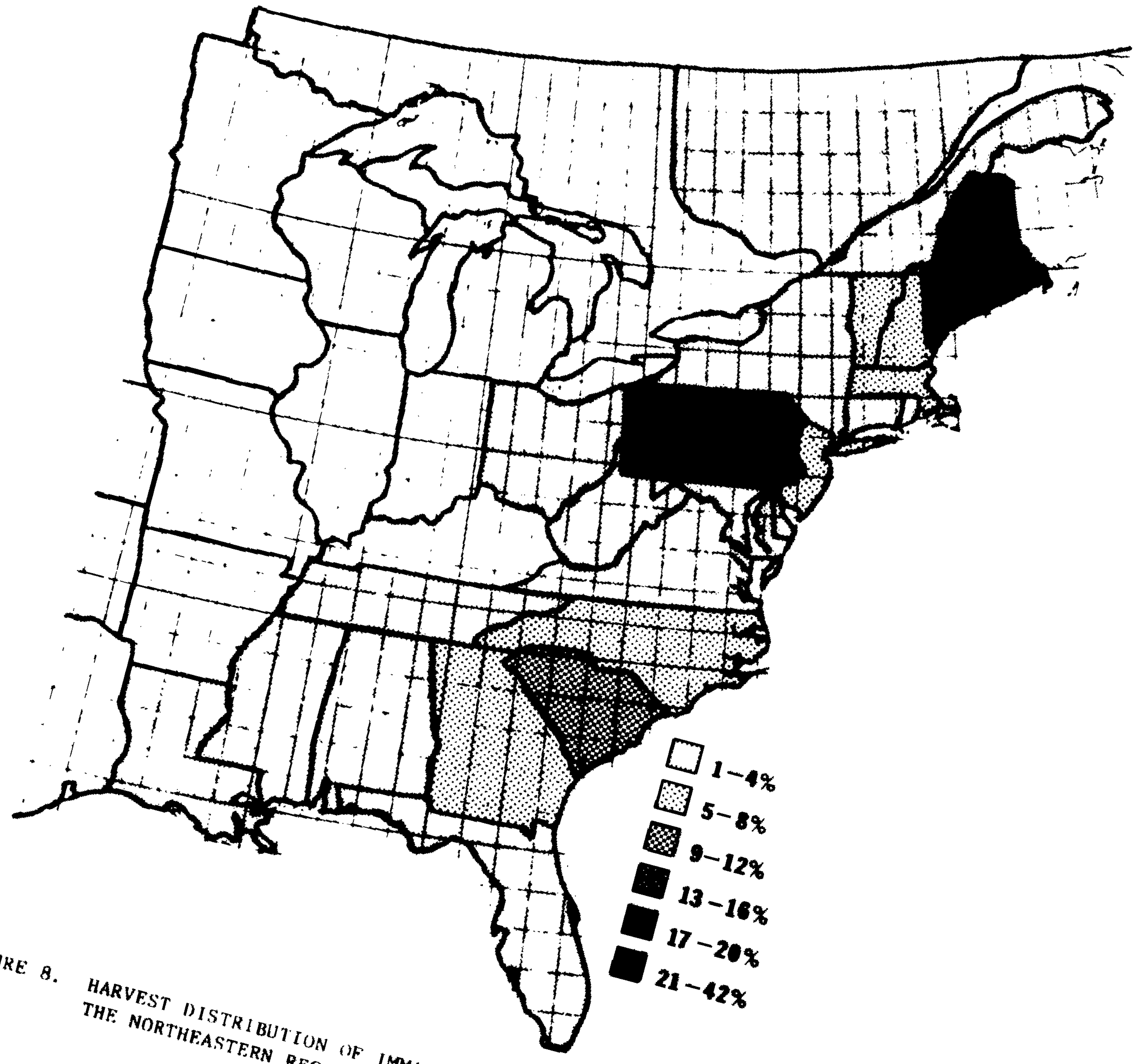


FIGURE 8. HARVEST DISTRIBUTION OF IMMATURE WOOD DUCKS BANDED IN THE NORTHEASTERN REGION.

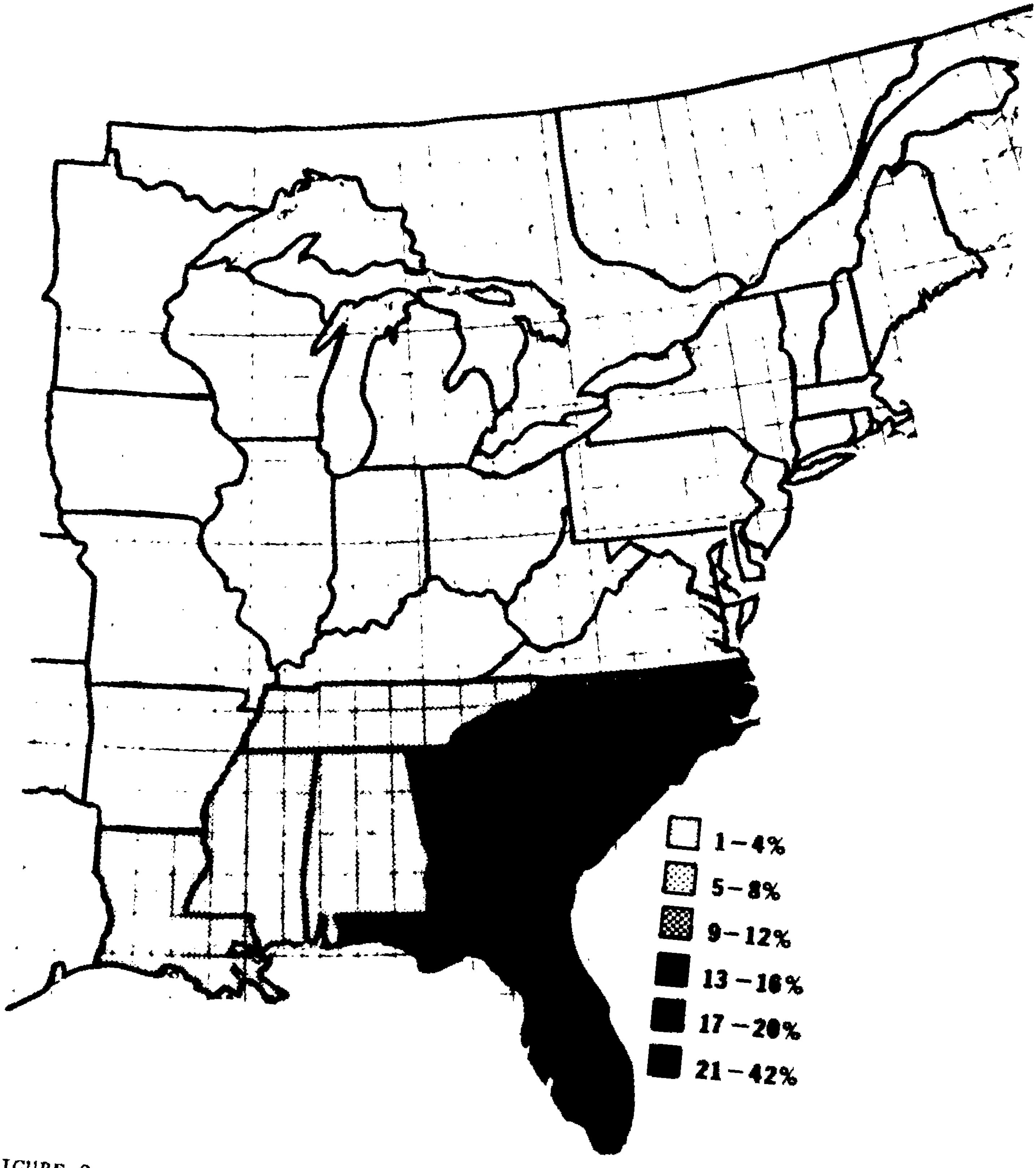


FIGURE 9. HARVEST DISTRIBUTION OF ADULT WOOD DUCKS BANDED IN THE SOUTHEASTERN REGION.

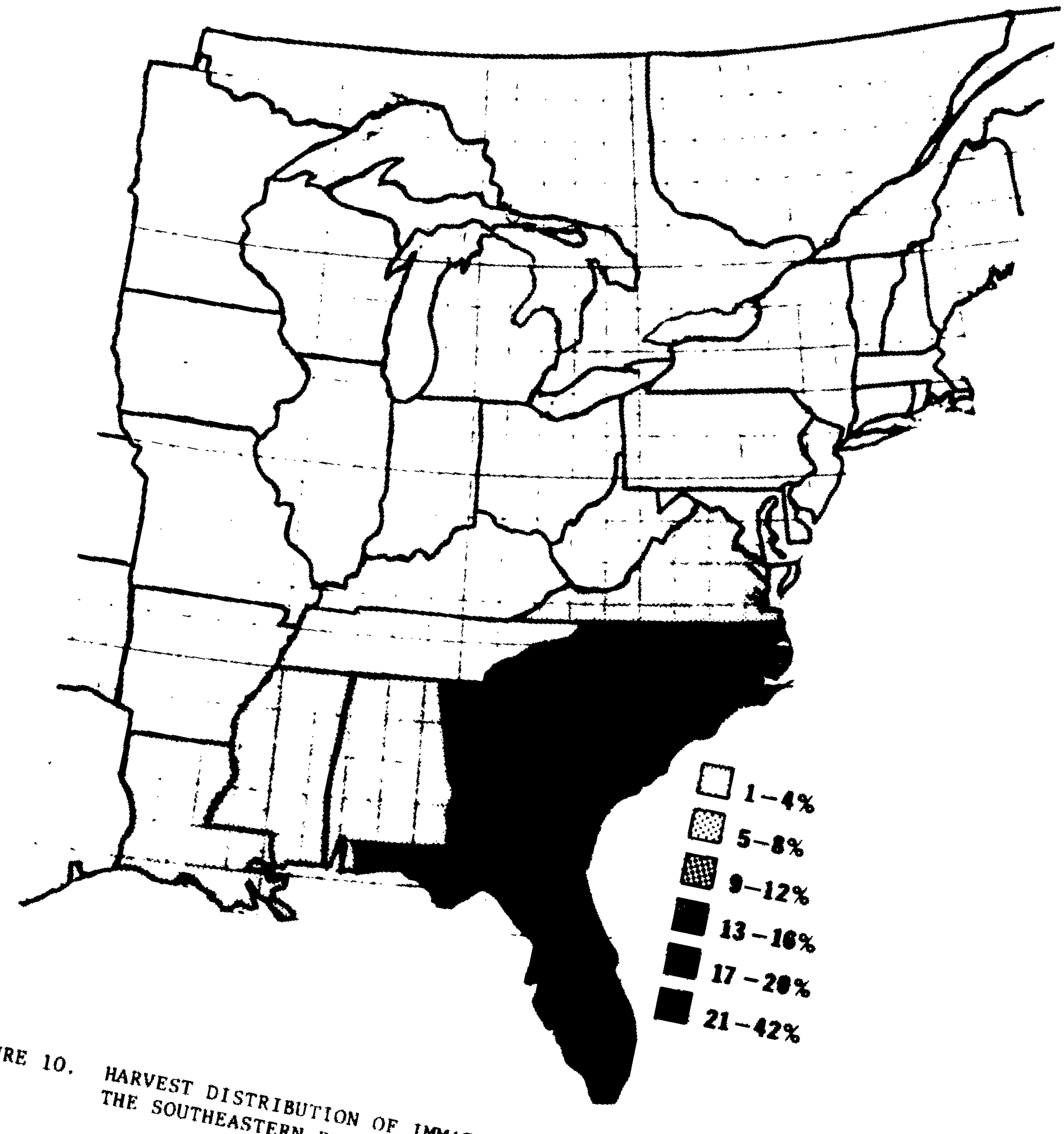


FIGURE 10. HARVEST DISTRIBUTION OF IMMATURE WOOD DUCKS BANDED IN THE SOUTHEASTERN REGION.

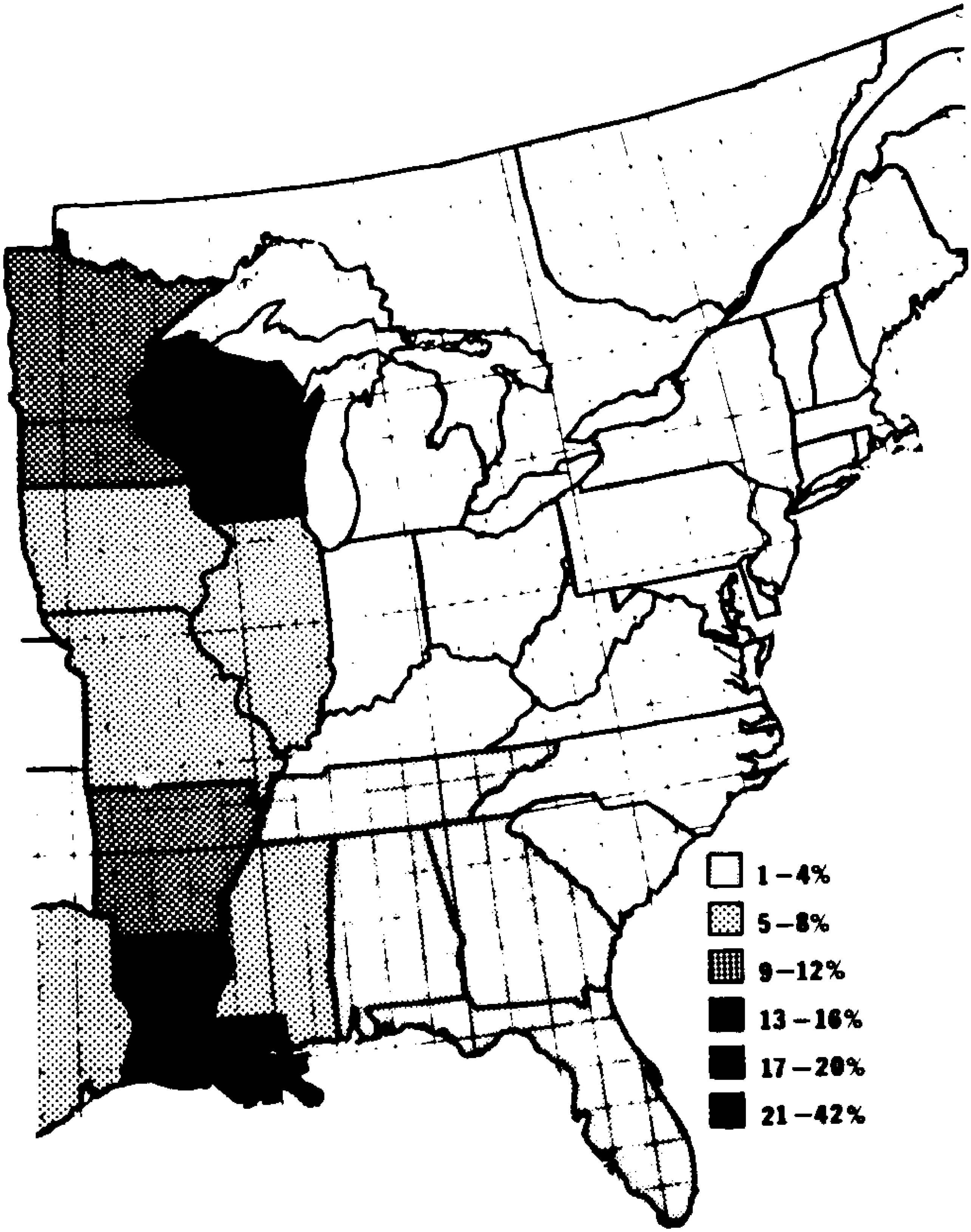


FIGURE 11. HARVEST DISTRIBUTION OF ADULT WOOD DUCKS BANDED IN THE NORTH CENTRAL REGION.

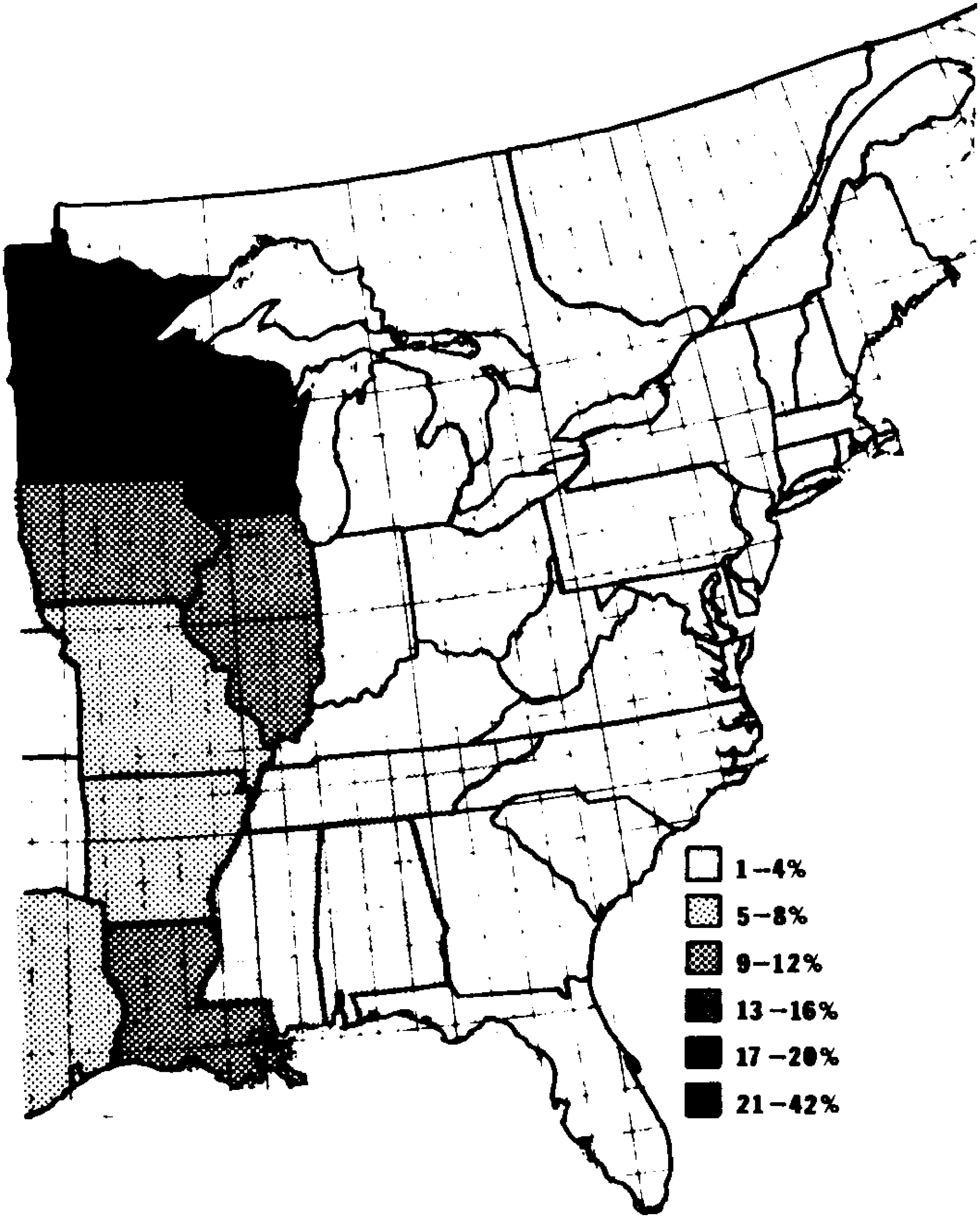


FIGURE 12. HARVEST DISTRIBUTION OF IMMATURE WOOD DUCKS BANDED IN THE NORTH CENTRAL REGION.

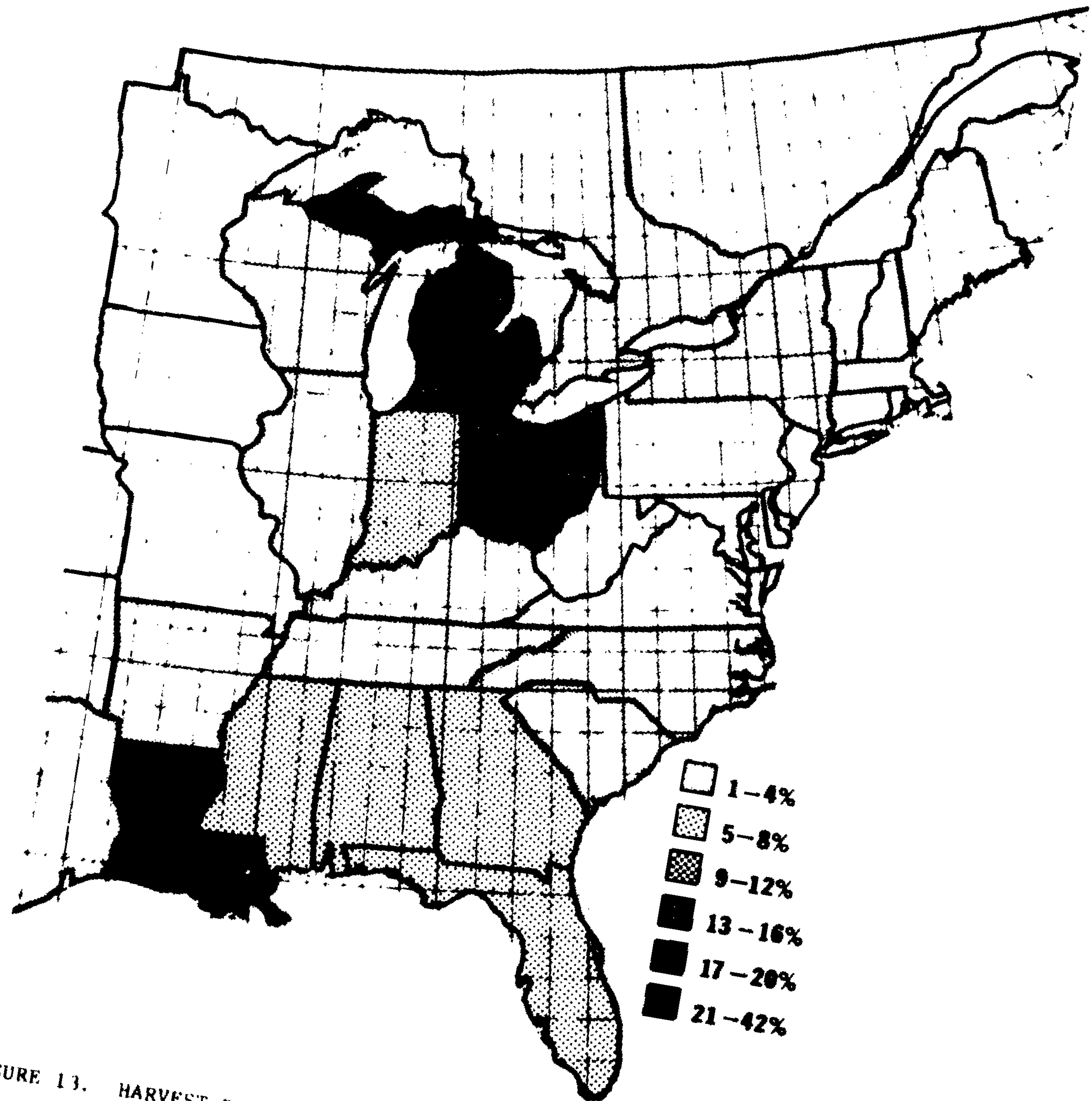


FIGURE 13. HARVEST DISTRIBUTION OF ADULT WOOD DUCKS BANDED IN THE LAKE STATES REGION.

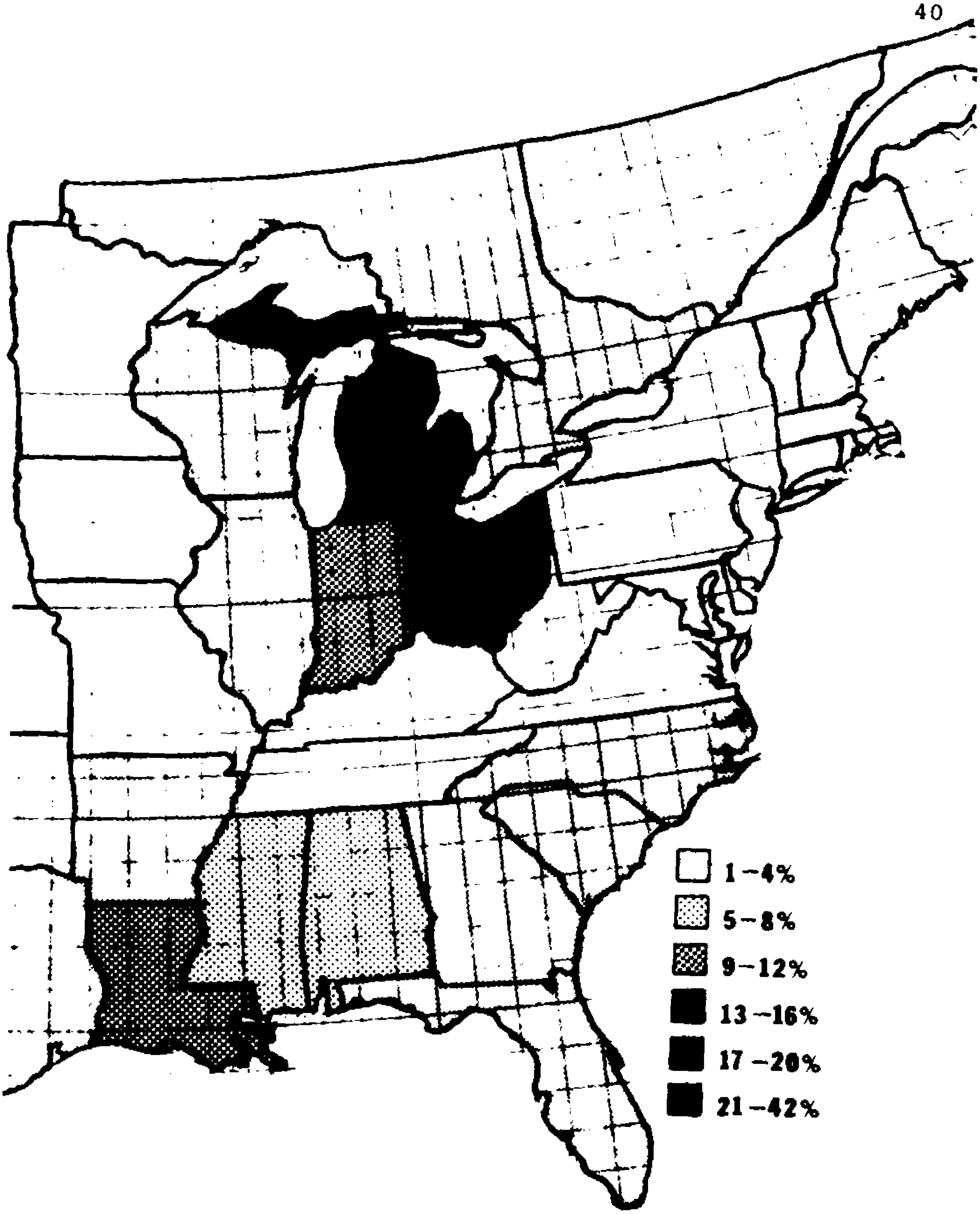


FIGURE 14. HARVEST DISTRIBUTION OF IMMATURE WOOD DUCKS BANDED IN THE LAKE STATES REGION.

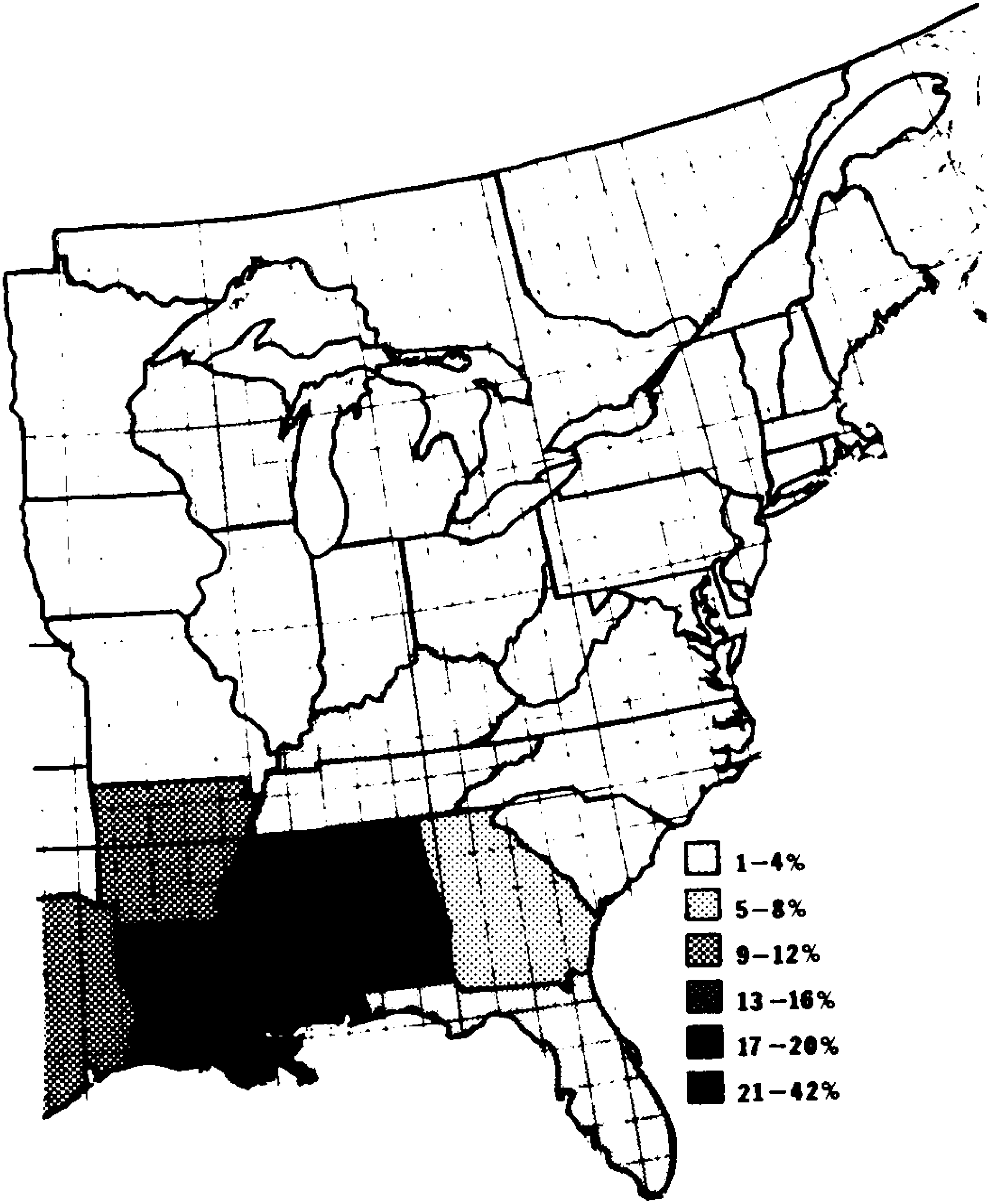


FIGURE 15. HARVEST DISTRIBUTION OF ADULT WOOD DUCKS BANDED IN THE SOUTHERN REGION.

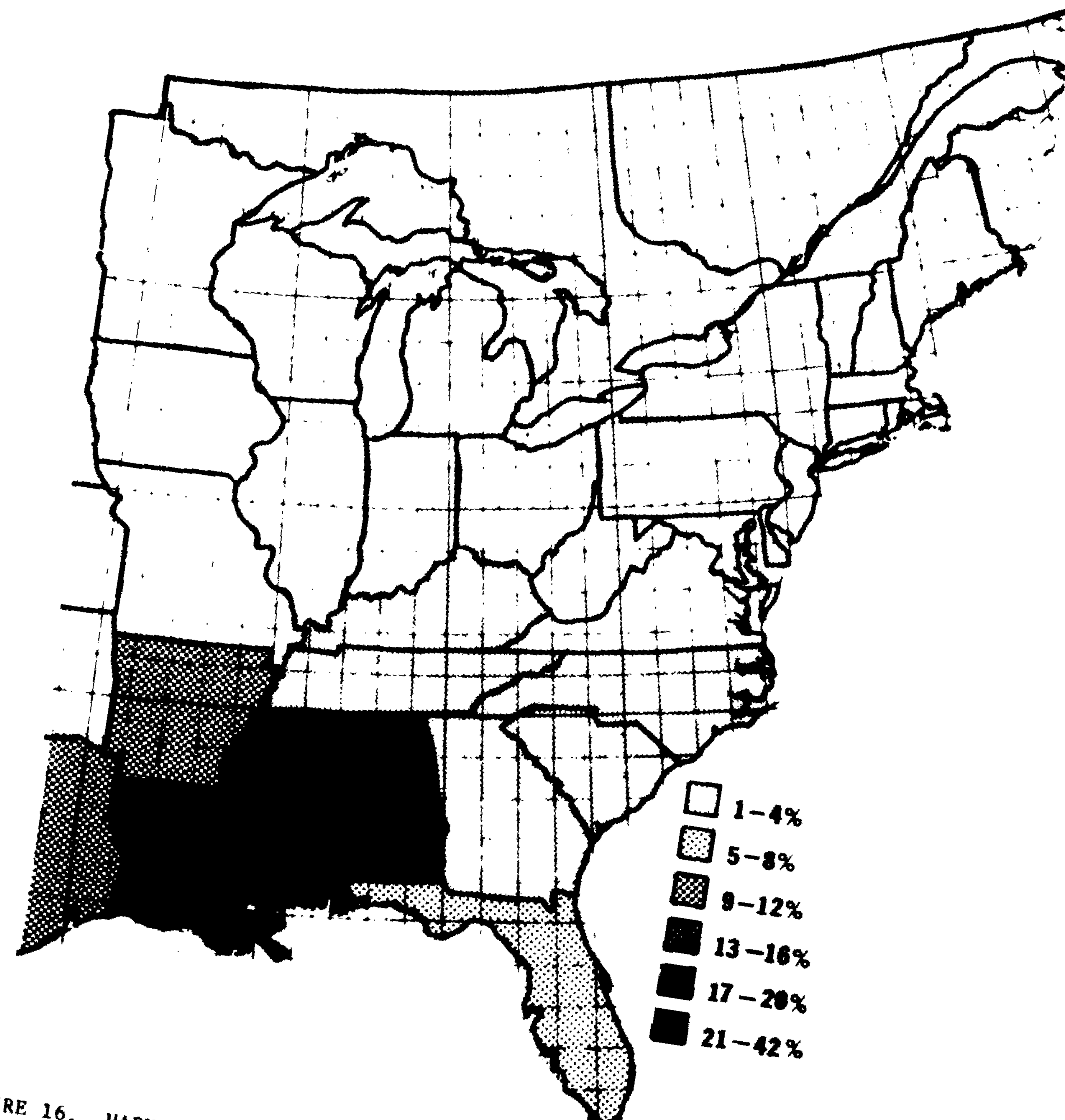


FIGURE 16. HARVEST DISTRIBUTION OF IMMATURE WOOD DUCKS BANDED IN THE SOUTHERN REGION.

manner in all of the 48 coterminous United States and 8 Canadian provinces during the 1950 through 1968 period (Appendix Table 54). The greatest numbers of wood ducks were banded in Illinois (29,008) and Wisconsin (28,194). Most of the eastern Canadian banding of wood ducks (5,996) was conducted in Ontario (4,627).

The number of normal, wild wood ducks banded in eastern North America (32 states and 2 Canadian provinces) during May through August 1950 through 1968 and later recovered during a hunting season are summarized in Appendix Table 55. Number of birds banded by reference areas was: North Central (63,524), Lake States (17,831), Southern (18,073), New York-Eastern Canada (8,633), Northeastern (18,730), and Southeastern (5,446).

Wood ducks banded May through September 1950 through 1968 are shown in Appendix Table 56. Appendix Table 57 is similar to Appendix Table 56, but additional restraints have been placed on age-sex categories and kinds of recoveries.

The number of winter bandings utilized throughout this study are shown in Appendix Table 58.

Banding Quotas

Reference-area survival rates and direct recovery rates used in recommending numbers to be banded are shown in Appendix Table 50. I believe the rates in Appendix Table 50 are typical to slightly conservative of the rates

prevailing during the 1950's and 1960's; therefore, banding quotas summarized in Table 1 should be adequate for estimating annual survival rates with acceptable variances. Approximately 45,700 wood ducks (22,500 adults and 23,200 immatures) would have to be banded annually if hunting pressures and survival rates of the 1950's and 1960's continue to prevail.

Population Indices

Forest Data

State acreages and associated wood duck values for six forest types are summarized in Appendix Table 42. Based on published wood duck habitat studies, associated plant species, and physiographic characteristics, the Oak-Gum-Cypress type was given the highest rating. This forest type occupied 15.0 percent of the Eastern hardwood forest in 1963 as compared to 12.0 percent in 1970 (U.S. Forest Service 1965 and 1973a). Nearly all of this type occurs in the Mississippi Delta and along other southern stream or river bottoms. Bottomland plant species, mixed bottomland hardwoods, and cypress-tupelo (*Taxodium distichum* L., *Nyssa aquatica* L.) stands predominate. Most sites are characterized by mesic conditions, floodplain situations, periodic flooding, and the presence of sloughs, flats, first bottoms, ridges and terraces, and fronts (Barrett 1962).

The Elm-Ash-Cottonwood type was rated second due to its occurrence along water courses, the association with

TABLE 1.—Suggested wood duck banding quotas for summer reference areas

Reference Area	Age and Sex Classes[1]				Total
	AM	AF	IM	IF	
	Numbers to be Banded				
Northeastern	1,700	1,800	1,900	2,100	7,500
Southeastern	1,900	2,200	2,000	2,400	8,500
New York-Eastern Canada	1,500	1,600	1,500	1,700	6,300
North Central	2,000	2,400	1,800	2,100	8,300
Lake States	1,500	1,800	1,500	1,800	6,600
Southern	1,900	2,200	2,000	2,400	8,500
Total	10,500	12,000	10,700	12,500	45,700

[1]A (Adults), I (Immatures), M (Males), F (Females).

high water tables, and presence on sites with poor internal drainage. It is often identified as a bottomland hardwood type with characteristic moist site species such as American elm (Ulmus americana L.), black ash (Fraxinus nigra Marsh.), green ash (Fraxinus pennsylvanica Marsh.), cottonwood (Populus spp. L.), black willow (Salix nigra Marsh.), sycamore (Platanus occidentalis L.), red maple (Acer rubrum L.), box elder (Acer negundo L.), and river birch (Betula nigra L.). This hardwood type is most concentrated in the Central and Lake States area of the United States. In 1963, it comprised 7.9 percent (20.4 million acres or 8.3 million hectares) of the Eastern hardwood types as compared to 9.7 percent (24.7 million acres or 10.0 million hectares) in 1970 (U.S. Forest Service 1965 and 1973a).

I judged the Aspen-Birch and Maple-Beech-Birch types to have similar rankings in their importance to, or use by, wood ducks. Although often described as occurring on the better drained sites of New England, the Lake States, and the Middle Atlantic states; Barrett (1952), Fowells (1965), and the U.S. Forest Service (1973b) attest to the occurrence of these types on lowlands, flood-plain sites, bogs, and poorly drained soils. Also of importance is the association with American elm, red maple, black ash, cottonwood, red and white oaks (Quercus spp. L.), and basswood (Tilia americana L.). During the 1950's and early 1960's, Aspen-Birch types comprised 9.2 percent (23.7 million acres or 9.6 million hectares) of the Eastern hardwoods. This percentage dropped

to 8.1 in 1970 (20.5 million acres or 8.3 million hectares). During the same period, Maple-Beech-Birch forest types occupied 12.9 percent of the hardwood forest (33.3 million acres or 13.5 million hectares) in 1963 and 12.3 percent (31.1 million acres or 12.6 million hectares) in 1970 (U.S. Forest Service 1965 and 1973a).

The Oak-Hickory and Spruce-Fir types were ranked fifth and sixth, respectively, either due to a lack of mesic conditions (Oak-Hickory) or absence of mast and den-producing tree species (Spruce-Fir). Oak-Hickory stands stretch from southern New England to Texas and represent the most widespread hardwood timber type, accounting for 44.9 and 44.1 percent of the 1963 and 1970 acreages of hardwoods in the East (U.S. Forest Service 1965 and 1973a). Total land area has varied from 116.0 to 111.9 million acres (46.9 to 45.3 million hectares) between 1963 and 1970 (U.S. Forest Service 1973a). Trees commonly found in this type are characteristically upland species that range from ridge sites to moist cove sites. White, northern red, and black oaks (Quercus spp. L.) predominate throughout the type. Other common oaks are scarlet (Quercus coccinea Muenchh.) and chestnut oaks (Quercus prinus L.) in the Appalachians, northern pines (Pinus spp. L.) and bur oaks (Quercus macrocarpa Michx.) in northern and western ranges, and post (Quercus stellata Wangenh.), blackjack (Quercus marilandica Meunchh.), and southern red oaks (Quercus falcata Michx.) to the west and south. Hickories--

especially shagbark (Carya ovata Mill.), pignut (Carya glabra Mill.), mockernut (Carya tomentosa Nutt.), and bitternut (Carya cordiformis Wangenh.)--are consistent forest components. Associated species are aspen (Populus spp. L.), ashes (Fraxinus spp. L.), blackgum (Nyssa sylvatica Marsh.), yellow poplar (Liriodendron tulipifera L.), elms (Ulmus spp. L.), sugar (Acer saccharum L.) and red maple (Acer rubrum L.), sassafras (Sassafras albidum Nutt.), black cherry (Prunus serotina Ehrh.), black locust (Robinia pseudoacacia L.), and black walnut (Juglans nigra L.) (U.S. Forest Service 1973b, Barrett 1962, and Fowells 1965). Although Oak-Hickory species are usually found on drier sites, they were related as moderately useful to wood ducks because: (1) wood ducks often nest up to one-half mile or more from water, (2) oak species possess desirable cavity traits, (3) previous studies have documented the use of Oak-Hickory types by wood ducks, and (4) attractive food producing qualities of the oaks.

The Spruce-Fir type is a softwood group most commonly found in Lake States and Northeastern States such as northern Minnesota, upper Michigan, and Maine (Society of American Foresters 1954). Although the major tree species of this forest type were judged to be of little importance to wood ducks, their association with organic soils of old lake beds, poorly drained soils, and bog and muck soils indicated that some use by brooding, molting, or loafing wood ducks was possible.

Descriptions of the Great Lakes-St. Lawrence and the Deciduous forest types of Canada (59.8 million acres or 24.2 million hectares) are given by Dixon (1963) and Manning and Grinnell (1971). Along the Great Lakes-St. Lawrence and Ottawa Valley, into southern Quebec and northern New Brunswick, and on into southwestern Ontario is the Great Lakes-St. Lawrence Forest Region. This forest possesses a mixed composition containing hardwoods found in the more southern Deciduous Region and conifers common to a Boreal Forest Region. The characteristic species are red (Pinus resinosa L.) and white pine (Pinus strobus L.), eastern hemlock (Tsuga canadensis L.), and yellow birch (Betula alleghaniensis Britton). There is a wide distribution of sugar and red maple, white birch (Betula papyrifera Marsh.), trembling aspen (Populus tremuloides Michx.), black (Picea mariana Mill.) and white spruce (Picea glauca Muench), white cedar (Chamaecyparis thyoides L.), balsam fir (Abies balsamea L.), and jack pine (Pinus banksiana Lamb.). In contrast, the Deciduous Forest Region located between Lakes Huron, Erie, and Ontario contains forest communities dominated by broad-leaved trees. The main Canadian distributions of beech (Fagus grandifolia Ehrh.) and sugar maple, basswood, red maple, red oak, white oak, and bur oak occur here. Associated tree species are black walnut, sycamore, swamp white oak (Quercus bicolor Willd.), shagbark and bitternut hickory, rock elm (Ulmus racemosa Thom.), silver maple (Acer saccharinum L.), and blue beech

(*Carpinus caroliniana* Walt.). Many of the tree species of these two forest regions are important to wood ducks, because these southern regions of Canada are characterized by millions of hectares of open water, bogs, streams, rivers, muskeg sites, and flooded brushland.

Products obtained when forest-type acreages and wood-duck values were multiplied and summed to produce a population density index for each state are exhibited in Appendix Table 43.

Population Model (FHMUP)

Population estimates calculated from the Flyway Habitat Management Unit Project (FHMUP) are shown in Table 2. The calculated density distribution of preseason wood ducks was as follows:

Reference area	Density distribution
	Percent
North Central	25.9
New York-Eastern Canada	17.0
Southeastern	16.7
Southern	15.1
Northeastern	14.1
Lake States	11.2

Simultaneous Equations

As previously noted, it was necessary to use an adjusted harvest for simultaneous equation estimates. The original harvest determined from U.S. Fish and Wildlife Service harvest surveys and the adjusted harvest based upon weighted direct recoveries are shown in Appendix Table 44.

TABLE 2.--Wood duck population estimates from the Fish and Wildlife Service's population model (FHMUP)[1]

Location	May Populations (thousands)	August Populations (thousands)	August minus May Populations (thousands)
Alabama	28	90	62
Arkansas	34	103	69
Illinois	60	159	99
Indiana	40	106	66
Iowa	30	79	49
Kentucky	12	28	16
Louisiana	31	75	44
Michigan	40	106	66
Minnesota	89	238	149
Mississippi	44	101	57
Missouri	29	79	50
Ohio	40	106	66
Tennessee	13	35	22
Wisconsin	70	185	115
Mississippi Flyway	560	1,490	930
Connecticut	8	21	13
Delaware	5	13	8
Florida	60	160	100
Georgia	30	95	65
Maine	17	45	28
Maryland	11	20	9
Massachusetts	25	65	40
New Hampshire	25	70	45
New Jersey	18	47	29
New York	40	110	70
North Carolina	40	95	55
Pennsylvania	23	60	37
Rhode Island	2	5	3
South Carolina	40	110	70
Vermont	15	45	30
Virginia	10	20	10
West Virginia	5	13	8
Atlantic Flyway	374	994	620
Canada (North)	105	277	172

[1]The FHMUP estimates relate to a 1965 time period.

The adjusted matrices of direct recovery rates used in simultaneous equation estimates of adult and immature densities are given in Appendix Tables 46 and 47.

Table 3 presents state and flyway population estimates. The average annual wood duck population in eastern North America during 1962 though 1968 was estimated by the simultaneous technique as 3,284,700 birds with 41.4 percent located in the Atlantic Flyway, 6.9 percent in Ontario and Quebec, and 51.7 percent in the Mississippi Flyway.

Population Estimates

Table 3 summarizes preseason population indices as estimated by forest data, FHMUP, and simultaneous equations. The last column, Row Sum, is the combined sum all three estimates and produces a set of values I believe to best represent the relative abundance of wood ducks in each state and province. Based upon "Row Sum" computations, 52.0 percent of the preseason wood duck population was allocated to the Mississippi Flyway, 38.0 percent occurred in the Atlantic Flyway, and 10.0 percent inhabited southeastern Ontario and southern Quebec. The calculated density distribution by reference areas was:

TABLE 3.--Wood duck population indices estimated by three techniques, 1962 through 1968

	FHMUP Bureau Model		Simultaneous Equation Estimate		Forest Values[1]	Row Sum[2]	
	Adults	Immatures	Adults	Immatures	Wood Ducks	Adults	Immatures
Alabama	28,000	62,000	55,569	156,991	33,862	117,431	252,853
Arkansas	34,000	69,000	40,653	7,752	48,517	123,170	125,269
Illinois	60,000	99,000	21,534	64,212	14,062	95,596	177,274
Indiana	40,000	66,000	40,058	47,554	13,279	93,337	126,833
Iowa	30,000	49,000	26,994	20,415	11,696	68,690	81,111
Kentucky	12,000	16,000	13,561	0	21,195	46,756	37,195
Louisiana	31,000	44,000	34,225	45,534	69,674	134,899	159,208
Michigan	40,000	66,000	58,477	84,825	76,333	174,810	227,158
Minnesota	89,000	149,000	124,394	190,768	99,394	312,788	439,162
Mississippi	44,000	57,000	137,590	56,459	47,894	229,484	161,353
Missouri	29,000	50,000	71,614	56,409	27,623	128,237	134,032
Ohio	40,000	66,000	27,884	27,284	16,425	84,309	109,709
Tennessee	13,000	22,000	0	3,819	14,669	27,669	40,488
Wisconsin	70,000	115,000	138,449	145,592	88,166	296,615	348,758
Mississippi Flyway	560,000	930,000	791,002	907,614	582,789	1,933,791	2,420,403
Connecticut	8,000	13,000	2,356	1,502	4,779	15,136	19,281
Delaware	5,000	8,000	6,921	814	998	12,919	9,812
Florida	60,000	100,000	92,701	51,907	55,496	208,197	207,403
Georgia	30,000	65,000	181,679	115,745	59,856	271,535	240,601
Maine	17,000	28,000	35,099	53,842	43,862	95,961	125,704
Maryland	11,000	9,000	4,002	2,425	5,804	20,806	17,229
Massachusetts	25,000	40,000	20,641	29,721	7,018	52,659	76,739
New Hampshire	25,000	45,000	16,514	29,001	11,330	52,844	85,331
New Jersey	18,000	29,000	20,876	20,502	3,899	42,775	53,401
New York	40,000	70,000	57,612	73,467	39,025	136,637	182,492
North Carolina	40,000	55,000	80,818	91,825	37,270	158,088	184,095

TABLE 3.--Continued

	FHMJP Bureau Model		Simultaneous Equation Estimate		Forest Values[1]	Row Sum[2]	
	Adults	Immatures	Adults	Immatures	Wood Ducks	Adults	Immatures
Pennsylvania	23,000	37,000	57,594	69,276	28,482	109,076	134,758
Rhode Island	2,000	3,000	1,818	5,723	1,073	4,891	9,796
South Carolina	40,000	70,000	13,341	62,418	34,948	88,289	167,366
Vermont	15,000	30,000	16,751	32,718	13,903	45,654	76,621
Virginia	10,000	10,000	5,014	34,272	14,183	29,197	58,455
West Virginia	5,000	8,000	22,067	48,821	17,134	44,201	73,955
Atlantic Flyway	374,000	620,000	635,804	723,979	379,060	1,388,864	1,723,039
Ontario	135,124	196,000	71,482	117,261	100,000	306,606	413,261
Quebec	25,169	19,264	20,316	17,244	26,000	71,485	62,508
Canada	160,293	215,264	91,798	134,505	126,000	378,091	475,769
Eastern North America	1,094,293	1,765,264	1,518,604	1,766,098	1,087,849	3,700,746	4,619,211

[1]The same value was used for immatures and adults.

[2]Total of the three estimates.

Reference area	Density distribution
	Percent
North Central	25.0
Southeastern	19.0
Southern	18.0
New York-Eastern Canada	14.0
Northeastern	14.0
Lake States	10.0

Estimates of the ten most populated states and provinces were:

State	Density distribution
	Percent
Minnesota	9.0
Ontario	8.6
Wisconsin	7.8
Georgia	6.2
Florida	5.0
Michigan	4.8
Mississippi	4.7
Alabama	4.4
North Carolina	4.1
New York	3.8

Weighting Data

State density values in Table 3 were divided by the number of adult and immature wood ducks banded May through September 1950 through 1968 to yield a weight per banded bird (Appendix Table 48). These weighted values were used in the calculations of harvest distribution and derivation as described by Geis (1972).

Reporting Rates

Reporting rate estimates, which were used when direct recovery rates were converted to harvest rates, are pre-

sented in Appendix Table 49.

Harvest

Annual Harvest

The 1962 through 1968 harvest estimates for the eastern United States ranged from 119,470 to 297,396 for adults and from 117,109 to 350,282 for immatures (Table 4). The average harvest was 187,778 adults and 291,189 immatures. The total average annual harvest, including unknown age and sex classes, was approximately 0.5 million wood ducks. Annual harvest by age and sex for the 1962 through 1968 hunting seasons as determined from weighted wing-collection data is shown in Tables 5 and 6. Based upon waterfowl survey estimates, 68.3 percent of the adult harvest in the eastern United States occurred in the Mississippi Flyway as compared to 31.7 percent in the Atlantic Flyway. The immature harvest was proportioned as 67.7 and 32.3 percent in the Mississippi and Atlantic Flyways, respectively.

Proportion Harvested and Total Kill

The proportion of the overall prehunting season wood duck population that was shot and retrieved (harvest rate) was determined by comparing the average annual 1962 through 1968 population size (as estimated from simultaneous equations) with the average harvest estimate occurring during the same years. The annual 1962 through

TABLE 4.--Size of adult and immature wood duck harvest by regions and flyways, 1962-68

Region	Adults							Immatures						
	1962	1963	1964	1965	1966	1967	1968	1962	1963	1964	1965	1966	1967	1968
North Central	29,016	58,153	43,986	33,152	86,419	48,426	67,571	38,857	116,045	104,455	116,128	124,177	102,307	87,762
Lake States	13,638	11,944	11,744	13,702	23,793	15,426	24,858	18,053	27,740	27,696	32,716	27,089	28,749	36,497
Southern	29,823	61,256	51,937	59,852	112,834	59,234	46,757	28,180	84,689	74,706	96,605	94,419	71,629	49,292
New York - E. Canada[1]	. . .	. . .	. . .	. . .	. . .	57,680	37,574	. . .	. . .	. . .	. . .	. . .	105,110	112,185
Northeastern	10,478	11,102	19,195	15,402	22,016	15,008	18,303	17,417	18,668	29,150	34,612	34,230	30,833	41,288
Southeastern	28,104	40,214	17,580	32,769	42,441	36,199	51,809	30,153	55,340	27,779	46,484	50,626	48,192	67,373
Atlantic Flyway	46,993	52,213	42,795	53,869	74,350	61,017	79,688	62,019	76,992	67,243	98,452	104,597	103,193	138,038
Mississippi Flyway[2]	72,477	131,353	107,667	106,706	223,046	123,086	139,186	85,090	228,474	206,857	245,449	245,685	202,685	173,551
E. Canada	. . .	. . .	. . .	. . .	. . .	47,870	27,998	. . .	. . .	. . .	. . .	. . .	80,942	82,808
Total[3]	119,470	183,566	150,462	160,575	297,396	184,103	218,874	147,109	305,466	274,100	343,901	350,282	305,878	311,589

[1]Data not available (1962-66) for Canada. [2]Includes the state of Texas. [3]Excludes Canadian data, but uses New York harvest data (1962-68).

TABLE 5.--Size of immature wood duck harvest by age and sex for six population regions, the Atlantic and Mississippi Flyways, and eastern Canada

Region	Immature Males 1962	1963	1964	1965	1966	1967	1968	Immature Females 1962	1963	1964	1965	1966	1967	1968
North Central	21,928	67,679	56,420	58,637	69,249	54,629	54,869	16,929	48,365	45,035	57,491	54,928	47,878	32,893
Lake States	10,100	14,714	15,554	17,518	15,257	17,349	21,273	7,453	13,026	12,142	15,198	11,832	11,400	15,224
Southern	17,533	55,613	46,855	59,474	62,037	46,952	31,311	10,647	29,076	17,651	37,131	32,382	24,677	17,981
New York - E. Canada[1]	. . .	. . .	. . .	. . .	. . .	68,962	72,662	. . .	. . .	. . .	. . .	. . .	36,148	39,523
Northeastern	9,622	10,864	15,954	19,864	19,112	16,671	22,397	7,795	7,804	13,196	14,728	15,118	14,162	18,891
Southeastern	20,222	34,038	18,403	29,803	29,397	28,025	41,114	9,931	21,302	9,376	16,681	21,229	20,167	26,259
Atlantic Flyway	37,891	46,577	39,425	59,950	59,289	59,555	80,921	24,128	30,415	27,818	38,502	45,306	43,638	57,117
Mississippi Flyway[2]	49,561	138,006	118,829	135,629	146,543	118,930	107,453	35,529	90,468	88,025	109,820	99,142	83,755	66,098
E. Canada	. . .	. . .	. . .	. . .	. . .	54,103	55,252	. . .	. . .	. . .	. . .	. . .	26,839	27,556
Total[3]	87,452	184,583	158,254	195,579	205,832	178,485	188,374	59,657	120,883	115,846	148,322	144,450	127,393	123,215

[1]Data not available (1962-66) for Canada. [2]Includes the state of Texas. [3]Excludes Canadian data, but uses New York harvest data (1962-68).

TABLE 6.--Size of adult wood duck harvest by age and sex for six population regions, the Atlantic and Mississippi Flyways, and eastern Canada

Region	Adult Males							Adult Females						
	1962	1963	1964	1965	1966	1967	1968	1962	1963	1964	1965	1966	1967	1968
North Central	15,959	30,652	21,689	18,312	40,870	26,574	35,277	13,057	27,501	22,297	14,840	45,549	21,852	32,294
Lake States	6,445	5,884	6,210	6,921	10,310	6,724	11,799	7,193	6,060	5,534	6,781	13,483	8,702	13,059
Southern	16,622	38,620	32,138	36,213	65,412	40,600	29,016	13,201	22,636	19,799	23,639	47,422	18,634	17,741
New York - E. Canada[1]	. . .	. . .	. . .	. . .	. . .	38,160	23,636	. . .	. . .	. . .	. . .	. . .	19,520	13,938
Northeastern	5,390	5,523	11,180	9,503	12,482	8,118	10,534	5,088	5,579	8,015	5,899	9,534	6,890	7,769
Southeastern	17,232	24,652	10,317	18,400	26,196	23,471	29,725	10,872	15,562	7,263	14,369	16,245	12,728	22,084
Atlantic Flyway	26,828	30,667	24,463	30,997	44,193	36,735	44,944	20,165	21,546	18,332	22,872	30,157	24,282	34,744
Mississippi Flyway[2]	39,026	75,156	60,037	61,446	116,592	73,898	76,092	33,451	56,197	47,630	45,260	106,454	49,188	63,094
E. Canada	. . .	. . .	. . .	. . .	. . .	33,014	18,951	. . .	. . .	. . .	. . .	. . .	14,856	9,047
Total[3]	65,854	105,823	84,500	92,443	160,785	110,633	121,036	53,616	77,743	65,962	68,132	136,611	73,470	97,838

[1]Data not available (1962-66) for Canada. [2]Includes the state of Texas. [3]Excludes Canadian data, but uses New York harvest data (1962-68).

1968 summer population in the eastern United States approached 3 million birds (Table 3). The estimated average annual harvest during the same years was 0.5 to 0.6 million wood ducks; therefore, hunters bagged 16.7 to 20.0 percent of the average wood duck population.

Kaczynski and Geis (1961) suggested that unretrieved kill of wood ducks has accounted for 25.0 percent of their total shooting loss. When this correction for crippling loss is made, the 1962 through 1968 total kill has fluctuated between 670 and 800 thousand or 22.0 to 27.0 percent of the eastern United States preseason population of wood ducks. If the crippling loss of wood ducks was 35 percent as suggested by Kaczynski (1968), the kill rate could have been as high as 30.0 percent.

Harvest Distribution (Surveys Versus Recoveries)

The Eastern harvest distribution of wood ducks estimated from 1962 through 1968 harvest survey data, in addition to estimates from weighted direct recoveries of wood ducks banded May through September 1950 through 1968, are given in Table 7. The harvest survey reveals the following distribution: Mississippi Flyway, 55.0 percent; Atlantic Flyway, 26.0 percent; eastern Canada, 17.0 percent; and Texas, 2.0 percent. Although the harvest distributions derived from weighted recoveries follow a similar pattern (Mississippi Flyway, 48.0 percent; Atlantic Flyway, 40.0 percent; eastern Canada, 9.0 percent; and Texas, 3.0

TABLE 7.—Estimated harvest distribution of wood ducks in eastern North America

	Age			
	Immatures		Adults	
Harvest Area	Harvest Survey	Weighted Recoveries[1]	Harvest Survey	Weighted Recoveries
	Percent			
Connecticut	0.4	0.4	0.4	0.2
Delaware	T[2]	0.2	0.1	0.3
Florida	3.5	5.7	4.1	8.5
Georgia	2.4	5.2	3.1	10.0
Maine	0.7	2.5	0.9	1.2
Maryland	0.2	0.2	0.2	0.2
Massachusetts	0.8	0.9	0.8	1.2
New Hampshire	0.6	1.4	0.6	0.8
New Jersey	1.0	1.2	1.1	1.2
New York	4.7	3.2	3.3	3.2
North Carolina	3.2	4.1	3.9	4.4
Pennsylvania	3.4	3.5	2.6	1.9
Rhode Island	T	0.1	T	T
South Carolina	3.8	5.7	5.2	6.2
Vermont	0.6	1.2	0.4	0.8
Virginia	0.9	1.1	1.0	0.6
West Virginia	0.2	0.4	0.2	0.4
Atlantic Flyway	26.4	37.0	27.9	41.1
Alabama	1.8	3.6	2.4	4.9
Arkansas	2.8	3.4	4.7	4.2
Illinois	4.0	3.2	3.7	2.5
Indiana	1.1	1.0	0.9	1.0
Iowa	3.7	2.7	2.5	2.0
Kentucky	0.6	0.2	0.1	0.5
Louisiana	10.0	9.0	12.4	10.8
Michigan	3.2	3.9	3.2	2.2
Minnesota	11.3	5.8	8.6	2.6
Mississippi	2.4	4.0	3.6	7.1
Missouri	1.4	1.7	1.3	1.7
Ohio	3.6	2.0	3.2	1.6
Tennessee	1.0	0.9	1.7	1.4
Wisconsin	7.2	7.8	8.1	4.9
Mississippi Flyway	54.1	49.2	56.4	47.4
Texas	2.0	3.5	2.7	3.8
Central Flyway	2.0	3.5	2.7	3.8
Ontario	15.5	8.5	11.0	5.9
Quebec	2.1	1.9	1.9	1.6
Canada	17.6	10.4	12.9	7.5
Total %	100.1	100.1	99.9	99.8

[1]Based on an average weighting factor for direct recoveries from bandings in 1950–68.

[2]Percentages less than 0.1% are indicated by T.

percent), a larger harvest percentage is attributed to the Atlantic Flyway and a lower percentage to Canada and the Mississippi Flyway.

The reference-area harvest distribution of immature wood ducks, calculated from weighted recoveries, is as follows:

Reference area	Harvest distribution
	Percent
Southern	24.6
Southeastern	21.7
North Central	21.2
New York-Eastern Canada	13.6
Northeastern	12.0
Lake States	6.9

Six states (Florida, Georgia, New York, North Carolina, Pennsylvania, and South Carolina) were responsible for 73.0 percent of the immature harvest occurring within Atlantic Flyway reference areas. Alabama, Arkansas, Illinois, Louisiana, Minnesota, Mississippi, and Wisconsin accounted for 72.0 percent of the immatures harvested in Mississippi Flyway reference areas.

With the exception of a tendency for larger percentages of adults to be harvested in southern states, the adult harvest distribution was similar to immature harvest distributions. The Southern Reference Area led in adult harvest (32.7 percent), followed by the Southeastern Area (29.7 percent), North Central Area (13.7 percent), New York-Eastern Canada Area (10.7 percent), Northeastern Area

(8.2 percent), and Lake States Area (4.8 percent).

The first-year harvest distributions of immature and adult wood ducks banded in different reference areas and later recovered by hunters are shown in Table 8. The most important states harvesting wood ducks banded in individual summer populations can be identified from this table. For example, five states (Michigan, Ohio, Louisiana, Indiana, and Mississippi) accounted for 69.0 percent of the harvest of immatures banded in the Lake States Reference Area. The five most important harvest states for other reference areas are outlined in Table 9. The tendency for northern immatures to be harvested in northern states, while northern adults contribute prominently to the harvest in southern states is also demonstrated in Table 9.

Table 10 summarizes the reference-area distribution patterns of adult and immature wood ducks. Based on weighted averages of the four northern reference areas, approximately 61 percent of the immatures banded in a northern reference area were harvested by states within that area, 9 percent were harvested by other northern reference areas, and 30 percent were harvested in southern reference areas. The average distribution pattern for adults banded in the four northern reference areas was 44 percent harvested within the reference area of banding, 7 percent harvested in other northern reference areas, and 49 percent harvested in southern reference areas. In contrast to northern-banded wood ducks, those banded in the Southern

TABLE 8.--Reference area harvest distribution of adult and immature wood ducks banded May-September, 1950-68[1]

Harvest Area[3]	Northeastern (%) A	Northeastern (%) I	New York--E. Canada (%) A	New York--E. Canada (%) I	Southeastern (%) A	Southeastern (%) I	Lake States (%) A	Lake States (%) I	Southern (%) A	Southern (%) I	North Central (%) A	North Central (%) I
Connecticut	1.1	2.0	0.0	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Delaware	2.1	1.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0
Florida	7.7	4.3	8.6	5.2	30.1	27.7	7.0	4.4	3.2	5.4	1.6	0.7
Georgia	10.3	6.3	11.3	5.0	28.1	22.0	6.7	3.6	6.5	4.2	1.5	0.4
Maine	8.0	13.7	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maryland	0.6	0.8	0.3	T	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
Massachusetts	6.5	4.6	0.7	T	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0
New Hampshire	5.4	7.5	0.0	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Jersey	6.4	4.7	0.9	1.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New York	2.0	1.9	15.4	14.2	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
North Carolina	8.1	7.3	5.6	5.4	13.8	15.4	1.4	1.2	0.0	0.9	0.2	0.2
Pennsylvania	7.7	13.9	3.4	3.0	0.0	0.0	0.3	0.0	0.0	0.0	T	T
Rhode Island	T[2]	0.5	0.0	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Carolina	14.0	8.7	6.7	6.0	17.7	26.7	3.2	2.4	0.0	1.3	0.6	0.2
Vermont	4.9	6.4	0.0	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Virginia	1.6	1.5	1.5	2.6	0.0	2.4	0.0	0.2	0.0	0.0	0.0	0.0
West Virginia	2.7	2.3	0.0	T	0.0	0.0	0.5	T	0.0	0.0	0.0	0.0
Atlantic Flyway	89.3	89.0	54.4	43.1	89.9	94.2	19.9	11.8	10.1	11.8	3.9	1.5
Alabama	2.8	3.7	2.5	1.8	3.7	1.5	5.9	5.2	14.9	13.5	3.1	1.4
Arkansas	0.8	T	0.9	0.6	0.0	0.3	2.7	3.4	9.2	11.4	8.6	5.1
Illinois	0.0	T	0.0	0.0	0.0	0.0	2.3	4.1	0.0	0.4	8.5	9.0
Indiana	0.0	0.0	4.0	0.0	0.0	0.0	5.8	8.6	0.0	0.3	0.7	0.1
Iowa	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.1	0.0	7.5	8.7
Kentucky	0.2	T	0.0	0.0	0.0	0.0	0.7	0.3	2.2	1.4	0.2	T
Louisiana	1.2	1.2	1.5	2.2	2.1	1.9	13.7	8.7	27.2	31.2	17.7	11.6
Michigan	0.6	T	0.7	0.5	0.0	0.0	18.2	32.1	0.1	0.0	0.5	0.2

TABLE 8.--Continued

Harvest Area[3]	Northeastern (%)		New York--E. Canada (%)		Southeastern (%)		Lake States (%)		Southern (%)		North Central (%)	
	A	I	A	I	A	I	A	I	A	I	A	I
Minnesota	0.0	0.0	0.0	0.5	0.0	0.0	0.3	0.0	0.0	0.0	9.8	19.7
Mississippi	0.2	0.8	4.5	1.2	2.1	2.1	8.4	6.2	21.1	16.0	7.9	3.[illegible]
Missouri	0.0	T	0.6	0.1	0.0	0.0	0.6	0.6	0.2	T	5.5	5.6
Ohio	0.2	1.2	0.7	0.6	0.0	0.0	13.4	13.4	0.0	0.0	0.3	0.3
Tennessee	0.5	1.3	0.1	0.3	2.0	0.0	2.0	0.4	3.5	1.5	1.2	1.1
Wisconsin	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.6	1.2	0.3	16.6	25.5
Mississippi Flyway	6.6	8.1	12.9	8.6	9.9	5.7	76.7	85.5	79.7	76.1	87.9	91.3
Texas	0.0	T	0.9	0.0	0.0	0.0	1.6	1.6	10.2	12.1	8.1	7.2
Central Flyway	0.0	T	0.9	0.0	0.0	0.0	1.6	1.6	10.2	12.1	8.1	7.2
Ontario	1.3	0.2	26.3	40.7	0.1	0.0	1.7	0.9	0.0	0.0	0.0	T
Quebec	2.5	2.3	5.2	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Canada	3.8	2.5	31.5	48.0	0.1	0.0	1.7	0.9	0.0	0.0	0.0	T
Total %	99.7	99.7	99.8	99.7	99.9	99.9	99.9	99.8	100.0	100.0	99.9	100.0

[1]Based on the average of three sources of weighted direct recoveries for A (Adults) and I (Immatures).

[2]Percentages less than 0.1% are indicated by T.

[3]Flyway values were calculated separately using larger volumes of data and do not necessarily correspond to column sums.

TABLE 9.--The five most important areas harvesting wood ducks produced in each reference area (demonstrates where most of a unit's wood ducks are shot)

AGE CLASS

Adults		Immatures	
Northeastern		Northeastern	
South Carolina	14.0%	Pennsylvania	13.9%
Georgia	10.3%	Maine	13.7%
North Carolina	8.1%	South Carolina	8.7%
Maine	8.0%	New Hampshire	7.5%
Florida	7.7%	North Carolina	7.3%
Total %	48.1	Total %	51.1
New York--E. Canada		New York--E. Canada	
Ontario	17.5%	Ontario	40.7%
New York	15.4%	New York	14.2%
Georgia	11.3%	Quebec	7.3%
Florida	8.6%	South Carolina	6.0%
South Carolina	6.7%	North Carolina	5.4%
Total %	59.5	Total %	73.6
Southeastern		Southeastern	
Florida	30.1%	Florida	27.7%
Georgia	28.1%	South Carolina	26.7%
South Carolina	17.7%	Georgia	22.0%
North Carolina	13.8%	North Carolina	15.4%
Alabama	3.7%	Virginia	2.4%
Total %	93.4	Total %	94.2

Adults		Immatures	
North Central		North Central	
Louisiana	17.7%	Wisconsin	25.5%
Wisconsin	16.6%	Minnesota	19.7%
Minnesota	9.8%	Louisiana	11.6%
Arkansas	8.6%	Illinois	9.0%
Illinois	8.5%	Iowa	8.7%
Total %	61.2	Total %	74.5
Lake States		Lake States	
Michigan	18.1%	Michigan	32.1%
Louisiana	13.7%	Ohio	13.4%
Ohio	13.4%	Louisiana	8.7%
Mississippi	8.4%	Indiana	8.6%
Florida	7.0%	Mississippi	6.2%
Total %	60.6	Total %	69.0
Southern		Southern	
Louisiana	31.2%	Louisiana	27.2%
Mississippi	16.0%	Mississippi	21.1%
Alabama	13.5%	Alabama	14.9%
Texas	12.1%	Texas	10.2%
Arkansas	11.4%	Arkansas	9.2%
Total %	84.2	Total %	82.6

TABLE 11.--Harvest distribution of adult and immature wood ducks banded May-September, 1950-68 (based on an average weighting factor for direct recoveries)[1]

Harvested in	Northeastern		New York--E. Canada		Southeastern		Lake States		Southern		North Central	
	A	I	A	I	A	I	A	I	A	I	A	I
Northeastern	45.6	58.9	5.1	7.0	0.1	T	0.8	T	0.4	0.0	T	T
New York - E. Canada	5.9	4.4	46.9	62.2	0.2	0.0	2.4	0.9	0.0	0.0	0.0	T
Southeastern	41.8	28.1	33.9	21.6	89.6	94.2	18.5	11.8	9.7	11.8	4.0	1.5
Lake States	0.9	1.3	2.7	1.4	0.0	0.0	37.4	54.1	0.0	0.2	1.4	0.8
Southern	5.7	7.2	10.7	6.2	10.1	5.8	34.9	25.9	88.3	87.0	46.7	29.3
North Central	T	T	0.7	1.6	0.0	0.0	6.0	7.3	1.5	1.0	47.8	68.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Atlantic Flyway	89.4	89.1	54.5	43.2	89.9	94.2	19.9	12.0	10.1	11.8	3.9	1.5
Mississippi Flyway	6.7	8.3	12.9	8.7	9.9	5.8	77.0	85.6	79.7	76.1	87.9	91.2
Central Flyway[2]	0.0	T	1.0	0.0	0.0	0.0	1.4	1.7	10.2	12.1	8.2	7.2
Canada[3]	3.9	2.5	31.6	48.1	0.2	0.0	1.7	0.7	0.0	0.0	0.0	T
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]Expressed as percentages for A (adults) and I (immatures). T equal to less than 0.1%

[2]Texas was the only state tabulated.

[3]Composed of eastern Ontario and southern Quebec.

and Southeastern Reference Areas and shot during the first hunting season after banding were harvested almost exclusively (97 percent) in southern states.

The unweighted percentage distribution of 730 recoveries (direct and indirect) of wood ducks banded between December and March 1950 through 1968 are described in Table 11. Approximately 77 percent of the adult wood ducks banded in the Atlantic Coast Reference Area were harvested in the Atlantic Flyway as compared to only 12 percent of the Gulf Coast adults. Most of the Gulf Coast adults (54 percent) were recovered in southern states of the Mississippi Flyway.

Harvest Derivation

The reference-area origins of immature and adult wood ducks harvested in states, flyways, and other harvest areas as determined from the average of three different sources of weighting factors are revealed in Tables 12 and 13. On the average, only 9 percent of the immatures harvested in the Atlantic Flyway were derived from reference areas of the Mississippi Flyway, and less than 8 percent of the immatures harvested in the Mississippi Flyway originated from Atlantic Flyway reference areas. The adult harvest derivation displayed a similar pattern with an approximate 10 percent interchange between flyway reference areas. Most of the interchange which did take place occurred at the southern end of the flyways.

The reference area derivation of harvest for adult

TABLE 11.--Distribution of unweighted total recoveries from wood ducks banded December-March, 1950-68. Numbers represent percentages of unweighted recoveries from winter reference areas to breeding reference areas[1]

	BREEDING AREA WHERE RECOVERED						
	Mississippi Flyway (+ E. Texas)			Atlantic Flyway (+ E. Canada)			
Winter Area Where Banded	North Central	Lake States	Southern	Northeastern	New York E. Canada	Southeastern	Total Percentage
	Percent						
Atlantic Coast	5.6	5.3	11.8	12.7	16.3	48.3	100.0
Gulf Coast	26.1	6.6	54.4	0.6	3.9	8.4	100.0

[1]Based on a total of 730 recoveries.

TABLE [illegible]—Derivation of harvest for immature wood ducks[1]

Harvest Area	Population-Unit Origin (%)[2]						
	Northeastern	New York - E. Canada	Southeastern	Lake States	Southern	North Central	Total Percent
Connecticut	97.3	2.7	0.0	0.0	0.0	0.0	100.0
Delaware	83.0	17.0	0.0	0.0	0.0	0.0	100.0
Florida	14.0	18.8	43.8	9.2	10.5	3.6	99.9
Georgia	22.2	19.9	38.6	5.3	8.7	2.4	100.0
Maine	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Maryland	90.7	9.3	0.0	0.0	0.0	0.0	100.0
Massachusetts	98.2	1.1	0.0	0.7	0.0	0.0	100.0
New Hampshire	98.9	1.2	0.0	0.0	0.0	0.0	100.0
New Jersey	72.5	27.5	0.0	0.0	0.0	0.0	100.0
New York	11.1	88.9	0.0	0.0	0.0	0.0	100.0
North Carolina	32.1	26.7	33.9	3.6	2.2	1.5	100.0
Pennsylvania	80.7	18.5	0.0	0.0	0.0	0.8	100.0
Rhode Island	91.5	8.5	0.0	0.0	0.0	0.0	100.0
South Carolina	27.8	21.5	42.1	5.0	2.5	1.0	99.9
Vermont	99.4	0.6	0.0	0.0	0.0	0.0	100.0
Virginia	25.5	50.5	21.3	2.7	0.0	0.0	100.0
West Virginia	94.5	2.8	0.0	2.7	0.0	0.0	100.0
Atlantic Flyway	44.2	24.2	23.2	4.1	3.1	1.1	99.9
Alabama	18.3	10.5	3.7	17.2	39.2	11.0	99.9
Arkansas	0.4	3.5	0.9	11.8	38.5	44.7	99.8
Illinois	0.1	0.0	0.0	16.1	1.6	82.3	100.1
Indiana	0.0	0.0	0.0	95.4	3.8	0.7	99.9
Iowa	0.0	6.2	0.0	0.0	0.0	93.8	100.0
Kentucky	12.2	0.0	0.0	21.5	55.0	11.2	99.9
Louisiana	2.5	5.0	1.9	11.6	40.3	38.6	99.9
Michigan	0.1	3.1	0.0	95.4	0.0	1.4	100.0

TABLE 12.--Continued

Harvest Area	Population-Unit Origin (%)[2]						
	Northeastern	New York - E. Canada	Southeastern	Lake States	Southern	North Central	Total Percent
Minnesota	0.0	2.0	0.0	0.0	0.0	98.0	100.0
Mississippi	3.6	5.8	4.7	18.4	45.8	21.8	100.1
Missouri	0.2	0.9	0.0	3.8	0.4	94.7	100.0
Ohio	12.9	6.0	0.0	77.2	0.0	4.0	100.1
Tennessee	28.8	6.9	0.0	5.6	20.7	38.1	100.1
Wisconsin	0.0	0.0	0.0	4.0	0.5	95.6	100.1
Mississippi Flyway	3.0	4.0	1.0	20.0	18.0	54.0	100.0
Texas	0.3	0.0	0.0	5.2	37.5	57.0	100.0
Central Flyway	0.3	0.0	0.0	5.2	37.5	57.0	100.0
Ontario	0.4	98.1	0.0	1.2	0.0	0.2	99.9
Quebec	24.4	75.6	0.0	0.0	0.0	0.0	100.0
Canada	5.0	94.0	0.0	1.0	0.0	T	100.0

[1]Expressed as a percent and based on weighted direct recoveries from bandings in May-September, 1950-68.

[2]Percentages less than 0.1% are indicated by T.

TABLE 13.--Derivation of harvest for adult wood ducks[1]

Harvest Area	Population-Unit Origin (%)[2]						
	Northeastern	New York - E. Canada	Southeastern	Lake States	Southern	North Central	Total Percent
Connecticut	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Delaware	94.6	0.0	0.0	0.0	0.0	5.4	100.0
Florida	14.4	20.0	47.2	8.4	5.2	4.9	100.1
Georgia	17.0	24.3	38.7	7.1	8.9	4.0	100.0
Maine	97.8	2.2	0.0	0.0	0.0	0.0	100.0
Maryland	50.6	24.9	0.0	0.0	24.4	0.0	99.9
Massachusetts	87.0	13.0	0.0	0.0	0.0	0.0	100.0
New Hampshire	100.0	0.0	0.0	0.0	0.0	0.0	100.0
New Jersey	81.9	16.4	1.7	0.0	0.0	0.0	100.0
New York	9.8	87.9	0.0	2.2	0.0	0.0	99.9
North Carolina	29.0	24.5	41.9	3.3	0.0	1.3	100.0
Pennsylvania	60.4	36.4	0.0	2.0	0.0	1.1	99.9
Rhode Island	100.0	0.0	0.0	0.0	0.0	0.0	100.0
South Carolina	36.1	20.7	35.5	5.5	0.0	2.2	100.0
Vermont	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Virginia	46.6	53.4	0.0	0.0	0.0	0.0	100.0
West Virginia	88.7	0.0	0.0	11.3	0.0	0.0	100.0
<u>Atlantic Flyway</u>	34.0	26.0	29.0	4.0	4.0	3.0	100.0
Alabama	9.1	10.7	10.1	12.4	41.0	16.8	100.1
Arkansas	3.2	4.5	0.0	6.6	30.4	55.3	100.0
Illinois	0.0	0.0	0.0	10.1	0.0	89.9	100.0
Indiana	0.0	26.6	0.0	55.5	0.0	17.9	100.0
Iowa	0.0	0.0	0.0	0.0	0.9	99.1	100.0
Kentucky	7.4	0.0	0.0	15.1	65.6	11.9	100.0
Louisiana	1.8	2.8	2.8	13.1	34.9	44.6	100.0
Michigan	4.6	6.5	0.0	82.3	0.7	5.9	100.0

TABLE [illegible].--Continued

Harvest Area	Population-Unit Origin (%)[2]						
	Northeastern	New York - E. Canada	Southeastern	Lake States	Southern	North Central	Total Percent
Minnesota	0.0	0.0	0.0	1.4	0.0	98.6	100.0
Mississippi	0.6	13.3	4.1	12.3	39.9	29.9	100.1
Missouri	0.0	8.4	0.0	3.3	2.0	86.2	99.9
Ohio	2.4	8.5	0.0	84.6	0.0	4.4	99.9
Tennessee	5.5	1.8	20.3	15.1	34.3	22.8	99.8
Wisconsin	0.0	0.0	0.0	5.9	3.5	90.6	100.0
Mississippi Flyway	2.0	5.0	3.0	17.0	23.0	50.0	100.0
Texas	0.0	4.8	0.0	4.0	35.6	55.5	99.9
Central Flyway	0.0	4.8	0.0	4.0	35.6	55.5	99.9
Ontario	3.7	92.8	0.3	3.2	0.0	0.0	100.0
Quebec	29.4	70.6	0.0	0.0	0.0	0.0	99.9
Canada	9.0	88.0	T	3.2	0.0	0.0	100.2

[1]Expressed as a percent and based on weighted direct recoveries from bandings in May-September, 1950-68.

[2]Percentages less than 0.1% are indicated by T.

and immature wood ducks based on an average weighting factor for direct recoveries is shown in Table 14. Northern reference areas derived most of their immature (92 percent) and adult (88 percent) harvest from locally produced wood ducks, but southern areas derived only 40 percent of their harvest from native birds. Few wood ducks banded in the Southern and Southeastern Reference Areas were recovered in northern regions during the first hunting season after banding; conversely, more than 57 percent of the harvest in southern areas was composed of northern-banded wood ducks.

Harvest Timing

The monthly porportion of the wood duck harvest, as derived from all sources, occurring in each region and flyway is given in Tables 15 and 16. There is a general "flyway" pattern in which the harvest is highest in October (50.0 percent), drops in November (20.0 percent) and December (26.0 percent), and reaches a low in January (3.0 percent). Reference-area harvest periods vary from this flyway pattern as demonstrated by northern areas where the October harvest is very large (84.0 percent), a substantial drop occurs in November (15.0 percent) and December (0.6 percent), and practically no harvest occurs in January. In southern reference areas, virtually no harvest occurs in October, harvest is moderate in November (32.0 percent), with a peak in December (59.0 percent) and another low in January (8.0 percent).

TABLE 14.--Reference area derivation of harvest for adult and immature wood ducks banded May-September, 1950-68[1]

Harvested In	Population Unit Origin (%)													
	Northeastern		New York - E. Canada		Southeastern		Lake States		Southern		North Central		Total Percent	
	A	I	A	I	A	I	A	I	A	I	A	I	A	I
Northeastern	85.3	91.3	12.5	8.4	0.2	T[2]	1.0	T	0.6	0.0	0.4	0.2	100.0	100.0
New York-E.Canada	8.9	6.2	88.6	92.9	0.1	0.0	2.4	0.8	0.0	0.0	0.0	0.1	100.0	100.0
Southeastern	22.1	23.8	21.7	22.3	41.9	39.3	6.3	6.6	4.5	5.9	3.5	2.1	100.0	100.0
Lake States	2.9	3.4	11.0	3.2	0.0	0.0	78.0	91.0	0.3	0.5	7.8	1.9	100.0	100.0
Southern	2.7	5.4	6.1	4.8	4.2	2.3	10.5	12.4	36.1	39.4	40.4	35.7	100.0	100.0
North Central	0.0	T	0.9	1.4	0.0	0.0	4.4	3.8	1.5	0.4	93.2	94.3	100.0	100.0

[1] Expressed as a percent and based on weighted direct recoveries from bandings in May-September 1950-68.

[2] Percentages less than 0.1% are indicated by T for adults (A) and immatures (I).

TABLE 15.--Monthly occurrence of the harvest within a reference area or flyway (pertains only to the harvest of immature wood ducks bagged within reference area boundaries--based on 1962-68 harvest survey data)

Reference Area	Immature Male (%)						Immature Female (%)					
	Oct.	Nov.	Dec.	Jan.	Other[1]	Total (%)	Oct.	Nov.	Dec.	Jan.	Other	Total (%)
Northeastern	85.7	11.5	1.9	0.2	0.7	100.0	86.9	11.0	0.9	0.3	0.9	100.0
Southeastern	0.3	39.3	50.3	9.1	1.0	100.0	0.8	40.8	48.9	8.5	1.0	100.0
Atlantic Flyway	41.6	25.2	27.2	5.2	0.8	100.0	47.6	23.7	23.4	4.3	1.0	100.0
New York - E.Canada[2]	81.6	16.7	0.5	0.5	0.7	100.0	81.0	16.8	0.2	0.4	1.6	100.0
North Central	81.7	16.8	0.5	0.0	1.0	100.0	82.0	16.0	0.7	0.0	1.3	100.0
Lake States	83.0	15.2	0.4	0.1	1.3	100.0	80.5	18.1	0.2	0.1	1.1	100.0
Southern	0.0	24.8	67.8	6.4	1.0	100.0	0.0	25.7	65.7	7.6	1.0	100.0
Mississippi Flyway	50.2	20.0	26.2	2.6	1.0	100.0	56.2	19.0	20.7	2.8	1.3	100.0

[1] Non-hunting season months.

[2] Canadian data were lacking; therefore, only New York data were tabulated.

TABLE 16.--Monthly occurrence of the harvest within a reference area or flyway (pertains only to the harvest of adult wood ducks bagged within reference area boundaries--based on 1962-68 harvest survey data)

Reference Area	Adult Male (%)						Adult Female (%)					
	Oct.	Nov.	Dec.	Jan.	Other[1]	Total (%)	Oct.	Nov.	Dec.	Jan.	Other	Total (%)
Northeastern	86.7	10.8	1.5	0.4	0.8	100.0	84.1	14.4	1.1	0.1	0.3	100.0
Southeastern	0.5	38.1	50.6	10.0	0.8	100.0	1.3	39.1	50.4	8.1	1.1	100.0
<u>Atlantic Flyway</u>	34.3	26.1	32.2	6.8	0.6	100.0	37.4	27.1	29.4	5.1	1.0	100.0
New York - E.Canada[2]	85.2	14.0	0.0	0.0	0.8	100.0	77.4	21.6	0.0	0.0	1.0	100.0
North Central	81.7	15.5	0.5	1.0	1.3	100.0	81.4	17.8	0.2	0.0	0.6	100.0
Lake States	83.9	14.5	0.5	0.1	1.0	100.0	83.1	15.1	0.5	0.1	1.2	100.0
Southern	0.0	25.2	66.0	8.1	0.7	100.0	0.0	21.4	71.7	6.3	0.6	100.0
<u>Mississippi Flyway</u>	40.5	21.4	33.1	4.0	1.0	100.0	48.7	19.8	28.8	2.2	0.5	100.0

[1] Non-hunting season months.

[2] Canadian data were lacking; therefore, only New York data were tabulated.

The tendency for a larger percentage of the immatures to be harvested in northern reference areas has already been documented (Table 9). Harvest distribution differences between adult males and adult females are demonstrated in Table 17. In most instances, adult females were dominant in the October and combined October-November harvest, while adult males dominated the harvest during December-January periods ($X^2 = 12.35$; d.f. = 1; $p \leq 0.01$).

Direct Recovery Rates

Age and Sex Differences

Direct recovery rate estimates by age and sex for ten states are shown in Tables 18 and 19. When tested by a least squares analysis of variance test, there were significant differences in recovery rates among the four age-sex groups ($F = 20.34$: d.f. = 3,51; $p \leq 0.01$). Specific comparisons revealed that immatures had the highest recovery rates ($F = 35.10$: d.f. = 1,51; $p \leq 0.01$). Comparisons of adult males versus adult females and immature males versus immature females suggested important differences between sexes; males were more likely to be recovered ($F = 5.31$: d.f. = 1,51; $p \leq 0.05$ and $F = 20.02$: d.f. = 1,51; $p \leq 0.01$).

Population Differences

When tested by Chi-square procedures, data in Tables 18 and 19 suggest a higher proportion of band recoveries

TABLE 17.--Monthly distribution of harvest for adult wood ducks banded May-September, 1950-68[1]

Banded In	Age and Sex	Sept.	Oct.	Nov.	Dec.	Jan.	Total Percent	Total Recoveries
		Percent						
North Central	AM	0.1	43.2	18.2	33.4	5.1	100.0	958
	AF	0.6	45.0	24.1	28.0	2.3	100.0	481
Lake States	AM	0.7	36.7	20.4	36.0	6.2	100.0	275
	AF	0.6	45.3	19.4	30.0	4.7	100.0	170
New York-E.Canada	AM	7.7	51.1	14.4	21.1	5.7	100.0	209
	AF	4.3	60.6	16.0	12.8	6.3	100.0	94
Northeastern	AM	2.3	47.2	21.8	23.1	5.6	100.0	390
	AF	3.5	47.0	21.8	22.7	5.1	100.1	256
Northern Regions[2]	AM	2.4	44.9	18.5	28.8	5.5	100.1	1,832
	AF	2.1	49.0	21.0	23.7	4.2	100.0	1,001

[1]Based on weighted recoveries for adult males (AM) and adult females (AF).

[2]Weighted average of the four regions.

TABLE 18.--Direct recovery rates for immature wood ducks banded May-September, 1950-68

	Immature Male		Immature Female	
Banded In	Direct Recoveries	Direct Recovery Rate[1]	Direct Recoveries	Direct Recovery Rate
Alabama	48	.0445	17	.0204
Illinois	549	.0611	427	.0543
Indiana	129	.0598	82	.0438
Iowa	498	.0814	375	.0715
Louisiana	42	.0549	24	.0281
Michigan	106	.0914	56	.0663
Minnesota	231	.0678	170	.0650
Mississippi	35	.0411	13	. . .
Missouri	151	.0555	107	.0446
Ohio	263	.0734	200	.0651
Tennessee	227	.0471	201	.0417
Wisconsin	705	.0891	539	.0818
Mississippi Flyway	2,984	.0667	2,198	.0560
		(.0168)		(.0197)
Maine	146	.0972	110	.0920
Massachusetts	37	.0684	21	.0434
New York	348	.0764	271	.0692
Pennsylvania	15	.0857	11	. . .
South Carolina	112	.0493	41	.0258
Vermont	408	.0972	360	.0873
West Virginia	53	.0540	51	.0510
Atlantic Flyway	1,119	.0748	723	.0602
		(.0178)		(.0247)
Ontario	95	.0979	64	.0800

[1]Parenthesized numbers are standard deviations.

TABLE 19.--Direct recovery rates for adult wood ducks banded May-September, 1950-68

Banded In	Adult Male		Adult Female	
	Direct Recoveries	Direct Recovery Rate[1]	Direct Recoveries	Direct Recovery Rate
Alabama	22	.0374	17	.0333
Illinois	121	.0560	136	.0445
Indiana	79	.0447	38	.0329
Iowa	84	.0551	83	.0779
Louisiana	14	.0454	11	.0296
Michigan	126	.0568	34	.0537
Minnesota	229	.0501	47	.0357
Mississippi	10	.0279	10	.0188
Missouri	88	.0453	91	.0412
Ohio	70	.0499	98	.0445
Tennessee	65	.0453	46	.0340
Wisconsin	438	.0581	124	.0564
Mississippi Flyway	1,346	.0478	735	.0409
		(.0096)		(.0141)
Maine	115	.0634	30	.0521
Massachusetts	30	.0605	64	.0653
New York	118	.0610	68	.0549
Rhode Island	0	0	21	.0383
South Carolina	81	.0436	34	.0297
Vermont	187	.0815	94	.0674
West Virginia	21	.0654	20	.0483
Atlantic Flyway	552	.0606	331	.0512
		(.0101)		(.0120)
Ontario	86	.0680	23	.0652

[1]Parenthesized numbers are standard deviations.

for wood ducks banded in the Atlantic Flyway as compared to wood ducks of the Mississippi Flyway ($p \leq 0.01$), but flyway differences in the recovery of immature females were not significant ($p > 0.05$).

Reference area recovery rates by age and sex are summarized in Tables 20 and 21. Recovery rates for adults ranged from a low of 0.0258 in the Southern Region to a high of 0.0666 in the Northeastern Region. Immature rates varied from 0.0250 in the Southern Region to 0.0914 in the New York-Eastern Canada Region.

Tables 18 and 19 were also used to compare recovery rates for three geographical zones: Zone 1--states above 42° north latitude (Iowa, Maine, Massachusetts, Michigan, Minnesota, New York, Ontario, Vermont, and Wisconsin); Zone 2--states between 37° north and 42° north latitude; and Zone 3--states below 37° north latitude (Alabama, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee). Chi-square tests for each age-sex class were conducted to discern significant zonal differences in proportion of recovered birds. The proportion of recoveries for Zone 3 (southern states) were lower in every comparison with Zone 1 ($p \leq 0.01$), and again in every comparison with Zone 2 ($p \leq 0.01$) with the exception of adult males ($p > 0.20$). The proportion of recovered birds for Zone 1 (northern states) significantly exceeded the recoveries for Zone 2 and Zone 3 in every comparison ($p \leq 0.01$).

TABLE 20.--Weighted regional direct recovery rates for immature wood ducks banded May-September, 1950-68

Banded In	Immature Male		Immature Female	
	Direct Recoveries	Direct Recovery Rate[1]	Direct Recoveries	Direct Recovery Rate
North Central Region	2,134	.0726 (.0122)	1,618	.0665 (.0122)
Lake States Region	498	.0785 (.0136)	338	.0599 (.0099)
Southern Region	352	.0465 (.0053)	242	.0250 (.0064)
Mississippi Flyway	2,984	.0667 (.0126)	2,198	.0561 (.0166)
Northeastern Region	659	.0827 (.0160)	542	.0718 (.0216)
N.Y.-E. Canada Region	443	.0914 (.0099)	335	.0767 (.0050)
Southeastern Region[2]	112	.0493 (.0000)	41	.0258 (.0000)
Atlantic Flyway[3]	1,214	.0824 (.0137)	918	.0675 (.0178)

[1]Standard deviations are parenthesized.

[2]Only one state, South Carolina, was considered.

[3]Includes N.Y.-E. Canada Region.

TABLE 21.--Weighted regional direct recovery rates for adult wood ducks banded May-September, 1950-68

Banded In	Adult Male		Adult Female	
	Direct Recoveries	Direct Recovery Rate[1]	Direct Recoveries	Direct Recovery Rate
North Central Region	960	.0531 (.0046)	481	.0474 (.0123)
Lake States Region	275	.0519 (.0052)	170	.0460 (.0087)
Southern Region	111	.0357 (.0076)	84	.0258 (.0066)
Mississippi Flyway	1,346	.0478 (.0078)	735	.0409 (.0097)
Northeastern Region	353	.0666 (.0074)	229	.0568 (.0081)
N.Y.-E. Canada Region	204	.0659 (.0033)	91	.0620 (.0048)
Southeastern Region[2]	81	.0436 (.0000)	34	.0297 (.0000)
Atlantic Flyway[3]	638	.0636 (.0072)	354	.0567 (.0100)

[1]Standard deviations are parenthesized.

[2]Only one state, South Carolina, was considered.

[3]Includes N.Y.-E. Canada Region.

Vulnerability to Shooting

The relative vulnerability to shooting for age-sex classes is outlined by reference areas in Table 22. For adults and immatures, male wood ducks in every region were more vulnerable than females. Weighted flyway averages for the eastern United States show adult males as being 1.14 times more likely to be shot than adult females and immature males 1.20 times more vulnerable than immature females. The estimated relative vulnerability of immatures to adults in the eastern United States was 1.31.

Survival

Adults

Estimated annual and average annual survival rates for adult male and adult female wood ducks banded during the spring and summer 1960 through 1968 are presented for individual states in Table 23. Adult comparisons revealed a lower female survival rate when comparisons were made for ten states with adequate banding data ($t = 2.76$: d.f. = 9; $p \leq 0.05$). The lowest adult female survival was exhibited by Vermont (33.8 percent) and Wisconsin (37.4 percent), northern states whose native wood ducks were subjected to a procession of opening, hunting-season dates and continuous gunning pressures as they migrated south. Adult male survival lows were also prominent in northern areas; for example, Ontario (47.6 percent) and Vermont (48.0 percent).

Reference-area survival estimates for recent bandings

TABLE 22.--Relative vulnerability for different age and sex classes of wood ducks banded in breeding reference areas, 1950-68

Banded In	Direct Recovery Rates[1]						Relative Vulnerability		
	AM	AF	IM	IF	Ad.	Imm.	AM/AF	IM/IF	I/A
North Central Region	.0531	.0474	.0726	.0665	.0503	.0696	1.12	1.09	1.38
Lake States Region	.0519	.0460	.0785	.0599	.0490	.0692	1.13	1.31	1.41
Southern Region	.0357	.0258	.0465	.0250	.0308	.0357	1.38	1.86	1.16
Mississippi Flyway	.0478	.0409	.0667	.0561	.0444	.0614	1.17	1.19	1.38
Northeastern Region	.0666	.0568	.0827	.0718	.0617	.0773	1.17	1.15	1.25
N.Y.-E. Canada Region	.0659	.0620	.0914	.0767	.0640	.0841	1.06	1.19	1.31
Southeastern Region	.0436	.0297	.0493	.0258	.0366	.0376	1.47	1.91	1.02
Atlantic Flyway	.0636	.0567	.0824	.0675	.0602	.0750	1.12	1.22	1.24
All Regions	.0554	.0485	.0742	.0616	.0514	.0675	1.14	1.20	1.31

[1]A(Adults), I(Immatures), M(Males), F(Females).

TABLE 23.--Adult survival estimates for wood ducks banded May-September, 1960-67 (Atlantic Flyway states) and 1962-68 (Mississippi Flyway states)

State	Sex[2]	Annual Survival Rates[1] (%) 1960	1961	1962	1963	1964	1965	1966	1967	Avg. Survival (%)	No. Rec.
Alabama	M	. . .	. . .	. . .	. . .	. . .	. . .	44.4	. . .	44.4	31
		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	
Illinois	M	. . .	. . .	. . .	50.9	47.0	65.0	44.6	81.2	57.7	182
		(-)	(-)	(-)	(13.3)	(11.5)	(15.0)	(15.2)	(35.4)	(15.3)	
	F	. . .	. . .	87.8	21.3	57.5	63.5	32.9	55.3	53.0	194
		(-)	(-)	(30.1)	(6.6)	(15.6)	(17.2)	(12.3)	(26.6)	(23.5)	
Indiana	M	. . .	. . .	55.8	70.9	30.5	95.1	64.6	24.9	57.0	95
		(-)	(-)	(20.2)	(30.1)	(12.6)	(33.4)	(25.3)	(9.9)	(26.2)	
Iowa	M	. . .	. . .	42.1	56.2	36.5	56.8	61.1	. . .	50.5	141
		(-)	(-)	(17.5)	(15.4)	(11.8)	(16.8)	(19.7)	(-)	(10.6)	
	F	. . .	. . .	. . .	35.4	38.2	57.5	. . .	. . .	43.7	69
		(-)	(-)	(-)	(12.1)	(17.4)	(22.7)	(-)	(-)	(12.0)	
Maine	M	. . .	45.8	48.9	53.8	67.9	37.8	. . .	. . .	50.8	131
		(-)	(17.3)	(12.1)	(15.4)	(22.7)	(14.1)	(-)	(-)	(11.2)	
Michigan	M	. . .	. . .	57.9	37.9	41.0	61.1	45.7	44.1	47.9	133
		(-)	(-)	(25.7)	(15.8)	(14.2)	(16.8)	(14.6)	(12.6)	(9.4)	
Minnesota	M	. . .	. . .	53.5	54.4	53.0	59.5	56.5	49.0	54.3	360
		(-)	(-)	(11.0)	(10.3)	(10.9)	(12.8)	(11.6)	(9.6)	(3.5)	
	F	. . .	. . .	. . .	. . .	19.7	81.2	64.6	26.0	47.9	46
		(-)	(-)	(-)	(-)	(9.3)	(43.2)	(42.7)	(15.5)	(29.8)	

TABLE 23.--Continued

State	Sex[1]	Annual Survival Rates[1] (%) 1960	1961	1962	1963	1964	1965	1966	1967	Avg. Survival (%)	No. Rec.
Missouri	M	. . .	. . .	53.9	52.8	49.9	. . .	. . .	49.8	51.6	148
		(-)	(-)	(16.4)	(11.8)	(14.4)	(-)	(-)	(22.2)	(2.1)	
	F	. . .	. . .	78.8	40.2	49.5	. . .	. . .	49.6	54.5	117
		(-)	(-)	(25.1)	(11.0)	(15.0)	(-)	(-)	(26.4)	(16.8)	
New York	M	33.5	60.1	39.3	30.4	74.9	64.6	34.7	. . .	51.1	153
		(16.2)	(21.6)	(15.9)	(18.5)	(21.3)	(15.1)	(10.5)	(-)	(16.1)	
	F	. . .	. . .	. . .	. . .	75.3	39.0	41.8	. . .	52.0	36
		(-)	(-)	(-)	(-)	(35.0)	(20.5)	(22.4)	(-)	(20.2)	
Ohio	M	. . .	. . .	49.1	65.7	51.0	94.9	31.9	. . .	58.5	113
		(-)	(-)	(17.3)	(19.9)	(18.9)	(32.0)	(11.9)	(-)	(23.6)	
	F	. . .	. . .	63.1	41.0	40.5	55.7	53.1	35.4	48.1	126
		(-)	(-)	(20.9)	(16.0)	(15.8)	(20.7)	(19.2)	(15.7)	(10.7)	
Ontario	M	. . .	. . .	34.9	57.6	46.6	59.0	48.8	38.8	47.6	113
		(-)	(-)	(15.0)	(20.7)	(17.4)	(18.2)	(16.4)	(17.4)	(9.7)	
South Carolina	M	31.7	53.2	69.2	. . .	. . .	59.5	. . .	. . .	53.4	105
		(19.9)	(17.7)	(14.1)	(-)	(-)	(25.5)	(-)	(-)	(15.9)	
	F	36.1	. . .	76.9	. . .	. . .	. . .	. . .	. . .	56.5	35
		(17.8)	(-)	(28.6)	(-)	(-)	(-)	(-)	(-)	(28.8)	
Tennessee	M	. . .	. . .	37.3	70.2	63.2	63.3	50.5	66.4	58.5	104
		(-)	(-)	(15.8)	(15.6)	(23.6)	(22.5)	(18.8)	(25.2)	(12.3)	
	F	. . .	. . .	100.0	54.1	78.3	32.9	28.8	15.8	51.6	69
		(-)	(-)	(58.2)	(23.2)	(41.4)	(17.3)	(17.2)	(9.4)	(32.3)	

TABLE 25.--*Continued*

State	Sex[2]	Annual Survival Rates[1] (%) 1960	1961	1962	1963	1964	1965	1966	1967	Avg. Survival (%)	No. Rec.
Vermont	M	28.4	53.5	78.7	39.9	42.9	44.3	. . .	. . .	48.0	143
		(11.2)	(16.2)	(26.4)	(15.4)	(16.4)	(15.0)	(-)	(-)	(17.1)	
	F	19.6	. . .	. . .	. . .	22.9	46.0	46.7	. . .	33.8	54
		(10.3)	(-)	(-)	(-)	(14.4)	(19.3)	(20.4)	(-)	(14.6)	
Wisconsin	M	. . .	. . .	66.4	43.6	50.4	57.6	50.0	53.1	53.5	665
		(-)	(-)	(8.5)	(7.1)	(8.4)	(7.8)	(7.1)	(12.2)	(7.8)	
	F	. . .	. . .	47.0	51.6	41.8	27.2	19.8	37.2	37.4	170
		(-)	(-)	(11.8)	(18.8)	(18.6)	(10.0)	(7.8)	(19.4)	(12.1)	

[1]Parenthesized numbers are standard deviations.

[2]M (males), F (females).

are demonstrated in Table 24. Average, adult female survival rates ranged from 49.1 percent in the Northeastern Area to 74.7 percent in the Southeastern Area. Adult male rates were highest in the Southern Area (60.7 percent) and low in the Northeastern Area (52.1 percent).

Survival estimates for an early time span (1949 through 1962) are summarized in Table 25. The Northeastern Reference Area possessed survival data that allowed comparisons of recent and early survival rates. Statistical tests for adult males ($t = 0.035$: d.f. = 17; $p > 0.50$) and adult females ($t = 0.269$: d.f. = 12; $p > 0.50$) revealed no significant differences in survival between early and recent banding periods.

Summary of Adult Estimates

Early, recent, and selected recent survival rates calculated not only by weighting and averaging state estimates, but also by compiling all banding and recovery data pertaining to each reference area are summarized in Table 26. Based on selected recent-rate composite estimates, survival rates (with one standard error) for adult males and adult females of the Mississippi Flyway were 56.2 ($\pm$1.93) percent and 51.5 ($\pm$2.70) percent, respectively. Survival estimates for adult males and adult females of the Atlantic Flyway were 53.4 ($\pm$0.69) percent and 48.7 ($\pm$0.25) percent. Adult female estimates in the Atlantic Flyway were probably too low, due to a lack of survival

TABLE 24.--Reference area survival estimates for adult wood ducks banded May-September, 1960-68 (Atlantic Flyway) and 1962-69 (Mississippi Flyway)

Reference Area[1]	Sex[2]	Annual Survival Rates[3] (%) 1960	1961	1962	1963	1964	1965	1966	1967	1968	Avg. Survival (%)	No. Rec.
NE	M	48.0	49.8	55.2	60.1	54.1	44.4	46.6	58.8	. . .	52.1	449
		(13.4)	(9.4)	(9.2)	(12.0)	(11.6)	(9.0)	(11.3)	(19.7)	(-)	(5.8)	
	F	27.8	76.3	27.3	54.1	59.1	35.6	32.8	79.4	. . .	49.1	243
		(12.1)	(23.0)	(8.4)	(14.4)	(16.6)	(10.1)	(10.1)	(26.7)	(-)	(21.2)	
NY--E. Canada	M	17.4	85.5	35.5	67.0	51.8	63.4	44.1	57.6	. . .	52.8	326
		(10.3)	(24.1)	(9.7)	(17.8)	(12.2)	(11.1)	(9.1)	(16.4)	(-)	(20.8)	
	F	. . .	. . .	25.6	73.8	56.4	39.8	50.0	44.5	. . .	48.4	93
		(-)	(-)	(13.8)	(32.1)	(22.5)	(16.1)	(18.7)	(20.9)	(-)	(16.2)	
SE	M	28.4	58.1	67.4	. . .	. . .	42.5	77.8	. . .	. . .	54.8	88
		(17.4)	(17.1)	(13.2)	(-)	(-)	(18.0)	(33.3)	(-)	(-)	(19.7)	
	F	62.1	82.7	79.3	. . .	. . .	. . .	. . .	. . .	. . .	74.7	50
		(28.9)	(32.2)	(26.1)	(-)	(-)	(-)	(-)	(-)	(-)	(11.0)	
LS	M	. . .	. . .	52.2	59.4	42.8	78.3	48.5	37.9	. . .	53.2	363
		(-)	(-)	(11.1)	(12.1)	(8.7)	(13.5)	(9.4)	(7.7)	(-)	(14.4)	
	F	. . .	. . .	53.2	49.8	44.3	60.7	59.6	40.7	. . .	51.4	215
		(-)	(-)	(14.1)	(14.6	(12.2)	(15.1)	(15.5)	(12.8)	(-)	(8.0)	
NC	M	. . .	. . .	61.0	48.1	48.2	60.0	50.7	59.2	51.1	54.0	1,895
		(-)	(-)	(5.8)	(4.4)	(4.6)	(5.5)	(5.2)	(7.1)	(6.6)	(5.8)	
		. . .	. . .	60.8	34.4	48.6	54.8	41.8	43.7	45.5	47.1	745
		(-)	(-)	(9.4)	(4.7)	(7.5)	(8.4)	(7.4)	(9.3)	(9.8)	(8.0)	
S	M	. . .	. . .	37.4	53.2	82.7	53.0	51.5	86.5	. . .	60.7	212
		(-)	(-)	(13.55)	(16.00)	(23.75)	(13.02)	(11.77)	(24.65)	(-)	(17.8)	
	F	. . .	. . .	73.3	67.0	85.3	33.0	51.8	34.5	. . .	57.5	136
		(-)	(-)	(27.2)	(26.8)	(35.5)	(11.3)	(15.7)	(11.7)	(-)	(21.3)	

[1]NE (Northeastern), NY--E.Canada (New York--Eastern Canada), SE (Southeastern), LS (Lake States), NC North Central), S (Southern).

[2]M (males), F (females).

[3]Parenthesized numbers are standard deviations.

TABLE 25.--Reference area survival estimates for adult wood ducks banded May-September, 1949-60 (Atlantic Flyway) and 1958-62 (Mississippi Flyway)

Reference Area[1]	Sex[2]	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	Avg. Survival (%)	No. Rec.
		Annual Survival Rates[3] (%)														
NE	M	44.3	47.3	72.7	24.6	62.1	33.7	53.6	59.0	40.9	57.8	69.6	. . .	. . .	52.3	317
		(14.4)	(15.1)	(24.2)	(7.9)	(14.2)	(9.6)	(20.3)	(17.8)	(11.5)	(17.6)	(21.2)	(-)	(-)	(15.3)	
	F	. . .	. . .	. . .	57.7	44.6	46.3	37.7	61.8	57.4	. . .	. . .	. . .	. . .	51.0	159
		(-)	(-)	(-)	(21.7)	(13.7)	(14.7)	(22.1)	(21.6)	(20.4)	(-)	(-)	(-)	(-)	(9.4)	
LS	M	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	100.0	44.3	43.3	94.9	70.6	170
		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(39.1)	(13.7)	(11.2)	(19.6)	(21.0)	
	F	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	33.8	54.0	40.6	42.8	93
		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(18.2)	(19.1)	(12.6)	(10.3)	
NC	M	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	68.5	47.7	47.7	73.6	59.4	449
		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(27.0)	(11.7)	(8.0)	(8.6)	(13.6)	
	F	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	43.3	71.3	31.9	63.7	52.6	167
		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(20.4)	(25.4)	(11.8)	(13.1)	(18.1)	

[1]NE (Northeastern), LS (Lake States), NC (North Central).

[2]M (male), F (female).

[3]Parenthesized numbers are standard deviations.

TABLE [illegible]6.--Reference area and flyway survival estimates for adult wood ducks banded and recovered during early and recent years[1]

Reference Area	Sex	Average Survival Rates[2] (%) Early	Average Survival Rates (%) Recent	Average Survival Rates (%) Selected Recent[3]	Composite Survival Rates[4] (%) Early	Composite Survival Rates (%) Recent	Composite Survival Rates (%) Selected Recent
North Central	M	43.0(2)	53.7(5)	53.4(3)	59.4(5)	54.0(5)	54.0(5)
	F	- (-)	45.6(5)	44.7(3)	52.6(5)	47.1(5)	47.1(5)
Lake State	M	- (-)	52.8(3)	52.5(3)	70.6(3)	53.2(3)	53.2(3)
	F	- (-)	48.1(1)	50.7(1)	42.8(3)	51.4(3)	51.4(3)
Southern	M	- (-)	51.4(2)	58.5(1)	- (-)	60.7(7)	60.7(7)
	F	- (-)	51.6(1)	- (-)	- (-)	57.5(7)	57.5(7)
<u>Mississippi Flyway</u>	M	43.0(2)	53.2(10)	53.4(9)	62.6(8)	56.2(15)	56.2(15)
	F	- (-)	46.0(7)	45.5(4)	49.8(8)	51.5(15)	51.5(15)
New York--E.Canada	M	- (-)	48.6(2)	48.6(2)	- (-)	52.8(3)	52.8(3)
	F	- (-)	52.0(1)	52.0(1)	- (-)	48.4(3)	48.4(3)
Northeastern	M	45.2(1)	49.9(2)	49.9(2)	52.3(11)	52.1(11)	52.1(11)
	F	42.0(1)	33.8(1)	33.8(1)	51.0(11)	49.1(11)	49.1(11)
Southeastern	M	- (-)	54.0(1)	54.0(1)	- (-)	54.8(5)	54.8(5)
	F	- (-)	56.5(1)	56.5(1)	- (-)	74.7(5)	- (-)
<u>Atlantic Flyway</u>	M	45.2(1)	49.5(5)	49.5(5)	52.3(11)	53.4(19)	53.4(19)
	F	42.0(1)	50.4(3)	50.4(3)	51.0(11)	59.8(19)	48.7(14)

[1] 1960-67 seasons in Atlantic Flyway areas and 1962-68 seasons in Mississippi Flyway areas for M(males) and F(females).

[2] A weighted average obtained by averaging rates from component states of each area (number of states are parenthesized).

[3] Selected rates were restricted to states or areas with three or more years of survival rates (data with a coefficient of variations exceeding 40% also excluded).

[4] Rates obtained by using all banding and recovery data from a reference area.

data for the Southeastern Reference Area.

Immatures

Immature survival rates for wood ducks banded and recovered during 1960 through 1968 are listed for individual states in Table 27. A comparison of average survival rates among 10 states possessing the most abundant banding and recovery data revealed no significant differences between immature female and immature male survival rates ($t = -1.60$: d.f. = 9; $p > 0.10$). The lowest immature rates were in New York (33.0 percent), Ontario (36.7 percent), and Vermont (26.4 percent). Immature comparisons by reference areas also demonstrated similar rates for each sex (Table 28).

Immature survival estimates for an early time period (1950 through 1962) are presented in Table 29. Comparisons between early and recent survival rates of the Northeastern Reference Area disclosed no significant differences between time periods for males ($t = -1.58$: d.f. = 16; $p > 0.10$) or females ($t = 0.22$: d.f. = 16; $p > 0.50$).

Summary of Immature Estimates

Presented in Table 30 are reference-area and flyway survival estimates calculated not only by weighting and averaging state estimates but also by using a composite of all banding and recovery data for each reference area. Based on weighted averages of the selected-recent column, composite survival estimates (with one standard error) for

TABLE [illegible].--Immature survival estimates for wood ducks banded May-September, 1960-68 (Atlantic Flyway states) and 1962-68 (Mississippi Flyway states)

Banded In	Sex[2]	Annual Survival Rates (%)[1] 1960	1961	1962	1963	1964	1965	1966	1967	Avg. Survival (%)	No Rec.
Illinois	M	. . .	. . .	60.8	48.0	30.6	39.0	36.5	67.4	47.0	755
		(-)	(-)	(13.0)	(9.2)	(6.2)	(7.6)	(10.8)	(23.6)	(14.5)	
	F	. . .	. . .	64.2	37.6	45.2	58.8	41.8	44.9	48.8	547
		(- _	(-)	(16.4)	(7.6)	(11.6)	(11.7)	(13.5)	(19.2)	(10.4)	
Indiana	M	. . .	. . .	42.2	71.2	17.6	55.6	60.0	22.9	45.0	135
		(-)	(-)	(14.0)	(29.2)	(9.5)	(20.4)	(33.0)	(10.6)	(21.3)	
	F	. . .	. . .	100.0	. . .	25.4	. . .	. . .	17.9	47.8	49
		(-)	(-)	(49.1)	(-)	(14.9)	(-)	(-)	(14.4)	(45.4)	
Iowa	M	. . .	. . .	57.8	36.5	30.5	39.1	37.7	52.9	42.4	663
		(-)	(-)	(10.5)	(9.5)	(8.2)	(8.5)	(11.1)	(23.2)	(10.6)	
	F	. . .	. . .	50.7	35.1	. . .	56.2	. . .	. . .	47.3	276
		(-)	(-)	(10.6)	(9.6)	(-)	(12.9)	(-)	(-)	(10.9)	
Michigan	M	. . .	. . .	53.6	. . .	41.5	13.9	52.0	42.1	40.6	76
		(-)	(-)	(35.4)	(-)	(19.5)	(10.0)	(23.0)	(18.1)	(15.9)	
Minnesota	M	. . .	. . .	41.5	29.3	41.3	58.3	20.0	30.3	36.8	223
		(-)	(-)	(14.3)	(10.7)	(15.5)	12.2)	(8.4)	(12.0)	(13.3)	
	F	. . .	. . .	58.8	64.5	25.6	47.1	68.9	. . .	53.0	140
		(-)	(-)	(33.8)	(22.5)	(13.5)	(20.2)	(35.2)	(-)	(17.4)	

TABLE 27.--Continued

Banded In	Sex[2]	Annual Survival Rates (%)[1] 1960	1961	1962	1963	1964	1965	1966	1967	Avg. Survival (%)	No. Rec.
Missouri	M	. . .	. . .	69.6	66.4	40.0	. . .	16.2	59.5	50.3	185
		(-)	(-)	(19.1)	(16.2)	(11.6)	(-)	(12.3)	(20.1)	(22.3)	
	F	. . .	. . .	. . .	23.4	45.6	27.2	78.0	. . .	43.6	105
		(-)	(-)	(-)	(10.2)	(14.3)	(16.9)	(33.5)	(-)	(24.9)	
New York	M	46.8	27.7	22.1	30.0	50.5	40.7	16.7	. . .	33.5	263
		(14.6)	(10.4)	(9.8)	(13.6)	(12.6)	(11.2)	(6.4)	(-)	(12.8)	
	F	. . .	. . .	. . .	20.5	26.6	39.0	45.8	. . .	33.0	123
		(-)	(-)	(-)	(10.4)	(13.0)	(15.5)	(18.5)	(-)	(11.5)	
Ohio	M	. . .	. . .	. . .	42.8	25.8	66.2	35.8	. . .	42.6	196
		(-)	(-)	(-)	(13.0)	(10.3)	(21.1)	(12.4)	(-)	(17.2)	
	F	. . .	. . .	30.2	52.4	45.7	69.7	51.2	33.6	47.1	220
		(-)	(-)	(11.2)	(19.8)	(17.3)	(25.3)	(17.8)	(13.7)	(14.3)	
Ontario	M	. . .	. . .	25.4	. . .	27.1	37.0	9.6	84.3	36.7	87
		(-)	(-)	(15.0)	. . .	(13.2)	(17.2)	(7.2)	(36.9)	(28.4)	
South Carolina	M	. . .	79.5	74.9	. . .	. . .	86.8	61.0	. . .	75.6	175
		(-)	(17.3)	(16.6)	(-)	(-)	(26.1)	(23.3)	(-)	(10.9)	
	F	. . .	. . .	73.1	. . .	. . .	44.6	. . .	. . .	58.8	44
		(-)	(-)	(25.6)	(-)	(-)	(20.6)	(-)	(-)	(20.2)	
Tennessee	M	. . .	. . .	40.3	60.9	45.8	53.2	57.6	44.6	50.4	378
		(-)	(-)	(13.4)	(16.6)	(13.5)	(15.9)	(16.8)	(15.9)	(8.1)	
	F	. . .	. . .	99.2	56.3	58.6	48.4	67.3	29.1	59.8	304
		(-)	(-)	(34.7)	(20.9)	(25.8)	(16.7)	(24.1)	(11.9)	(23.2)	

TABLE 27.--Continued

Banded In	Sex[2]	Annual Survival Rates (%)[1] 1960	1961	1962	1963	1964	1965	1966	1967	Avg. Survival (%)	No. Rec.
Vermont	M	27.1	24.0	20.2	45.4	55.9	40.6	13.3	9.7	29.5	254
		(8.2)	(10.5)	(12.3)	(17.2)	(16.0)	(13.6)	(7.3)	(6.2)	(16.3)	
	F	14.7	. . .	. . .	27.9	59.6	15.8	22.1	18.4	26.4	189
		(5.6)	(-)	(-)	(12.0)	(21.3)	(7.4)	(11.5)	(11.1)	(16.9)	
Wisconsin	M	. . .	. . .	43.2	37.0	41.7	33.7	. . .	29.6	37.0	574
		(-)	(-)	(10.4)	(8.0)	(7.1)	(6.0)	(-)	(6.8)	(5.6)	
	F	. . .	. . .	35.9	56.8	56.8	45.0	21.2	23.8	39.9	584
		(-)	(-)	(12.0)	(20.3)	(17.9)	(9.4)	(6.6)	(9.4)	(15.6)	

[1]Parenthesized numbers are standard deviations.

[2]M(males), F(females).

TABLE 25.--Reference area survival estimates for immature wood ducks banded May-September, 1960-69 (Atlantic Flyway) and 1962-69 (Mississippi Flyway)

Reference Area	Sex[2]	Annual Survival Rates (%)[1] 1960	1961	1962	1963	1964	1965	1966	1967	1968	Avg. Survival (%)	No. Rec.
Northeastern	M	28.8	38.5	32.1	48.9	63.1	40.3	22.7	38.1	40.7	39.2	553
		(7.9)	(8.9)	(7.5)	(11.3)	(12.3)	(8.8)	(7.1)	(11.8)	(13.9)	(11.7)	
	F	29.0	53.5	22.4	35.0	72.8	19.3	25.6	18.4	37.7	34.9	445
		(9.3)	(15.5)	(8.0)	(10.5)	(18.1)	(6.7)	(8.4)	(7.5)	(14.4)	(17.9)	
New York -- E. Canada	M	42.8	29.6	23.1	27.3	43.8	37.8	17.9	59.4	43.3	36.1	499
		(12.4)	(10.4)	(7.6)	(9.8)	(9.3)	(8.7)	(5.3)	(15.9)	(14.8)	(12.8)	
	F	34.6	34.1	14.0	40.2	27.5	42.8	37.8	49.4	. . .	35.0	338
		(24.0)	(14.0)	(6.1)	(15.6)	(10.7)	(13.1)	(12.3)	(19.1)	. . .	(10.7)	
Southeastern	M	. . .	75.4	67.5	79.2	57.6	89.2	81.4	. . .	. . .	75.0	278
		. . .	(15.7)	(14.0)	(36.7)	(27.4)	(23.5)	(30.7)	. . .	. . .	(11.1)	
	F	. . .	22.8	87.8	51.4	. . .	62.4	. . .	. . .	. . .	56.1	89
		. . .	(12.0)	(27.4)	(26.4)	. . .	(23.9)	. . .	. . .	. . .	(26.9)	
Lake States	M	. . .	. . .	45.5	52.2	28.8	. . .	50.0	30.8	. . .	41.5	457
		. . .	. . .	(9.2)	(10.7)	(6.9)	. . .	(10.1)	(6.5)	. . .	(10.9)	
	F	. . .	. . .	47.9	. . .	43.4	51.7	44.8	32.5	. . .	44.1	295
		. . .	. . .	(11.4)	. . .	(11.9)	(12.9)	(12.3)	(10.3)	. . .	(7.2)	
North Central	M	. . .	. . .	54.9	42.7	36.2	44.7	34.0	43.3	40.4	42.3	2,952
		. . .	. . .	(5.2)	(4.2)	(3.5)	(3.9)	(3.7)	(5.1)	(5.4)	(6.8)	
	F	. . .	. . .	53.4	41.8	43.2	56.2	40.7	51.2	35.7	46.0	2,169
		. . .	. . .	(6.7)	(5.0)	(6.1)	(6.3)	(6.2)	(8.6)	(7.0)	(7.6)	
Southern	M	. . .	. . .	40.8	56.8	59.4	47.6	66.6	64.9	. . .	56.0	593
		. . .	. . .	(10.3)	(12.9)	(13.6)	(10.7)	(12.6)	(17.5)	. . .	(10.1)	
	F	. . .	. . .	90.1	68.3	80.8	41.3	62.9	39.5	. . .	63.8	410
		. . .	. . .	(24.0)	(23.0)	(25.8)	(11.1)	(15.4)	(11.7)	. . .	(20.5)	

[1] Parenthesized numbers are standard deviations.

[2] M(males), F(females).

TABLE 29.--Reference area survival estimates for immature wood ducks banded May-September, 1950-60 (Atlantic Flyway) and 1958-62 (Mississippi Flyway)

Reference Area	Sex[2]	Annual Survival Rates[1] (%) 1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	Avg. Survival (%)	No. Rec.
North-eastern	M	17.9	57.5	29.0	25.4	21.6	35.3	27.9	21.8	. . .	37.4	. . .	. . .	30.4	483
		(6.3)	(18.3)	(6.8)	(6.3)	(6.7)	(10.2)	(10.0)	(7.0)	. . .	(13.2)	. . .	. . .	(12.0)	
	F	. . .	28.8	42.2	41.7	41.5	43.2	48.6	40.5	47.1	41.7	. . .	. . .	41.7	402
		. . .	(9.2)	(13.6)	(11.1)	(12.7)	(11.8)	(18.4)	(14.7)	(19.6)	(17.3)	. . .	. . .	(5.6)	
New York--E. Canada	M	. . .	. . .	24.0	25.6	. . .	. . .	. . .	. . .	. . .	65.9	. . .	. . .	38.5	62
		. . .	. . .	(9.9)	(10.0)	. . .	. . .	. . .	. . .	. . .	(32.8)	. . .	. . .	(23.7)	
	F	. . .	. . .	27.6	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	27.6	12
		. . .	. . .	(12.2)	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	(-)	
Lake States	M	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	31.7	25.7	44.8	70.8	43.3	137
		. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	(18.9)	(12.0)	(12.9)	(15.2)	(20.0)	
	F	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	45.9	97.2	36.7	59.9	69
		. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	(24.6)	(31.9)	(11.9)	(32.6)	
North Central	M	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	54.9	48.2	38.1	58.5	49.9	493
		. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	(17.5)	(8.8)	(5.4)	(7.0)	(8.9)	
	F	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	35.8	91.5	. . .	35.4	54.2	194
		. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	(15.9)	(26.2)	. . .	(6.9)	(32.3)	

[1]Parenthesized numbers are standard deviations.

[2]M(males), F(females).

TABLE [illegible].--Reference area and flyway survival estimates for immature wood ducks banded and recovered during early and recent years[1]

Reference Area	Sex	Average Survival Rates (%)[2] Early	Average Survival Rates (%)[2] Recent	Average Survival Rates (%)[2] Selected Recent[3]	Composite Survival Rates (%)[4] Early	Composite Survival Rates (%)[4] Recent	Composite Survival Rates (%)[4] Selected Recent
North Central	M	47.4(2)	40.3(5)	41.1(5)	49.9(5)	42.3(5)	42.3(5)
	F	41.6(2)	47.0(5)	43.7(3)	54.2(5)	46.0(5)	46.0(5)
Lake States	M	- (-)	42.3(3)	42.6(1)	43.3(3)	41.5(3)	41.5(3)
	F	24.4(1)	47.5(2)	47.1(1)	59.9(3)	44.1(3)	44.1(3)
Southern	M	- (-)	50.4(1)	50.4(1)	- (-)	56.0(7)	56.0(7)
	F	- (-)	59.8(1)	60.1(1)	- (-)	63.8(7)	63.8(7)
Mississippi Flyway	M	47.4(2)	41.1(9)	41.7(7)	48.0(8)	46.5(15)	46.5(15)
	F	38.6(3)	47.3(8)	44.6(7)	55.8(8)	51.3(15)	51.3(15)
New York--E.Canada	M	36.4(1)	35.7(2)	36.5(1)	38.5(3)	36.1(3)	36.1(3)
	F	26.9(1)	33.0(1)	- (-)	27.6(3)	35.0(3)	35.0(3)
Northeastern	M	24.1(1)	29.5(1)	42.2(1)	30.4(11)	39.2(11)	39.2(11)
	F	49.6(1)	26.4(1)	- (-)	41.7(11)	34.9(11)	34.9(11)
Southeastern	M	- (-)	75.6(1)	75.6(1)	- (-)	75.0(5)	- (-)
	F	- (-)	- (-)	- (-)	- (-)	56.1(5)	- (-)
Atlantic Flyway	M	32.8(2)	41.1(4)	52.8(3)	34.4(14)	52.2(19)	37.8(14)
	F	33.6(2)	41.9(3)	- (-)	34.8(14)	43.4(19)	34.9(14)

[1]1960-67 seasons in Atlantic Flyway areas and 1962-68 seasons in Mississippi Flyway areas for M(males) and F(females).

[2]A weighted average obtained by averaging rates from component states of each area (number of states are parenthesized).

[3]Selected rates were restricted to states or areas with three or more years of survival rates (data with a coefficient of variation exceeding 40% were also excluded).

[4]Rates obtained by using all banding and recovery data from a reference area.

the Mississippi Flyway were 46.5 (±3.77) percent for immature males and 51.3 (±4.98) percent for immature females. Similarly, composite estimates in the Atlantic Flyway were 37.8 (±1.10) percent for immature males and 34.9 (±0.35) percent for immature females. Immature survival rates for the Southeastern Area could not be determined; therefore, the Atlantic Flyway estimates were probably too low. In all survival comparisons between immatures and adults, immatures demonstrated lower survival rates ($F = 25.71$: d.f. = 1,26; $p \leq 0.01$).

Geographical Differences

In order to test the hypotheses that survival rates differed by geographical regions, comparisons were made for states above and below 42° north latitude. There were significant differences (t test: $p \leq 0.05$) in mean survival between geographical regions for all age-sex classes except immature females ($p > 0.05$). States above 42° north latitude with adequate data for survival estimates (Iowa, Maine, Michigan, Minnesota, New York, Ontario, Vermont, and Wisconsin) had lower survival rates than states farther south (Illinois, Indiana, Missouri, Ohio, South Carolina, and Tennessee).

Mortality Due to Hunting

An estimate of the influence of hunting mortality in relation to other death causes was obtained by comparing

average annual mortality rates with kill rates (Table 31). Reporting rates were assumed to be 28.0 percent and crippling loss 25.0 percent; therefore, the annual recovery rate in Table 31 was multiplied by 4.76 to give an estimate of total hunting kill.

A greater percentage of the adult male (58.3 percent) and immature male (59.4 percent) loss, as compared to adult females (44.0 percent) and immature females (51.4 percent), was due to hunting. Of special interest is the high non-hunting mortality loss of adult females (29.4 percent).

Age and Sex Composition

Indirect population estimates derived from simultaneous equations suggested that immatures averaged 53.7 percent of the preseason population or an age ratio of 1.2 immatures per adult. Another estimate of age ratios was obtained by adjusting annual age ratios in the harvest to those in the preseason population (Table 32). This procedure described by Geis (1972) produced an average 1962 through 1968 ratio of 1.34 immatures per adult.

The estimated sex ratio of adult wood ducks in the 1962 through 1968 preseason population was 1.13 adult males per adult female. The sex ratio of immature wood ducks was also calculated as 1.19 males per female.

Average Survival and Productivity

Wood duck populations will increase, decline, or remain relatively stationary depending upon the extent to

TABLE 31.--Estimate of the proportion of wood duck mortality in eastern North America due to hunting[1]

	Immature		Adult	
	Male	Female	Male	Female
Average annual mortality rate	0.594	0.570	0.453	0.525
Average annual recovery rate	0.074	0.061	0.055	0.048
Average total kill rate[2]	0.353	0.293	0.264	0.231
Average non-hunting mortality rate	0.241	0.277	0.189	0.294
Proportion of total deaths due to hunting	0.594	0.514	0.583	0.440

[1]Based on preseason bandings during the 1950-68 period.

[2]Assumes 0.28 of banded birds shot were reported and 0.25 of birds killed were not retrieved; therefore, to account for unreported and unretrieved kill, reported recovery rates were multiplied by 4.76. That is for every 1,000 birds reported, 4,760 were actually killed (1,000/0.28 = 3,571; 3,571/0.75 = 4,762; and 4,762/1,000 = 4.76).

TABLE 32.--Annual age ratios of wood ducks in the eastern United States for the years 1962-68

Year	Relative Vulnerability Immature/Adult	Age Ratio Harvest Immature/Adult	Age Ratio Population[1] Immature/Adult
1962	1.27	1.23	0.96
1963	1.03	1.66	1.61
1964	1.10	1.82	1.65
1965	1.21	2.14	1.77
1966	1.09	1.18	1.08
1967	1.25	1.66	1.33
1968	1.15	1.42	1.23

[1]Determined by dividing age ratio in harvest by relative vulnerability.

which productivity matches mortality. The estimated annual survival of adult females averaged 50.2 percent as compared to 45.5 percent for immature females. With these survival statistics, approximately 1.10 immature females per adult female must have been alive at time of banding in order to maintain population stability in eastern North America. The average 1962 through 1968 preseason ratio of immature females per adult female was 1.14. This was determined by dividing age ratios in the 1962 through 1968 harvest by appropriate relative recovery rates to obtain a ratio in the preseason population. The calculated ratio of 1.14 immature females per adult female indicates that wood duck populations were slightly increasing during the 1962 through 1968 period.

Hunting Regulations

Harvest

Selected regulation factors and a harvest index corresponding to 1962 through 1968 hunting seasons of the Mississippi Flyway are shown in Table 33. Factors believed to influence numbers harvested were: (1) number of active hunters; (2) daily bag limits for wood ducks, mallards, and other ducks; (3) total number of hunting days in a flyway; (4) total number of October hunting days; and (5) number of wood ducks available to be harvested.

The fewest number of active hunters, lowest total number of flyway hunting days, and the most restrictive bag

TABLE 33.--Hunting regulations and corresponding harvest indices for 1962-68 hunting seasons of the Mississippi Flyway

Year	Season Length[1]	October Days[2]	Active Hunters (Thousands)	Daily Bag Limits[3]			Wood Duck Harvest (Thousands)	PPI (Thousands)[4]	Harvest index[5]
				Wood Duck	Mallard	Ducks			
1962	25(350)	10.5(84)	371.4	2.0	1.0	2.0	157.6	2,106.4	.08
1968	29(400)	9.5(76)	694.4	2.0	1.0	3.0	312.7	2,871.6	.11
Average	27(375)	10.0(80)	532.9	2.0	1.0	2.5	235.2	2,489.0	.10
1963	34(481)	13.5(108)	520.1	2.0	2.0	4.0	359.8	2,512.3	.15
1964	38(548)	12.8(102)	628.8	2.0	2.0	4.0	314.5	2,484.5	.12
1965	39(552)	11.8(94)	624.0	2.0	1.0	4.0	352.2	2,761.2	.13
Average	37(527)	12.7(101)	590.9	2.0	1.7	4.0	342.2	2,586.0	.13
1966	44(622)	13.8(110)	745.8	2.0	2.0	4.0	468.7	3,266.5	.15
1967	40(553)	12.8(102)	704.8	1.0	2.0	4.0	325.8	2,349.2	.14
Average 1962-68	37(519)	12.3(98.2)	612.8	1.8	1.6	3.6	343.0	2,621.7	.13

[1]Season length expressed as an average for Mississippi Flyway states. Parenthesized numbers represent the total number of hunting days in the flyway.

[2]Average number of hunting days in October for the North Central and Lake State regions. Parenthesized numbers represent the total number of October hunting days in the flyway.

[3]Exceptions: 1967, 2 wood ducks in Alabama and Mississippi - 1968, 2 mallards in Arkansas.

[4]Preseason population index for eastern U. S. and Canada based on data from U. S. Fish and Wildlife Service.

[5]Estimated harvest divided by PPI.

limits where in 1962 when the harvest index was only 0.08. Conversely, 1966 demonstrated the highest harvest index (0.15), the largest number of active hunters, an increased season length, the most October hunting days, and a more liberal duck bag limit.

A comparison of three increasingly liberal hunting regulation periods revealed increases in the harvest index (0.10 to 0.15) as regulations become more lax (Table 33).

Direct Recovery Rates

Table 34 was constructed to show the relationship of direct recovery rates and hunting regulations of the North Central Reference Area. In every comparison for different age and sex classes, direct recovery rates were lowest in the two most restrictive hunting seasons, 1962 and 1968, and highest in 1966 when regulations were most liberal.

Although banded samples of wood ducks were usually too small to show annual differences in recovery rates as related to hunting regulations, comparisons were possible when years with similar regulations were combined (Table 35). In 47 immature male and 45 immature female comparisons, direct recovery rates increased 40 times in direct relation to increases in liberalization of hunting regulations (significant at 0.01, Sign Test). Direct recovery rates were also greater for adult males (15 of 16 comparisons) and adult females (6 of 6 comparisons) when regulations were changed from restrictive to liberal (significant

TABLE 34.--Comparisons of wood duck direct recovery rates and hunting regulations in the North Central Area, 1962-68

Reference Area and Banding Year	Direct Recoveries				Direct Recovery Rates[1]				Total Days[2]	Total Days Flyway Average[3]	Bag Limit[4]
	AM	AF	IM	IF	AM	AF	IM	IF			
North Central											
1962	68	22	112	63	.0361	.0338	.0655	.0525	25(9.8)	25(350)	2.0(2)
1963	248	129	289	196	.0739	.0575	.0817	.0712	34(14.0)	34(481)	2.0(4)
1964	112	87	293	231	.0531	.0592	.0842	.0824	39(12.8)	38(548)	2.0(4)
1965	102	24	298	247	.0514	.0381	.0717	.0683	40(12.0)	39(552)	2.0(4)
1966	161	95	422	316	.0731	.0692	.1091	.0921	45(15.0)	44(622)	2.0(4)
1967	97	46	308	246	.0474	.0492	.0702	.0655	40(12.8)	40(553)	1.2(4)
1968	61	21	144	109	.0365	.0252	.0550	.0452	29(8.2)	29(400)	2.0(3)

[1]Weighted rates.

[2]Season length expressed as an average for reference area. Parenthesized numbers represent the average number of hunting days in October for the North Central Region.

[3]Flyway average obtained by summing and averaging season lengths of all states in the Mississippi Flyway. Parenthesized digits represent the sum total of hunting days within the Mississippi Flyway.

[4]Shows the average wood duck limit for states in the Mississippi Flyway. Parenthisized numbers reveal the average duck limit for states within the flyway.

TABLE 35.--**Comparison** of direct recovery rates and hunting regulations for wood ducks banded in selected states, 1962-68

Banded In	Banding Data				Regulations[1]		
	Age	Years	Number Recovered	Direct Recovery Rate	Season Length (days)[2]	October Days[3]	Daily Bag Limit (ducks)
Illinois	IM[4]	1962,68	56	0.0410	27 (375)	80	2-3
		1967	56	0.0550	40 (553)	102	4
		1963-65	231	0.0612	37 (527)	101	4
		1966	143	0.0784	44 (622)	110	4
	IF	1962,68	45	0.0378	27 (375)	80	2-3
		1967	39	0.0448	40 (553)	102	4
		1963-65	190	0.0566	37 (527)	101	4
		1966	111	0.0665	44 (622)	110	4
	AM	1963-65	59	0.0581	37 (527)	101	4
		1966	33	0.0892	44 (622)	110	4
	AF	1963-65	70	0.0503	37 (527)	101	4
		1966	37	0.0557	44 (622)	110	4
Indiana	IM	1962,68	25	0.0439	27 (375)	80	2-3
		1967	11	0.0421	40 (553)	102	4
		1963-65	50	0.0772	37 (527)	101	4
	IF	1968	14	0.0355	29 (400)	76	3
		1964-65	24	0.0632	38 (550)	98	4

TABLE 35.--Continued

	Banding Data				Regulations[1]		
Banded In	Age	Years	Number Recovered	Direct Recovery Rate	Season Length (days)[2]	October Days[3]	Daily Bag Limit (ducks)
Iowa	IM	1962,68	56	0.0559	27 (375)	80	2-3
		1967	68	0.0659	40 (553)	102	4
		1963-65	262	0.1007	37 (527)	101	4
		1966	70	0.0888	44 (622)	110	4
	IF	1962,68	45	0.0497	27 (375)	80	2-3
		1967	61	0.0672	40 (553)	102	4
		1963-65	177	0.0809	37 (527)	101	4
		1966	59	0.0882	44 (622)	110	4
	AM	1963-65	51	0.0644	37 (527)	101	4
		1966	16	0.0721	44 (622)	110	4
	AF	1963-64	42	0.0925	36 (514)	105	4
		1966	19	0.1098	44 (622)	110	4
Minnesota	IM	1962,68	71	0.0644	27 (375)	80	2-3
		1967	22	0.0673	40 (553)	102	4
		1963-65	71	0.0764	37 (527)	101	4
		1966	44	0.1164	44 (622)	110	4
	IF	1962,68	48	0.0585	27 (375)	80	2-3
		1967	17	0.0437	40 (553)	102	4
		1963-65	48	0.0644	37 (527)	101	4
		1966	36	0.1014	44 (622)	110	4

TABLE 35.--Continued

Banded In	Banding Data				Regulations[1]		
	Age	Years	Number Recovered	Direct Recovery Rate	Season Length (days)[2]	October Days[3]	Daily Bag Limit[4] (ducks)
Minnesota	AM	1962,68	41	0.0346	27 (375)	80	2-3
		1967	42	0.0437	40 (553)	102	4
		1963-65	94	0.0620	37 (527)	101	4
		1966	33	0.0692	44 (622)	110	4
Missouri	IM	1968	13	0.0478	29 (400)	76	3
		1967	16	0.0418	40 (553)	102	4
		1963-65	89	0.0645	37 (527)	101	4
	IF	1967	14	0.0423	40 (553)	102	4
		1963-65	59	0.0513	37 (527)	101	4
		1966	10	0.0559	44 (622)	110	4
	AF	1967	11	0.0423	40 (553)	102	4
		1963-64	54	0.0571	36 (514)	105	4
New York	IM	1961	19	0.0627	43 (732)	101	2-3
		1960,62-63	54	0.0796	46 (787)	115	2-4
		1964-67	151	0.0870	48 (810)	146	3-4
	IF	1961	24	0.0945	43 (732)	101	2-3
		1960,62-63	44	0.0681	46 (787)	115	2-4
		1964-67	113	0.0725	48 (810)	146	3-4
Ohio	IM	1962,68	54	0.0730	27 (375)	80	2-3
		1967	47	0.0733	40 (553)	102	4

TABLE 35.--Continued

Banded In	Age	Years	Number Recovered	Direct Recovery Rate	Season Length (days)[2]	October Days[3]	Daily Bag Limit (ducks)
		Banding Data			Regulations[1]		
Ohio	IM	1963-65	69	0.0756	37 (527)	101	4
		1966	56	0.0701	44 (622)	110	4
	IF	1962,68	41	0.0578	27 (375)	80	2-3
		1967	19	0.0375	40 (553)	102	4
		1963-65	61	0.0792	37 (527)	101	4
		1966	47	0.0686	44 (622)	110	4
Tennessee	IM	1968	25	0.0343	29 (400)	76	3
		1967	20	0.0329	40 (553)	102	4
		1963-65	105	0.0496	37 (527)	101	4
		1966	68	0.0662	44 (622)	110	4
	IF	1968	21	0.0302	29 (400)	76	3
		1967	21	0.0326	40 (553)	102	4
		1963-65	97	0.0444	37 (527)	101	4
		1966	54	0.0574	44 (622)	110	4
	AM	1968	11	0.0464	29 (400)	76	3
		1966	15	0.0528	44 (622)	110	4
Vermont	IM	1961	12	0.0622	43 (732)	101	2-3
		1960,62-63	54	0.0792	46 (787)	115	2-4
		1964-67	111	0.1028	48 (810)	146	3-4

TABLE 35.--Continued

Banded In	Age	Years	Number Recovered	Direct Recovery Rate	Season Length (days)[2]	October Days[3]	Daily Bag Limit(ducks)
		Banding Data			Regulations[1]		
Vermont	IF	1961	18	0.0793	43 (732)	101	2-3
		1960,62-63	52	0.0812	46 (787)	115	2-4
		1964-67	98	0.0965	48 (810)	146	3-4
	AM	1961	22	0.0821	43 (732)	101	2-3
		1960,63	23	0.0689	47 (796)	112	3-4
		1965-66	33	0.0811	48 (830)	147	3-4
Wisconsin	IM	1962,68	51	0.0636	27 (375)	80	2-3
		1967	146	0.0935	40 (553)	102	4
		1963-65	227	0.0870	37 (527)	101	4
		1966	156	0.1435	44 (622)	110	4
	IF	1962,68	28	0.0399	27 (375)	80	2-3
		1967	115	0.0859	40 (553)	102	4
		1963-65	200	0.0909	37 (527)	101	4
		1966	100	0.1082	44 (622)	110	4
	AM	1962,68	60	0.0442	27 (375)	80	2-3
		1967	37	0.0642	40 (553)	102	4
		1963-65	196	0.0645	37 (527)	101	4
		1966	79	0.0722	44 (622)	110	4

TABLE 35.--Continued

		Banding Data			Regulations[1]		
Banded In	Age	Years	Number Recovered	Direct Recovery Rate	Season Length (days)[2]	October Days[3]	Daily Bag Limit(ducks)
Wisconsin	AF	1962	13	0.0362	25 (350)	84	2
		1967	13	0.0861	40 (553)	102	4
		1966	31	0.0904	44 (622)	110	4

[1]Wood duck bag limits were restricted to two except in 1967 when only one wood duck was allowed in the Mississippi Flyway.

[2]Season length expressed as an average for Atlantic or Mississippi Flyway states. Parenthesized numbers represent the total number of hunting days obtained by summing all hunting days of each state in a flyway.

[3]Total number of October hunting days in a flyway obtained by summing all October days of component flyway states.

[4]I (immatures), A (adults), M (males), F (females).

at 0.05, Sign Test).

Although the correlation coefficients for direct recovery rates and various regulation variables of the North Central Area were usually high, the coefficient of determination (R^2) was not statistically significant ($p > 0.05$) when all four regulation variables were used in the regression model (Table 51). Of particular interest is the large amount of variation in recovery rates explained by regressing direct recovery rates on the total number of October hunting days. The coefficient of determination ranged from 0.77 to 0.89 and was significant at the 0.01 level for all age-sex classes.

Appendix Tables 52 and 53 reveal stepwise regression procedures used to promote insight into the relative strength of the relationships between hunting regulations for selected states and the dependent variable, direct recovery rate. A maximum R^2 improvement technique by Barr and Goodnight (1972) was used for the regression analysis. Although each of the five independent regulation variables was considered the "best" single variable for one or more situations, variables x_3 (total hunting days in October) and x_2 (total hunting days in the flyway) were most prominent and frequent in exhibiting the largest coefficient of determination.

Survival

To discern the relationship of direct recovery rates

and survival, comparisons of first hunting-season band recovery rates and corresponding survival rates were made for selected states (Table 36). When associations were based on 10 or more recoveries, only adult females demonstrated a statistically significant correlation ($r = 0.74$, $p \leq 0.05$). Restricting comparisons to years with 20 or more band recoveries increased the number of significant relationships: Immature males ($r = -0.69$, $p \leq 0.01$), immature females ($r = -0.23$, $p > 0.05$), adult males ($r = -0.84$, $p \leq 0.01$), and adult females ($r = -0.67$, $p > 0.05$).

Comparisons of immature survival rates with the extreme low and high direct recovery rates occurring in selected states during the 1962 through 1967 hunting seasons are given in Table 37. In 6 of 9 possible comparisons for immature males and 4 of 8 comparisons for immature females, survival rates were higher in years with lowest recovery rates. A Sign Test indicated a probability of 0.25 (immature males) and 0.64 (immature females) that changes in survival rates and extremes of direct recovery rates were not related. Sufficient data were not available to test this relationship for adult wood ducks.

A hypothesis that survival rates would change in the opposite direction as regulations (i.e., survival rates would decrease as hunting regulations became more liberal) was tested for immatures within each reference area (Table 38). The associated probability of occurrence of high survival rates with strict regulations was 0.19 for imma-

TABLE 36.--A comparison of direct recovery rates and survival estimates for wood ducks banded in selected states, 1962, 1967, 1963-65, and 1966

Banded In	Bandings and Recoveries				Survival Rate (%)
	Banding Period	Age Sex[1]	Number Recovered	Direct Recovery Rate	
Illinois	1962	IM	25	0.0506	60.8
	1967		56	0.0550	67.4
	1963-65		231	0.0612	39.2
	1966		143	0.0784	36.5
	1962	IF	30	0.0651	64.2
	1967		39	0.0448	44.9
	1963-65		190	0.0566	47.2
	1966		111	0.0665	41.8
	1963-65	AM	59	0.0581	54.3
	1966		33	0.0892	44.6
	1963-65	AF	70	0.0503	47.4
	1966		37	0.0557	32.9
Indiana	1962	IM	16	0.0648	42.2
	1967		11	0.0421	22.9
	1963-65		50	0.0772	48.2
Iowa	1962	IM	38	0.0542	57.8
	1967		68	0.0659	52.9
	1963-65		262	0.1007	35.4
	1966		70	0.0888	37.7
	1962	IF	27	0.0448	50.7

TABLE 36.--Continued

Banded In	Bandings and Recoveries				Survival Rate (%)
	Banding Period	Age Sex[1]	Number Recovered	Direct Recovery Rate	
Iowa	1963,65	IF	118	0.0786	45.6
	1963-65	AM	51	0.0644	49.8
	1966		16	0.0721	61.1
	1963-64	AF	42	0.0925	36.8
Minnesota	1962	IM	14	0.0725	41.5
	1967		22	0.0673	30.3
	1963-65		71	0.0764	43.0
	1966		44	0.1164	20.0
	1962	IF	12	0.0706	58.8
	1963-65		48	0.0644	45.7
	1962	AM	10	0.0275	53.5
	1967		17	0.0437	49.0
	1963-65		48	0.0644	55.6
	1966		33	0.0692	56.5
Missouri	1967	IM	16	0.0418	59.5
	1963-64		64	0.0706	53.2
	1963-65	IF	59	0.0513	32.1
	1966		10	0.0559	78.0
	1967	AF	11	0.0423	49.6
	1963-64		54	0.0571	44.8

TABLE 36.--Continued

Banded In	Bandings and Recoveries: Banding Period	Age Sex[1]	Number Recovered	Direct Recovery Rate	Survival Rate (%)
Ohio	1963-65	IM	69	0.0756	44.9
	1966		56	0.0701	35.8
	1962	IF	18	0.0465	30.2
	1967		19	0.0375	33.6
	1963-65		69	0.0756	55.9
	1966		56	0.0701	51.2
Tennessee	1967	IM	20	0.0329	44.6
	1963-65		105	0.0496	53.3
	1966		68	0.0662	57.6
	1967	IF	21	0.0326	29.1
	1963-65		97	0.0444	54.4
	1966		54	0.0574	67.3
	1966	AM	15	0.0528	50.5
Wisconsin	1962	IM	26	0.0732	43.2
	1967		146	0.0935	29.6
	1963-65		227	0.0870	37.5
	1962	IF	10	0.0426	35.9
	1967		115	0.0859	23.8
	1963-65		200	0.0909	52.9
	1966		100	0.1082	21.2

TABLE 36.--Continued

Banded In	Bandings and Recoveries				Survival Rate (%)
	Banding Period	Age Sex[1]	Number Recovered	Direct Recovery Rate	
Wisconsin	1962	AF	13	0.0362	47.0
	1967		13	0.0861	37.2
	1966		31	0.0904	19.8

[1]I (immature), A (adults), M (males), F (females).

TABLE 37.--A listing of high and low direct recovery rates with corresponding survival rates for immature wood ducks banded in selected states

Banded In	Recovery and Survival Data				
	Age and Sex[1]	Year	Recoveries	Recovery Rate	Survival Rate (%)
Illinois	IM	1962	25	.0506	60.8
		1966	143	.0784	36.5
	IF	1962	14	.0305	64.2
		1966	111	.0665	41.8
Indiana	IM	1967	11	.0421	22.9
		1965	24	.0819	55.6
	IF	1967	9	.0435	17.9
		1964	11	.0683	25.4
Minnesota	IM	1967	22	.0673	30.3
		1966	44	.1164	20.0
	IF	1965	22	.0587	47.1
		1966	36	.1014	68.9
Missouri	IM	1967	16	.0418	59.5
		1964	44	.0766	40.0
New York	IM	1964	13	.0398	50.5
		1966	58	.1122	16.7
	IF	1965	13	.0422	39.0
		1966	46	.0911	45.8

TABLE 37.--Continued

Banded In	Recovery and Survival Data				
	Age and Sex[1]	Year	Recoveries	Recovery Rate	Survival Rate (%)
Ohio	IM	1964	16	.0530	25.8
		1963	37	.0914	42.8
	IF	1967	19	.0375	33.6
		1963	34	.1130	52.4
Tennessee	IM	1967	20	.0329	44.6
		1966	68	.0662	57.6
	IF	1962	16	.0288	99.2
		1966	54	.0574	67.3
Vermont	IM	1961	12	.0622	24.0
		1966	32	.1306	13.3
	IF	1963	16	.0630	27.9
		1966	100	.1082	22.1
Wisconsin	IM	1962	26	.0732	43.2
		1964	75	.0922	41.7
	IF	1962	10	.0426	35.9
		1966	100	.1082	21.2

[1]I (immature), A (adult), M (male), F (female).

TABLE 38.--Comparisons of immature wood duck survival rates and hunting regulations for selected seasons

Banded In	Years	Survival Rate (%)		REGULATIONS[1]		
		IM	IF	Season Length (days)	Wood Duck Bag Limit	Duck Bag Limit
North Central	1962,68	47.6	52.3	27 (375)	2	2-3
	1963-65	41.2	47.1	37 (527)	2	4
	1967	43.3	51.2	40 (553)	1	4
	1966	34.0	40.7	44 (622)	2	4
Lake States	1962	45.5	47.9	25 (350)	2	2
	1963-64	40.5	47.4	36 (514)	2	4
	1967	30.8	32.5	40 (553)	1	4
	1966	50.0	44.8	44 (622)	2	4
Northeastern	1961	38.5	53.5	43 (732)	2	2-3
	1960,62-63	36.6	28.8	46 (787)	2	2-4
	1964-65,67	47.2	36.8	46 (789)	2	3-4
	1966	22.7	25.6	51 (875)	2	3-4
New York-E.Canada[2]	1960	42.8	34.6	63 (874)	1-2	3-6
	1961-63	26.7	29.4	57 (835)	2	2-5
	1964-65,67	47.0	39.9	61 (864)	2-4	3-5
	1966	17.9	37.8	65 (950)	2-4	3-5

[1]Average for flyway. Parenthesized numbers are total days in the flyway.

[2]Hunting seasons for Atlantic Flyway and Southern District of Ontario.

ture males and 0.27 for immature females (Sign Test).

Forest Habitat

Trends in Forest Habitat

During a recent eight-year span (1963 through 1970), forest habitat for wood ducks has decreased by more than 13 million acres (5.3 million hectares) (Table 39). Since several of the forest types affected were of limited value to wood ducks, it is important to note the change in forest types which provide high-quality habitat (Elm-Ash-Cottonwood, Maple-Beech-Birch, and Oak-Gum-Cypress). The acreage of Elm-Ash-Cottonwood has increased approximately 20 percent, but this increase was offset by a 7 percent decrease in the acreage of Maple-Beech-Birch and a 20 percent decrease in Oak-Gum-Cypress. Most of the decrease of important forest types has occurred in southern states where more than 7 million acres (2.8 million hectares) of important breeding and wintering habitat have been destroyed (Table 40).

Reference Areas and States

The top ten states in terms of forest-type values were: Minnesota, Wisconsin, Michigan, Louisiana, Georgia, Florida, Arkansas, Mississippi, Maine, and New York. These ten states contained over 119 million acres (48.1 million hectares) of forests important to wood ducks, or an area equivalent to 47.5 percent of the total 1963 acreage of all

TABLE 39.--Change in acreages of forest types between 1963 and 1970 for the eastern United States[1]

	Forest Acreages - In Thousands		
Forest Type	1963	1970	Change
Spruce-Fir	19,638	18,913	- 725
Oak-Hickory	115,963	111,861	- 4,102
Oak-Gum-Cypress	37,788	30,630	- 7,158
Maple-Beech-Birch	33,318	31,140	- 2,178
Elm-Ash-Cottonwood	20,403	24,728	+ 4,325
Aspen-Birch	23,715	20,484	- 3,231
Total	250,825	237,756	-13,069

[1]Based on United States Forest Service, Forest Resource Report Numbers 17 (1965) and 20 (1973a).

TABLE 40.--Change in acreages of forest types between 1963 and 1970 for northern and southern wood duck reference areas[1]

Forest Type	Forest Acreages - In Thousands					
	Northern Reference Areas			Southern Reference Areas		
	1963	1970	Change	1963	1970	Change
Spruce-Fir	19,623	18,899	- 724	15	13	- 2
Oak-Hickory	58,896	55,536	-3,360	57,067	56,324	- 739
Oak-Gum-Cypress	1,678	1,361	- 317	36,110	29,268	-6,842
Elm-Ash-Cottonwood	18,301	21,971	+3,670	1,273	2,756	+1,483
Maple-Beech-Birch	32,812	30,657	-2,155	506	482	- 24
Aspen-Birch	23,715	20,484	-3,231	0	0	0
Total	155,025	148,908	-6,117	94,971	88,843	-6,124

[1]Based on United States Forest Service, Forest Resource Report Numbers 17 (1965) and 20 (1973a) and United States Forest Service (1972).

hardwood and Spruce-Fir types in the eastern United States.

A similar ranking of forest values by reference areas showed the following order of importance:

Reference area	Forest-value rank
	Percent
Southern	23.2
North Central	21.7
Southeastern	18.2
New York-Eastern Canada	14.9
Northeastern	12.5
Lake States	9.5

States in the Southern and Southeastern Reference Areas accounted for 101 million acres (40.9 million hectares) or 41.7 percent of the United States hardwood forests important to wood ducks. Northern states provided 141 million acres (57.1 million hectares) or 58.3 percent of the Eastern hardwood acreage useful to wood ducks.

DISCUSSION

Banding Data

Use and Assumptions

The use of band recoveries to identify waterfowl populations having characteristic distribution and derivation of harvest patterns is a common waterfowl management technique. Banding, recovery, and harvest data have been analyzed for black ducks, *Anas rubripes* (Geis et al. 1971); mallards (Bellrose and Crompton 1970, Anderson and Henny 1972); green-winged teals (Moisan et al. 1967); and canvasbacks, *Aythya valisineria* (Stewart et al. 1958). The problems and assumptions associated with use of band-recovery data to indicate waterfowl characteristics have been discussed by Crissey (1955) and Stewart et al. (1958). In general, reliability depends on the extent to which the following are true: (1) recoveries from the banded sample reflect the characteristics of the population they represent and (2) the sampled population is of known size and geographic distribution.

In order for the banded sample to be representative, the following assumptions must be made:

1. Distribution of the kill of the banded sample is the same as the distribution of the kill of the true population.

2. The proportion of recovered bands that is reported is the same for all areas at all times or can be determined.
3. The banded samples are large enough to minimize sampling error.

Assumption number one can be insured if a random or systematic sampling scheme is devised and executed throughout the sampled population. Although random and systematic sampling techniques were not attempted during wood duck banding programs, banding stations were widely distributed within the six major reference areas and large numbers were banded. This, coupled with the fact that recovery distributions were separated by age and sex, lends support to the opinion that assumption number one was satisfied.

Throughout many sections of the study I assumed that direct recovery rates provided valid indices of rates of harvest. If the proportion of recovered bands reported was higher in some areas and higher at different times, the harvest rate data were biased.

Assumption three, adequate banded samples, was probably valid for the North Central and Lake States Reference Areas where more than 81 thousand wood ducks were banded preseason. Although more than 27 thousand wood ducks were banded preseason in the New York-Eastern Canada and Northeastern Reference Areas, numerous states and provinces had not banded sufficient numbers to minimize sampling error. Many of the coastal states within the Northeastern Refer-

ence Area as well as such inland states as Pennsylvania and New Hampshire displayed inadequate banded samples. The Great Lakes-St. Lawrence Forest Types of Canada also harbored unsampled wood duck populations. Quebec (south of 47° north latitude and along the St. Lawrence River), sections of southwest Ontario, extreme southeast Manitoba, and the Maritime Provinces should have been represented by larger banded samples. With the exceptions of South Carolina and Tennessee, states composing the Southern and Southeastern Reference Areas were grievously lacking in representative preseason banded samples.

Only 730 recoveries of winter banded wood ducks were available for study; therefore, results based on the winter banding period were limited due to associated large sampling errors.

Banding Period

Hunting season recoveries used in defining reference areas were related to wood ducks on production areas, because banding data of my study were limited to a May through August banding period. Although wood duck nesting activities can begin as early as February in the far south (Odom 1970) and late March in northern areas (Grice and Rogers 1965), most wood ducks are on their breeding grounds in April or May (Beshears 1974, Cunningham 1968, Decker 1959, and Leopold 1951). The fall movement of wood ducks from breeding areas and the influx of migrating birds were also

determined to ensure that banding periods of my study were related to wood ducks on production areas. Several investigations on roosting habits of wood ducks gave insight to time of influx at different geographical locations. North Carolina investigations by Hester and Quay (1961) demonstrated a large buildup in wood duck roost during late October and November. Tabberer (1969) found that the largest influx of roosting flocks in Louisiana also occurred in October and November. Massachusetts studies by Grice and Rogers (1965) indicated that wood ducks began congregating and migrating southward by the middle of September. Martin and Haugen (1960) suggested that the major influx and efflux of wood ducks in Iowa occurred during October and early November. However, Barden (1968) found that immature wood ducks banded in Maine after September first were less likely to be recovered in the state than those banded before this date. He also discovered that very few Maine wood ducks were recovered in the state after October 20.

Banding Requirements

A large percentage of the wood duck bandings between 1950 and 1968 could not be used due to: (1) season of banding, (2) inability of banders to age and sex birds, (3) inconsistency of banding efforts, and (4) banding of other than normal, wild wood ducks.

Results of this study have shown that approximately 46 thousand wood ducks would have to be banded annually in

the six reference areas to allow meaningful, yearly estimates of survival. A banding program of this size conducted during May through August in northern areas and May through September in southern regions should amply sample wood duck populations associated with specific natal areas. However, bandings would have to be consistent, adequate for each age and sex, and proportionally distributed among all important breeding populations. Banding quotas could be proportionally allocated to each state or province based on the density index in Table 3. If the annual banding of 46 thousand wood ducks proves too difficult, an alternative would be to analyze banding data on an average annual basis. If this occurs, the span of years to be averaged should not exceed five; because, additional years of hunting seldom add recoveries that are used in survival estimates.

Because the number to be banded is dependent on direct recovery rates and survival, a change in these variables could decrease banding needs. For example, if the increased hunting pressures (direct recovery rates) of recent years (1969 through 1972) have not been accompanied by similar increases in mortality, a reduction in banding quotas would be appropriate.

Reference Areas

Defining Boundaries

Wood duck reference areas were delineated by grouping those states and provinces showing consistencies and

differences in the distribution of hunting recoveries of banded ducks. Although their outer perimeters were subjective and confined to political state boundaries, reference areas larger than states and provinces were believed practical because: (1) there were too many instances of insufficient data from individual states, and (2) the continuity as well as size of the data base was improved by combining states with similar harvest distributions. There was evidence that reference-area borders not conforming to state and provincial boundaries could have been defined if banded samples had been larger. Better banding programs of the future will undoubtedly modify boundaries of the six reference areas identified in this research.

Reference Area Management

At present, a uniform set of wood duck harvest regulations apply throughout the entire eastern United States. Identification of the six major summer breeding populations should encourage management by these reference areas. If the reference-area differences in survival, hunting pressure, population densities, production, and harvest patterns were acknowledged before the formulation of hunting laws, regulation frameworks could be patterned toward individual populations. This would allow maximum recreational use of the resource without excessive harvest.

Optimal wood duck management can be achieved by gathering comparable data for major populations represented

by reference areas. Results of this study have indicated those states which are most important in the harvest of specific breeding populations. In addition, the breeding-ground origin of the kill in states and reference areas has been assessed. Consequently, if major changes in hunting regulations are made, it would be possible to judge their impact on different summer populations. Conversely, it should be possible to evaluate effects that habitat or population changes in summer reference areas would have upon the harvest in different states or groups of states.

Population Indices

Annual waterfowl population surveys which provide information on most duck species do not yield useful information on the wood duck. At present, there are no census techniques which can be used to accurately count wood duck numbers for every geographical area; therefore, indices of abundance are needed to compare the relative densities of different regions.

Forest Index

The use of forest acreages to indicate relative densities of wood ducks assumed a correlation existed between the distribution and abundance of suitable forest habitats and wood duck numbers. Life history studies by Grice and Rogers (1965), McGilvrey (1968), and Beshears (1974) support this contention. A statistical comparison of forest values produced in this study and FHMUP population

estimates provided by the U.S. Fish and Wildlife Service also exhibited a high correlation coefficient ($r = 0.78$). However, this correlation may have been expected since some of the judgements used in tabulating FHMUP estimates were tinted by forest habitat characteristics of the states involved.

The importance values associated with each of the six forest types were based on the author's judgement as well as a limited amount of published research on the wood duck's use of forest habitat types. Important forest characteristics considered were cavity forming traits, nearness or association with water, associated plant species, physiography of the state in which the types occurred, and wood duck brood-rearing habitat requirements. Few studies have investigated the actual quantitative importance of tree species and forest types for nesting and brooding wood ducks. Hansen (1966) discussed the silvical characteristics of tree species as they relate to cavity production, and he produced tables listing the more important tree species containing usable cavities. Highest ranking were baldcypress, sycamore, maples, black and red oaks, American elm, and ash. Similar studies by Gigstead (1938), Bellrose et al. (1964), and Hawkins and Bellrose (1941) pointed out that old growth black oaks (*Quercus velutina* Lam.), sycamore, elm, maple, basswood, and pin oaks (*Quercus palustris* Muenchh.) in Illinois usually possessed the most suitable cavities for wood ducks. Weier (1966) studied wood-duck

cavity densities in three timber types of Missouri (Pin Oak-Overcup Oak, Elm-Ash-Maple, and Upland Hardwoods). Important species were black oak, sweetgum (Liquidambar styraciflua L.), elm, blackgum, red maple, black willow, ash, and baldcypress. McGilvrey (1968) listed the more important forest types attractive to breeding wood ducks:

1. Southern floodplain forests: cypress, tupelo, blackgum, beech, ash, blackwillow, and cherrybark oak (Quercus falcata var. pagodaefolia Ell.).
2. Red maple swamps: silver and red maple, tupelo, and sycamore.
3. Central floodplain forest: cottonwood, silver maple, elm, blackwillow, pin oak, and sycamore.
4. Temporarily flooded oak-hickory forests.
5. Northern bottomland hardwoods: oak, maple, cottonwood, ash, and elm.

The brood rearing habitat required by wood ducks was also a necessary consideration in determining the relative value of forest types and their associated plant species. A description of brood rearing habitats and movement of ducklings to them are given by Webster and McGilvrey (1966), McGilvrey (1968), Hardister et al. (1965), and Stewart (1958). Four important aspects necessary for brood habitats were described: animal foods, availability of persistent water, dense low-growing cover, and herbaceous aquatic emergents. Optimum brood habitat was described as

tangles of dead, dying, and downed trees in shallow water surrounded by dense shrubs within a foot or two of the water surface.

The aforementioned studies when coupled with silvical, physiographic, site, and associated plant species descriptions of each forest type as given by Barrett (1962) and the U.S. Forest Service (1965 and 1973b) provided a necessary base for judgemental ratings of the six major hardwood forest types of eastern North America. Wetland potentials of each state as described by Shaw and Fredine (1956) were, and will continue to be, valuable in the importance rating of forest types for wood ducks.

Fish and Wildlife Service Model

Estimates by this model were based partially on quantitative biological data, but the primary input was collective reasoning and subjective work by men most familiar with wood duck populations in each of the coterminous United States. Although a portion of these estimates were founded on a concensus of opinions, I considered them a viable source for comparing relative wood duck densities between the various reference areas.

Simultaneous Equations

Geis (1966) described the conditions necessary for reliable indirect waterfowl density estimates when the simultaneous equation technique is used:

1. Distribution of the kill from each banding area is not the same. Wood ducks banded in different reference areas tend to be harvested in different regions.
2. All populations of significant size are represented by banded samples that reflect the kill distribution.
3. Size of the kill in various harvest areas is known.
4. Band-reporting rates are of the same magnitude in all harvest areas, or they can be estimated.

Condition one was satisfied due to the identification of reference areas based on differences in recovery distributions of banded wood ducks. Although more than 350 thousand banded wood ducks were available for study, it is doubtful if all major wood duck populations were adequately banded. This study was restricted to the eastern United States, and it was assumed that populations immediately west of 97^{o} east longitude harbored insignificant wood duck numbers. The lack of representative banded samples for certain states and Canadian provinces has already been documented. If the wood duck populations of southeastern Manitoba, southwestern Ontario, and the Canadian Maritimes were large, wood duck estimates in Canada were underestimated.

The lack of precise and accurate harvest and reporting-rate estimates within individual states was probably

the most important factor contributing to erroneous state population estimates. The U.S. Fish and Wildlife Service's harvest survey was designed to estimate kill of "all" waterfowl on a "flyway" basis. Using this survey and the wing survey to estimate wood duck harvest for specific states increased the sampling error. Atwood (1956) and the U.S. Fish and Wildlife Service (1961) discussed procedures and validity of mail-survey data to estimate bagged waterfowl. The sampling scheme was designed to estimate percentages of species harvest in the total waterfowl kill with a sampling error of about 17 percent for states where large waterfowl kills usually occur, and about 33 percent for less important states. It was supposed that flyway species estimates would have a sampling error of about 6 percent. As stated by the U.S. Fish and Wildlife Service (1961): "Statistical reliability is greater for areas with the larger number of post-office outlets sampled, highest number of hunters, largest kills, and for species where the larger bags are recorded over wider areas." Conversely the statistical reliability is less where there are fewer outlets, fewer hunters, low kills, and where hunting for a species is concentrated at relatively few points.

There is evidence that reporting rates of retrieved banded-birds differ by questionnaire used, regions, and temporally (Martinson 1966, Geis and Atwood 1961). Geis and Atwood (1961) quote a sampling error of ±17.6 percent at the 95 percent confidence level when reporting rates

were used to estimate total kill of banded waterfowl during the 1956 through 1957 hunting season. Sampling errors for estimates of individual administrative flyways ranged from 24.5 to 35.9 percent.

In summary, I believe the simultaneous equation technique is a potentially useful model for indirectly estimating the size of wood duck populations. The ambiguous estimates obtained in this study were probably the result of inadequate survey and banding data rather than failure of the model. Although Chan (1972) in a more involved population modeling study concluded that the simultaneous equation technique was mathematically sound, I believe additional investigations are needed to determine the effects that changing harvest, recovery, and reporting rates will have on indirect population estimates obtained via this model.

Population Estimates and Weighting Factors

Because simultaneous equations did not always yield realistic abundance estimates, and since the figures are not independent of either forest values or FHMUP, all three estimates of abundance were summed to produce the Row Sum column in Table 3. I believe this Row Sum value represents the best means of comparing relative abundances of wood ducks in the eastern United States and southeastern Canada during the 1962 through 1968 period. Ten states possessed over 53 percent of the total eastern United

States breeding population; therefore, any adverse habitat or regulation changes in Alabama, Florida, Georgia, Louisiana, Michigan, Minnesota, Mississippi, New York, North Carolina, and Wisconsin could greatly affect wood duck numbers throughout the United States. Canada was an important production area responsible for at least 10 percent of the breeding wood ducks in eastern North America. This implies that even though wood ducks are present in every eastern state, Canadian regulations and breeding habitats could have an important effect on wood duck numbers present in the United States during the fall hunting seasons.

Harvest

A major goal for obtaining relative density estimates in each state and province was the use of such information to correct for disproportionate banding efforts. Once data were corrected (weighted), survival and hunting pressure comparisons could be made between states, and the harvest derivation and distribution patterns for reference areas could be determined.

Harvest and Hunting Kill

The wood duck harvest remained fairly stable during the 1963 through 1968 period and ranged from 425 thousand to 650 thousand, which indicated a slight upward trend in numbers shot. This agrees closely with harvest data compiled by Kaczynski (1968) and Kimball and Anderson (1969); however, personal communication with Dr. Fant Martin

(August 1974, Migratory Bird and Habitat Research Laboratory, Laurel, Maryland) revealed that wood duck harvest has increased dramatically in more recent years. During the 1969 through 1972 hunting seasons, estimated average harvest was 886 thousand--a percentage increase of approximately 77 percent over the 1962 through 1968 periods of this study.

The rate of kill for wood ducks, like other waterfowl species, varied by age-sex classes and ranged from 23.1 percent for adult females to 35.3 percent for immature males (Table 31). These kill rates are similar to those calculated by Martinson (1966) and Kimball and Anderson (1969) for wood ducks harvested during 1965 and 1968. However, the overall average kill rate of 29.0 percent is slightly lower than similar averages for black ducks (Geis et al. 1971), canvasbacks (Geis 1959), and mallards (Geis et al. 1969) but higher than green-winged teal estimates (Moisan et al. 1967). Accuracy of the wood duck estimates was influenced by size of the banded sample and reporting rate estimates.

Harvest Distribution

Geis and Cooch (1972) showed that over 90 percent of the wood duck harvest in North America during 1967 through 1969 occurred in states composing the six reference areas identified by this study. Approximately 15 percent of the harvest was attributed to Canada and 85 percent to the United States, figures which are similar to those in

Table 7. Geis and Cooch (1972) also revealed that the Mississippi Flyway harvest of wood ducks was more than double that occurring in the Atlantic Flyway. Although harvest survey estimates of this research (Table 7) reveal a similar trend, weighted recoveries show less discrepancy between harvest of the Atlantic and Mississippi Flyways. It does appear that wood duck harvest in the Mississippi Flyway exceeds that of the Atlantic Flyway but not to the extent indicated by previous U.S. Fish and Wildlife harvest surveys.

Carney et al. (1975) documented the average number of wood ducks harvested during the 1961 through 1970 hunting seasons for each county and state in the continental United States. Seven states (Florida, Illinois, Louisiana, Minnesota, New York, South Carolina, and Wisconsin) were responsible for over 56 percent of the harvest in the eastern United States. Data from my study reveal a similar trend for flyways. Relatively few states are responsible for more than one-half of the flyway harvest. This information should be useful when reductions of harvest are desired. It may be possible to achieve the desired results by limiting restrictive regulations to only a few important harvest areas.

More than 60 percent of the immatures banded within a northern reference area were harvested therein. Hunting seasons of these northern units were such that the harvest of local populations occurred before southern migration

had been completed, resulting in a high local kill. The interchange between northern breeding areas appeared to be small; therefore, hunting regulations of these units will have little direct effect on other northern populations. However, within flyways, major regulation changes in northern or southern reference areas could be important because approximately 33 percent of the northern-banded wood ducks were harvested in southern reference areas.

Harvest Derivation

Weighted direct recoveries demonstrated an approximate 10 percent interchange of wood ducks between the Atlantic and Mississippi Flyways. This suggests that there is a good biological basis for management of the species within existing boundaries of these flyways. But in the future, it would be advantageous to manage by breeding populations within a flyway. For example, a desire to decrease the kill of wood ducks produced in the North Central Area would require no curtailment of the Lake States harvest because only a small percentage of the Lake States' harvest is derived from the North Central Area. Similar relationships exist for other northern reference areas; however, more than 57 percent of the southern harvest was of northern origin, indicating that harvest on the wintering grounds could have an impact on wood duck numbers returning north.

Age and Sex Differences

There were differences among northern wood ducks in the distribution and derivation of harvest. Adult females and immatures of each sex were predominant in the harvest of northern states. In contrast, a higher proportion of the northern adult-male harvest occurred on wintering grounds later in the year. Similar age and sex patterns in harvest have been reported for black ducks (Geis et al. 1971) and mallards (Anderson and Henny 1972). Explanations are linked to the opening dates of waterfowl seasons and migrational behavior of wood ducks. Whatever the cause, there are important management implications for wood ducks. Changes in harvest levels within northern states are more likely to affect immatures of both sexes and adult females. Changes in harvest levels late in the year on the wintering grounds will have a greater impact upon adult males from northern populations.

Harvest Timing

Dates of waterfowl hunting seasons are usually selected in accordance with migratory behavior and generally occur during a time of peak waterfowl abundance. Most northern reference areas select seasons which include October and November, while southern regions select for late November and December. These dates, in combination with age and sex migrational differences, account for the dominance of immatures and adult females in the October-

November hunting period and the preponderance of adult males in the December-January harvest.

Migrational studies in northern states point out that after October few wood ducks remain; most have begun drifting southward in a leisurely fashion (Grice and Rogers 1965, Barden 1968). An example of the importance of these temporal movements is demonstrated by the 1963 monthly harvest of New York wood ducks (Table 41). In 1963, the New York waterfowl season opened in early November, not the usual mid-October opening. The results showed 88.0 percent of the harvest occurring in November as opposed to a usual high percentage harvest in October. The effect of this late season beginning was a 1963 harvest of only 3,900 wood ducks as opposed to previous annual averages of 27 thousand. A similar occurrence was recorded in Massachusetts by Grice and Rogers (1965) when the 1952 hunting season was postponed until November 11. Wood ducks composed only 9 percent of the November waterfowl bag as compared to 25 percent in 1953 when the season opened on October 27.

Direct Recovery Rates

Age and Sex

Bellrose and Chase (1950), Smith and Geis (1961), Moisan et al. (1967), and Geis (1959) revealed that among mallards, black ducks, green winged teals, and blue winged teals - immatures had higher recovery rates than

TABLE 41.--Monthly distribution of the wood duck harvest occurring in New York (based on harvest survey data 1962-68)

Year	Percent Distribution					Total
	October	November	December	January	Other[1]	
1962	94.7	5.1	0.0	0.0	0.2	100.0
1963	10.8	88.0	0.6	0.6	0.0	100.0
1964	93.0	6.4	0.2	0.0	0.4	100.0
1965	93.0	6.0	0.1	0.0	0.9	100.0
1966	94.5	4.9	0.0	0.0	0.6	100.0
1967	94.0	4.8	0.4	0.0	0.8	100.0
1968	93.1	6.9	0.0	0.0	0.0	100.0

[1]Non-hunting season months.

adults. Preseason banding data of my study show that a differential likelihood of recovery between immatures and adults was also characteristic of wood ducks, indicating higher gunning pressure upon immatures. Possible explanations for differential vulnerability among waterfowl are: lack of wariness by immatures, migrational timing, differences in natural mortality, and behavioral characteristics involving feeding and molting periods.

Male wood ducks were more likely to be recovered than females, probably as a result of hunter selectivity for the more colorful males in combination with lower natural mortality rates for adult males.

Regional Variations

Kimball and Anderson (1969) and Kaczynski and Geis (1961), using limited data, concluded that wood duck direct recovery rates for northern banding areas were generally higher than recovery rates of southern areas. My study corroborates their findings, indicating that differences in shooting pressure between different populations do exist. This may have been expected, since wood ducks from northern reference areas encountered a procession of opening hunting seasons during their southward migration, resulting in an extended open season. Recovery rates of southern reference areas were lower because of the buffering effect of northern birds during the hunting season and because southern wood ducks were exposed to a

shorter hunting period.

Smith et al. (1963) stated that wood duck recovery rates in the Atlantic Flyway were about 30 percent higher than recovery rates in the Mississippi Flyway. I reached a similar conclusion. The higher recovery rates in the Atlantic Flyway were probably due to a limited habitat combined with total flyway hunting periods that averaged 287 days longer than those in the Mississippi Flyway (based on the total sum of hunting days in every flyway state).

Differences in migrational behavior suggest that relative recovery rate disparities among reference areas were due in part to availability of age-sex groups. For example, the adult male/adult female ratio in northern reference areas was low when compared to southern regions as a result of the migratory behavior of adult males, allowing them to escape the high October hunting pressures in northern units. Low adult male/adult female ratios could be due also to closer association of females with the more susceptible young during the first few months of fall. Anderson and Henny (1972) discussed this possibility in relation to disproportionate harvest of adult male mallards. They hypothesized that the later molting of adult females and their tendency to associate with immatures male adult females more vulnerable to shooting early in the hunting season. Like mallards, adult female wood ducks may have needed considerably more food than adult

males to replenish their energy for fall flights. This would necessitate more feeding flights and also subject adult females to additional hunting exposure early in the fall.

The lack of wariness of immatures during early fall in northern areas was also a factor in regional recovery-rate differences. Geis et al. (1971) found that immature black ducks were less vulnerable later in the hunting season due to a learning process as the season progressed and through elimination by shooting of many of the more reckless individuals.

Survival

Previous Studies

Wood duck survival studies have been restricted to state or local estimates; few regional computations have been attempted. Mortality investigations in Maine and Vermont (Barden 1968), Massachusetts (Grice and Rogers 1965), and Pennsylvania (Decker 1959) demonstrated a wide range of composite-dynamic mortality estimates for adult males (47.0 percent to 54.0 percent), adult females (51.0 percent to 55.0 percent), and immatures (52.0 percent) to 82.0 percent). Smith et al. (1963) estimated wood duck mortality rates prior to 1962 in 10 northern states. The "unweighted" averages were: adult males, 49.6 percent; adult females, 52.6 percent; and immatures, 61.2 percent. In summarizing wood duck banding data prior to 1962,

Kimball and Anderson (1969) estimated a mortality rate of approximately 50 percent for adults and 60 percent for immatures.

None of the above studies used weighted estimates and most were based on the composite-dynamic technique which required the following strict assumptions: (1) constant annual survival rate, (2) constant population size, (3) constant recruitment rate, (4) constant hunting pressure, and (5) constant band reporting rate.

Survival estimates by the Seber method, which was used in my study, required none of the above assumptions. However, 1962 through 1968 mortality estimates of my investigation varied little from the above studies (adult males 45.0 percent, adult females 49.8 percent, immature males 57.1 percent, and immature females 55.5 percent).

Survival calculations for southern regions had large estimated variances due to insufficient banding and recovery data. The lack of survival estimates for immatures in the Southeastern Reference Area was partially responsible for low survival estimates of the Atlantic Flyway as shown in Table 30.

Differences in Survival

Earlier investigations by Smith et al. (1963), Grice and Rogers (1965), and Kaczynski (1968) revealed age and sex survival differences among wood ducks. Comparisons within my research produced similar findings; immatures

were less likely to survive than adults and adult females showed lower survival rates than adult males. The following factors, which were responsible for differences in recovery rates, were also believed to be responsible for survival descrepancies: (1) differential lack of wariness --immature versus adults, (2) differential chronology of migration, (3) higher natural mortality rates--especially adult females, (5) prolonged adult female associations with immatures, and (6) different nesting and behavioral characteristics.

Several earlier reports describing possible survival differences between populations of wood ducks were prepared by Grice and Rogers (1965) and Geis (1966). Their suspicions were confirmed by the results of my research. Wood ducks nesting above 42° north latitude had higher mortality rates than populations farther south. Direct recovery rates for southern populations were also significantly lower than those of northern populations, indicating that survival differences could have been due to hunting pressure. Similar hunting pressure and survival relationships have been documented for other species of waterfowl (Hickey 1952, Geis 1959, Geis and Smith 1962). However, correlations between high hunting pressure and low survival do not necessarily dictate a cause and effect relationship to shooting. The lower survival rates could also be influenced by high losses due to natural mortality elements. For example, Anderson (1975) concluded that mallard popu-

lation fluctuations were more closely associated with annual changes in productivity than with annual changes in survival rates.

Hunting Mortality

The proportion of total wood duck mortality due to hunting (51 to 59 percent for immatures and 44 to 58 percent for adults) compares favorably with estimates for other waterfowl species. However, comparisons with upland wildlife species reveal that wood ducks are more adversely affected by hunting than squirrel, rabbit, or quail populations. Geis (1963) discussed the role of hunting on waterfowl and pointed out the differential effects on resident game species and waterfowl. Waterfowl do not benefit from a self-regulation hunting-pressure process that occurs when resident species numbers are low. Migratory birds such as ducks are gregarious and utilize specific, limited types of habitat. Even when populations are low, sportsmen are able to locate and harvest waterfowl effectively. Also, unlike resident game species, waterfowl are exposed not to a single hunting season but a procession of hunting seasons as they migrate. Waterfowl have a hunting-season span many times longer than that of wildlife residing in one state, and they are exposed to the high hunting pressures of opening days in several states with continuing new groups of hunters. Studies on resident game species by Baskett (1947), Errington (1945), and Allen (1962) demon-

strated that increased hunting mortality is compensated for by decreases in natural mortality along with increases in production due to lessening of density dependent limiting factors. This is in contrast to studies on migratory game birds by Hickey (1952), Lauckhart (1956), and Geis (1963) which indicated that hunting pressure influences mortality rates of waterfowl. However, Anderson (1975) found that sampling variances of average mortality rates and average harvest rates for mallards were highly correlated. Such relationships would suggest that past correlation and regression analyses of harvest rates and survival rates produced misleading results. More recent studies of waterfowl populations have presented evidence that compensation of natural mortality does occur as a result of shooting (Anderson and Burnham 1976).

Hunting Regulations

Relationship to Direct Recovery Rates

Previous studies concerning waterfowl populations have led to conclusions that changes in hunting regulations were an effective way of reducing hunting pressure (Geis et al. 1971, Geis and Crissey 1969, Geis and Smith 1962). Some earlier wood duck studies have indicated similar relationships. Smith et al. (1963) showed that as hunting-season length increased or decreased, wood duck recovery rates changed in the same direction in 23 of 28 comparisons. Carney and Craft (1968) estimated that a wood duck

bag restriction from two to one was responsible for a 22.7 percent decrease of wood ducks in the hunters' bag.

Results of my study show that wood duck recovery rates were influenced by hunting-season length and bag limits. For reference areas above 42° north latitude, one of the most influential variables on direct recovery rates and thus hunting pressure was the total number of October hunting days. As previously mentioned, the migration of wood ducks is well underway during September and October in northern reference areas. Most of the wood ducks in far northern states have departed by late October; therefore, earlier seasons expose more birds to hunters and the heavy hunting pressures associated with opening dates.

Survival Relationships

In general, wood duck recovery rates were significantly correlated with survival rates, indicating a relationship between shooting pressure and survival. A trend which has been noted for other waterfowl species (Geis 1963, Martinson et al. 1968). Due to relationships between direct recovery rates and survival and direct recovery rates and regulations, inductive reasoning would also indicate a correlation between survival and hunting regulations. However, this could not be verified. Again, insufficient data coupled with wood duck regulation variables that changed very little during the period of study were believed to preclude any meaningful comparisons.

Another possible reason for ambiguity was the effects of bag limits of other waterfowl species. Other inconsistencies of survival and regulation comparisons could have been due to the fact that harvest, number of active hunters, and wood duck abundance were each estimates and, as such, were subject to the vagaries of sampling and bias error.

Population Status

Population Trends

Wood duck densities in the United States are estimated annually by the U.S. Fish and Wildlife Service following a technique described by Kaczynski and Geis (1961) and Geis (1966). Estimates by the Fish and Wildlife Service method from 1962 through 1968 revealed a slightly increasing wood duck population with a seven-year average of 2.6 million birds in the eastern United States. Estimates by the simultaneous equation technique of my study showed approximately 3.3 million wood ducks during the same period; a slightly higher estimate due mostly to the inclusion of eastern Canada, and the use of individual state direct-recovery rates in the recovery matrix. Other discrepancies between the two estimates are attributed to the following sources of error associated with the U.S. Fish and Wildlife Service technique: (1) the use of unweighted recovery rates to calculate an average recovery rate for each flyway, (2) an assumption that reporting rates were the same for all states, and (3) the disregard

for crossing over of wood ducks between flyways and Canada. Both techniques have common sources of error: (1) inadequate banded samples, (2) use of a parts-collection survey which is subject to large sampling errors, (3) reliance on harvest data that are subject to bias and sampling vagaries, and (4) imprecise means of estimating reporting rates.

The extent to which wood duck populations will increase, decline, or tend to stabilize depends upon the extent to which productivity matches mortality. Indirect population estimates derived from simultaneous equations show that over the 1962 through 1968 period immatures averaged 53.7 percent of the preseason population or an age ratio of 1.2 immatures per adult. Estimates obtained by adjusting annual age ratios in the harvest to those in the preseason population show a ratio of 1.14 immature females per adult female. A production ratio of 1.14 versus 1.10 (as estimated from survival rates of 50.2 percent for adult females and 45.5 percent for immature females) does indicate a trend of slightly increasing wood duck numbers during the 1962 through 1968 period. Admittedly the information used to assess population status was limited in both quantity and precision, and a comparison of rates of survival and productivity would have been more meaningful if measured on an annual rather than average basis. Nevertheless, these data do indicate a trend toward increasing wood numbers in the eastern United States and Canada. But as previously mentioned, survival rates, harvest, and loss of

forest habitats have differed within the various defined reference areas. Population levels within individual breeding areas could be increasing or declining, and this might not be reflected in the overall eastern North America trend.

Forest Habitat Trends (1950's and early 1960's)

During a 1965 wood duck management and research symposium, trends in forest habitats during the 1950's and early 1960's were discussed for various regions of the eastern United States. Stearns (1966) discussed forest habitat trends for the North Central states and emphasized changes in acreages of lowland hardwood forests and associated communities. Trends in these lowland types were believed to be most important due to associations with water as well as other biological and physical characteristics of lowlands. Characteristics such as (1) low durability and persistance leading to decay, (2) spreading crown forms contributing to splitting and breakage, and (3) low wood strength of such species as willow, cottonwood, and sycamore were considered important attributes contributing to cavity development. Stearns (1966) concluded that the forest acreages of these lowland types had declined greatly in the last 150 years, but recent indications (1950 to 1960) were that the decline had reversed.

In a similar review of five forest types thought to be important to wood ducks in the Northeastern sector of

the United States, Aultfather (1966) found that acreages of Oak-Gum-Cypress types had declined by 2.3 million acres (0.9 million hectares) during the 1950's and early 1960's. However, he concluded that this loss was being offset by gains in Oak-Hickory (plus 537 thousand acres or 217 thousand hectares), Elm-Ash-Cottonwood (plus 1.8 million acres or 0.7 million hectares), Maple-Beech-Birch (plus 152 thousand acres or 62 thousand hectares), and Aspen-Birch (plus 278 thousand acres or 112 thousand hectares).

In contrast to trends of stability in the northern sections of the United States, Hankla and Carter (1966) concluded that land use activities in the Southeastern states during the 1950's and early 1960's had produced an overall adverse impact on wood-duck forest habitats. Drainage and clearing were cited as the most prominent causes of decreasing wood duck habitats with flood control, pollution, and forest management practices also being cited as detrimental factors.

Forest Habitat Trends (1960 to 1970)

The 1950 and 1960 trends of stability in northern wood duck habitats and slightly decreasing acreages for southern hardwood forest began to change during the mid-1960's. Although commercial forest land of the northern United States increased by 2.8 million acres (1.1 million hectares) during this period, there was a 7.4 million acre (3.0 million hectares) loss of forest habitat in the

southern regions (U.S. Forest Service 1973a). More importantly, the combined acreages of hardwood forest types most essential to wood ducks (Oak-Gum-Cypress, Maple-Beech-Birch, and Elm-Ash-Cottonwood) revealed an overall net decrease in the eastern United States of 5.0 million acres (2.0 million hectares) during the 1960's (U.S. Forest Service 1965 and 1973a). Bottomland-hardwood forest types were reduced nearly 20 percent during this decade as a result of clearing forest lands for crops along the deltas of the Mississippi River and its tributaries. Although the net growth of Eastern hardwoods exceeded removal during the 1960's, the extensive clearing of bottomlands in the southern United States has resulted in a hardwood volume removal exceeding net growth (U.S. Forest Service 1973a).

Flood control, channelization, watershed protection, expanding agriculture, urban development, industrial use, irrigation, and water diversion projects were the incentives that resulted in a clearing of millions of acres of bottomland-hardwood forests and ditching of thousands of miles of streams in the southeastern and north-central sections of the United States.

Twenty million acres (8.1 million hectares) of wooded swamps, batture land, and overflow hardwood bottomlands remained along the Mississippi River and its tributaries during the 1950's. By mid 1960 hardwood-forest conversion to croplands in the lower half of the Mississippi River basin had resulted in a reduction of waterfowl

habitat values on approximately two-thirds of the overflow areas (U.S. Fish and Wildlife Service 1975). During the 1960's, an average of 200 thousand acres (81 thousand hectares) of bottomland hardwoods were cleared annually in the lower Mississippi River region (Ladd et al. 1974).

The rapid loss of prime wood duck habitat in southern reference areas is illustrated in Table 40. Almost 7 million acres (2.8 million hectares) of the best wood duck habitat (Oak-Gum-Cypress Type) was lost between 1963 and 1970. Madson (1974) and Yancey (1970) attributed a large portion of this forest loss to channelization which has led to the drainage of lowland forests and subsequent wholesale cutting. Madson (1974) pointed out that in western Tennessee, channelization has devasted 75 percent of the floodplain forest. During the 1960's, 150 thousand acres (60.7 thousand hectares) of bottomland timber and wetlands were also destroyed annually in neighboring Arkansas. Of the original 10 million acres (4 million hectares) of bottomland hardwoods in eastern Arkansas, less than 2 million (0.8 million hectares) remains. Similar circumstances have been documented for Louisiana by Yancey (1970). The bottomland-hardwood region of northern Louisiana was originally composed of approximately 5.6 million acres (2.3 million hectares). By 1969, land clearing operations had reduced this to 2.5 million acres (1.0 million hectares)--a rate of loss equal to 111 thousand acres (44.9 thousand hectares) per year between 1962 and 1968.

Assuming that this rate of loss will continue, only 630 thousand acres (255 thousand hectares) will be left in north Louisiana by 1985. Yancey (1970) predicted that such a loss will decrease wood duck populations in north Louisiana from the present 56 thousand to 8 thousand.

The overall decline of Eastern forest habitats important to wood ducks does not coincide with population trends that show an increase in wood duck numbers. Possible explanations for this anomaly are: (1) regional differences in forest trends and wood duck breeding densities, (2) nesting adaptability of the wood duck, (3) benefits of man-made nesting structures, (4) the expansion of beaver populations, and (5) an increase in the volume of hardwood growing stock classified as occurring in the larger tree-diameter classes.

Sixty percent of the Eastern wood duck breeding population occurred in northern reference areas where there was a 3.7 million acre (1.5 million hectare) increase in the Elm-Ash-Cottonwood forest type. I believe increases in this forest type more than compensated for decreases in northern forest types less valuable to the wood duck. The greatest loss of important forest habitats occurred in southern reference areas; however, only 40 percent of the breeding population was harbored in the south, and this is where a large resurgence of beaver populations has originated. The heavy use of beaver ponds by wood ducks and the importance of such ponds to wood duck broods has been

well documented (Beard 1953, Arner 1963, Webster and McGilvrey 1966). During the 1950's and 1960's, there was a pronounced increase in the density and range of beavers in the southern United States (Speake 1956, Arner et al. 1969, Woodward and Hair 1976, Hill 1976). The willingness of wood ducks to nest more than one-half mile from water and their enthusiasm for nesting in thousands of available man-made nesting boxes were other factors which could have cushioned the loss of bottomland-hardwood habitats. Another trend which offset the loss of forest habitats was an increase in the volume of hardwood growing stock classified in the larger tree-diameter classes. The production of tree cavities suitable for wood ducks, increases with an increase in tree diameter, especially when diameters at breast height exceed 19 inches (48.7 cm). Statistics compiled by the U.S. Forest Service for the period 1962 through 1970 show an 8 percent increase of hardwood growing stock exceeding 19 inches (48.7 cm) in diameter (U.S. Forest Service 1965 and 1973a).

Estimating Future Habitat Trends

Difficulties inherent with assessing wood duck habitat trends during the 1950's and early 1960's remained the same for evaluating trends during the 1960's and 1970's. Limiting factors were the lack of on-the-ground studies to define quantitatively and qualitatively forest habitats preferred by wood ducks. Because basic biological and

ecological forest habitat requirements are not available on a state or regional basis, there was no way of accurately verifying the impacts of land use other than in general terms such as changing acreages of various forest types.

There are several characteristics of trees and forest types which could influence their importance to wood ducks. Hansen's (1966) discussion of the decay process in specific trees and forest types shows that such features as tree size, longevity, distribution and density, sprouting, and susceptability to decay are important in cavity formation. Hansen also concluded that trees with the following traits were most likely to produce suitable wood duck cavities: a diameter at breast height greater than 16 inches (40.6 cm), long life expectancy, and location on a floodplain site. This was particularly true for species such as basswood and sycamore that could regenerate from sprouts, or those that were subject to splits, wind breakage, stem cankers, and woodpecker damage.

Weier's (1966) summary of wood duck nest sites in Missouri serves as an example of the type of field work presently needed in major forest types of each state. He conducted a cavity survey of the three timber types (Pin Oak-Overcup Oak, Elm-Ash-Maple, and Upland Hardwoods) occurring in the Mingo National Wildlife Refuge. The highest density of tree cavities was found in the Elm-Ash-Maple type (2.2/acre or 5.4/hectare), followed by the Upland Hardwood type (1.0/acre or 2.5/hectare), and Pin

Oak-Overcup Oak type (0.5/acre or 1.2/hectare). However, the greatest number of "suitable" wood duck cavities were found in the Upland Hardwoods type (0.3/acre or 0.7/hectare). In all forest types, the occurrence of cavities increased with tree size. There were few cavities in trees less than 15.5 inches (39.4 cm) dbh while trees greater than 27.5 inches (69.8 cm) dbh had the greatest number of cavities. Broken limbs were the origin of 61 percent of cavities, 18 percent were due to fire scar, lightning and logging caused 8 percent of the cavities, and at least 4 percent were due to woodpeckers. Cavities were most prominent in such species as black oak, black gum, willow, elm, red maple, cypress, and ash; thus leading to the conclusion that forest types with such mature and overmature cavity-prone species would be best for breeding wood ducks.

Bellrose et al. (1964), studying the relative value of natural cavities in Illinois wood lots and bottomland areas, found one natural cavity per 5 acres (2.0 hectares) in black-oak wood lots as opposed to one natural cavity per 16 acres (6.5 hectares) in bottomland species. Natural cavities with small entrances were preferred, with cavities containing over 5 thousand cubic inches not acceptable. Cavities high in trees, less than 50 inches (1.3 m) deep, and located over water were also preferred. Next in acceptance were those located in open parklike woods with cavities in dense woods being the least acceptable.

Prince (1968) found that silver maple and elm were

the better cavity forming species in floodplain forests of New Brunswick, and he also concluded that nesting wood ducks preferred forests that were relatively open.

Gigstead (1938) inspected actual nests of wood ducks in the Illinois River bottoms and found that 58 nests were located as follows: 51 percent in black oaks, 14 percent in red oaks, 12 percent in sycamore, 9 percent in pin oak, 8 percent in elm, and 6 percent in maple and basswood. He concluded that oak wood lots within a third of a mile from water made the most attractive nesting locations.

Baumgartner (1939) stated that the most important conditions in den formation for squirrels were size of limbs in which decay enters, location of tree, site factors influencing growth, presence of squirrels, water draining on the tree trunk, and age and density of the stand. It was also important to have a mixture of trees that would decay and develop den cavities at varying rates. For example: blackgum, beech, and maples were good candidates for forming dens within a few years, and oaks were good in their later years (Uhlig 1956, Nixon 1968).

It is apparent from the above studies that research concerning trends in forest habitats important to wood ducks must take into consideration the characteristics of individual tree species composing each forest type. Resistance to breakage and splitting, susceptibility to decay and bird damage, size and longevity, cavity formation, and sprouting characteristics are important factors to be

weighed. The densities (basal area) associated with various forest types and relationships with mesic sites must also be brought into play. The issue is further complicated by the importance of wood duck "brood" habitats. As with nesting habitats, there remains a lack of knowledge on the site and plant constituents that produce good brood habitat. Although some research describes what is believed to be the general characteristics of ideal brood habitat (Webster and McGilvrey 1966, Hardister et al. 1965), it has been pointed out that the descriptions were largely a matter of judgement or experience and not quantitative measurements.

SUMMARY AND CONCLUSIONS

This research was initiated in 1970 to study the wood duck, a waterfowl species dependent upon forest environments for food, shelter, and nesting. The wood duck is an important wildlife resource which consistently ranks third or fourth in the total United States waterfowl harvest and second in the Atlantic and Mississippi Flyway waterfowl harvests. Because its breeding range includes every state in the eastern United States, the wood duck is judged our most important resident waterfowl species.

Most studies of the wood duck have been local in nature and concentrated on life history events. The evaluation of wood duck populations on a broad regional or population-unit basis has been curtailed by their forest habitat, which precludes the use of conventional waterfowl survey methods to estimate wood duck population densities and production. The status and dynamics of the major wood duck populations of eastern North America have not been adequately assessed. A knowledge of regional differences in population size, forest habitats, harvest characteristics, hunting pressure, and survival would encourage more intensive management of this waterfowl resource.

The objectives of this study were to (1) identify different summer and winter populations of wood ducks in

eastern North America, (2) analyze survival, harvest, and density characteristics of each identified population, (3) determine area trends in forest habitats important to wood ducks, and (4) evaluate effects of hunting regulations and harvest on wood duck population status.

Data Source and Methods

Banding, recovery, and waterfowl survey records assembled by fish and wildlife agencies of the United States and Canada were the major sources of data used to identify and characterize wood duck populations in eastern North America. Only band recoveries obtained from wild wood ducks caught, banded, and released in a normal manner during the preseason (May through September) and winter (December through March) periods of 1950 through 1968 were used. Restrictions on periods of banding and recovery, status of banded birds, and manner of band recovery (shot or found dead) were necessary to ensure that banded birds were representative estimators of sampled populations.

Different populations were identified by plotting the geographic band-recovery locations (1 degree blocks of latitude and longitude) of wood ducks banded during preseason and winter periods, 1950 through 1968, and later shot or found dead during a hunting season. States and provinces from which the geographic distribution of recoveries showed similar patterns were combined into reference areas.

Three indirect approaches were used to estimate average indices of wood duck abundance for states and provinces within each reference area. The first estimate, forest values, was based on a subjective assignment of importance values to six major forest types occurring in eastern North America. Numerical importance values (0.5 to 10.0) for each type were based upon known wood duck habitat requirements, silvical characteristics of each forest type, and the general physiography of the state in which each type occurred. A population density index was obtained by summing the products of forest-type acreages and assigned wood duck importance values. The second method (FHMUP) used estimates of wood duck abundance described in a 1965 waterfowl population-density model developed jointly by state conservation departments and the U.S. Fish and Wildlife Service. The third technique consisted of solving a set of simultaneous linear equations by means of computer. Adjusted matrices of harvest rates and wood duck harvest were utilized in this mathematical estimate of wood duck abundance.

Weighting factors for banded wood ducks were obtained by dividing the number of preseason banded birds of each state or province into the estimated population density of that area. This provided an estimate of the number of wood ducks represented by each banded sample.

Numbers of wood ducks harvested during 1962 through 1968 were obtained from hunter harvest-survey and wing-

collection data filed with the U.S. Fish and Wildlife Service. The harvest distribution of adults and immatures was determined from weighted direct recoveries (1950 through 1968) and weighted wing-collection surveys (1962 through 1968) administered by the U.S. Fish and Wildlife Service. The source of wood ducks harvested in states and reference areas was calculated exclusively from weighted direct recoveries of wood ducks banded May through September 1950 through 1968. Temporal harvest patterns by age and sex were estimated from monthly direct recoveries of wood ducks banded May through September 1950 through 1968 and from weighted wing-collection data, 1962 through 1968.

Estimated annual and average annual survival rates for adult and immature sex classes were calculated from banding and recovery data, 1950 through 1968. These data were submitted to a computer program which provided time-specific survival estimates, associated variances, and goodness-of-fit tests. Reference-area survival rates were estimated by weighting (based on population density) and averaging the annual survival rates of component states or by calculating annual survival rates from the composite of all banding and recovery data related to a reference area.

Reference area banding quotas necessary to reduce survival variance estimates were obtained from survival and direct recovery rates. The procedure was to create numerous sets of data by utilizing constant survival rates

and fixed direct recovery rates, but varying the numbers-banded variable. Deterministic data sets were submitted continuously to a computer program until a change in the numbers-banded variable produced the predetermined survival rate and an associated coefficient of variation between 10 and 20 percent.

Chi-square tests were used to see if the proportion of banded wood ducks recovered by hunters differed between geographic areas or time intervals. A least squares analysis of variance and orthogonal comparisons were conducted to evaluate age-sex differences in direct recovery rates.

The student's "t" test and paired "t" tests were employed to examine mean survival differences for birds banded above and below 42° north latitude and for differences among wood ducks banded in various flyway states. Nonparametric tests were used to test the response of recovery and survival rates to changes in hunting regulations. Nonparametric tests were also employed to determine what directional change (+ or -) survival rates would take when compared with periods of extremely low and high hunting pressure.

Multiple regression analyses, with the maximum R^2 improvement procedure, were conducted to identify what hunting-regulation variables explained the greatest variation in hunting pressure as measured by direct recovery rates.

Populations

Large numbers of wood ducks had been banded and recovered prior to 1969, but restrictive criteria left a maximum of 14 thousand recoveries for identification of breeding reference areas. Plotted recoveries revealed little interchange of wood ducks (8 to 10 percent) between the two eastern flyways; however, the geographic recovery distributions of more than 130 thousand banded birds were of sufficient difference to identify six major summer reference areas. States within the Atlantic Flyway, plus Ontario and Quebec, were grouped into three reference areas (Northeastern, New York-Eastern Canada, and Southeastern). Three reference areas were also identified for the Mississippi Flyway (North Central, Lake States, and Southern). Only 730 recoveries were available to define the two winter reference areas (Atlantic and Gulf Coast).

Combined population density estimates showed that 52 percent of the summer wood duck population of eastern North America occurred in the Mississippi Flyway, 38 percent inhabited the Atlantic Flyway, and 10 percent were harbored in Ontario and Quebec. The calculated density distribution by reference areas was as follows:

Reference Area	Density Distribution
	Percent
North Central	25
Southeastern	19
Southern	18
New York-Eastern Canada	14
Northeastern	14
Lake States	10

A combination of 10 states possessed more than 50 percent of the Eastern breeding population.

The limited crossover of wood ducks between flyways indicates a good biological basis for administrative management within existing flyway boundaries. However, more intensive management can be obtained if a reference-area management scheme is adopted. Differences in hunting pressure, kill, and harvest characteristics are sufficiently large to warrant a movement toward differential hunting regulations for wood ducks. However, optimal management by reference areas cannot be obtained until more accurate density estimates are possible for each population. Individually, forest value and FHMUP techniques are too subjective for present use. Limiting factors are a lack of field studies that document forest habitats preferred by wood ducks and their broods. I believe mathematical techniques (simultaneous equations) hold more promise as a useful means for indirectly estimating population numbers. Unfortunately, U.S. Fish and Wildlife waterfowl-survey techniques and state banding efforts are currently

inadequate for reliable mathematical estimates.

Harvest

Total annual harvest, 1962 through 1968, averaged 0.5 million wood ducks, but harvest approached 1.0 million during the early 1970's. Hunters bagged almost 20 percent of the preseason population. Corrections for crippling loss elevated wood duck kill rates to 30 percent of the preseason population. Estimates of harvest distribution varied; however, most wood ducks were bagged in the Mississippi Flyway (48 to 55 percent), Atlantic Flyway (26 to 40 percent) and eastern Canada (10 to 17 percent). A few states, six or seven within each flyway, were responsible for 70 percent of flyway harvest.

An average of 3 to 4 percent of the wood ducks banded in southern regions were harvested in northern states the first year following banding; conversely, an average of more than 40 percent of the northern banded birds were harvested on the wintering grounds. Among northern banded birds, most were harvested within the reference area of banding (immatures 61 percent, adults 44 percent) or on southern wintering sites. Few were harvested in adjacent northern reference areas (immatures 9 percent, adults 7 percent). Harvest distributions for northern wood ducks differed significantly among age-sex groups ($p \leq 0.01$). Immatures and adult females were more

likely to be shot within the reference area where banded (October and early November harvest), whereas northern adult males predominated in the late winter harvest of southern states (December and January). Harvest derivation data demonstrated that northern states derived most of their harvested wood ducks (88 to 92 percent) from locally produced birds as opposed to southern states which derived, on the average, only 40 percent of their harvest from native wood ducks. Peak harvest of northern populations occurred in October as compared to December for southern populations. A delay, until early November, in the opening of northern hunting seasons was often followed by marked decreases in the number of wood ducks harvested.

Wood duck distribution, derivation, and temporal differences in harvest lead to several conclusions. Changes in harvest within northern states are more likely to affect immatures and adult females, rather than adult males. Changes in harvest levels late in the year on wintering grounds will have greater impact upon adult males from northern populations. However, other age-sex groups can be affected by late winter harvest since more than one-half of the southern bag is composed of northern birds. The relationships between northern hunting seasons and temporal movements of wood ducks demonstrate that a delay in the opening of northern hunting seasons beyond October can reduce wood duck numbers harvested in northern states.

Recovery and Survival Rates

First year recovery rates differed significantly between wood duck age-sex groups ($p \leq 0.01$). Immature recovery rates were higher than adult rates ($p \leq 0.01$), and males were more likely to be recovered than females ($p \leq 0.05$). In general, band recoveries of Atlantic Flyway birds were higher than those of wood ducks banded in the Mississippi Flyway ($p \leq 0.01$). Adult wood duck recovery rates in eastern North America ranged from 0.026 to 0.066, and immature rates varied from 0.025 to 0.091. Recovery rates for birds banded above 42° north latitude were significantly higher than rates for wood ducks banded below this line ($p \leq 0.01$).

Throughout their range, adult wood ducks demonstrated significantly higher rates of survival than immatures ($p \leq 0.01$). Average adult male survival rates were higher than those of adult females ($p \leq 0.05$), but average survival was essentially the same for immatures ($p > 0.10$). The lowest survival rates were most often associated with birds banded in northern states; whereas, the higher survival rates were characteristic of southern banded birds. Excluding immature females, wood ducks banded above 42° north latitude had significantly lower survival rates than birds banded below this line ($p \leq 0.05$). The average survival rates for wood ducks banded 1960 through 1968 was

as follows: adult males, 45.0 percent; adult females, 49.8 percent; immature males, 57.1 percent; and immature females, 55.5 percent. The proportion of total annual mortality due to hunting averaged 54.0 percent and ranged from a high of 59.4 percent for adult males to a low of 44.0 percent for adult females.

The variations in recovery rates among wood duck age-sex groups and geographical areas are indicative of hunting pressure discrepancies. A lack of wariness by immatures, migrational timing, differences in natural mortality, behavioral characteristics, and hunter selectivity were forces responsible for recovery differences among wood ducks. The heavy hunting pressures experienced by migrating northern wood ducks were the result of encountering a procession of opening hunting-season dates of several states. The overall effect was an extended hunting season and heavy gunning pressure. Recovery rates and thus hunting pressure of southern wood duck populations were low due to buffering effects of northern wood ducks, and because southern birds were exposed to shorter hunting periods.

Throughout eastern North America there are age and sex and often geographical differences in wood duck survival rates. However, I feel that banding and recovery records were not adequate to assess the extent to which there were real differences in survival rates between the

six population reference areas. Higher survival rates of several southern areas do suggest an opportunity for increases in hunting recreation. However, any increased harvest in southern regions should occur before the major influx of northern migrants and preferably only after additional banding programs have verified significant survival differences between populations.

Hunting Regulations

Comparisons between hunting regulations and the wood duck harvest index revealed a direct relationship. A larger fraction of the eastern North American population (0.08 to 0.15) was harvested during periods of liberal waterfowl regulations. In 47 immature male and 45 immature female comparisons of direct recovery rates and hunting regulations, direct recovery rates increased 40 times in direct relation to increases in liberalization of hunting regulations ($p \leq 0.01$). Similar relationships prevailed for adults ($p \leq 0.05$). The total number of waterfowl hunting days in October and total Flyway hunting days were regulation variables exhibiting high coefficients of determination with the dependent variable, direct recovery rate.

Correlation tests involving direct recovery rates and corresponding survival rates for selected states revealed the following relationships: immature male, $r = -0.69$

($p \leq 0.01$); immature female, $r = -0.23$ ($p > 0.05$); adult male, $r = -0.84$ ($p \leq 0.01$); and adult female, $r = -0.67$ ($p > 0.05$). Changes in survival rates could not be related to extreme changes in the direct recovery rates of immature males ($p > 0.25$) or immature females ($p > 0.64$). The associated probability of occurrence of high survival with strict hunting regulations was 0.19 for immature males and 0.27 for immature females.

It appears that wood duck direct recovery rates, and thus hunting pressure, are influenced by length of waterfowl season and "duck" bag limits. In years with liberal regulations, direct recovery rates will be high and the harvest index will increase. Conversely, the more restrictive waterfowl regulations will be characterized by lower recovery rates and a reduced harvest index. Influential regulation variables affecting hunting pressures on "northern" populations are the total number of October hunting days and total hunting days in a parent flyway. This implies that a delaying of the hunting season until late October or early November, and/or a reduction of total flyway hunting days, will be most productive in decreasing hunting pressure. Relationships between hunting regulations and survival rates are not conclusive. Significant associations may materialize when direct recovery rate and survival comparisons are limited to periods with large banded samples, but even then, exceptions can occur. This

does not mean that wood duck survival rates are not influenced by hunting regulations. Insufficient recovery data, inaccurate surveys, hunting regulations for other waterfowl species, and relatively stable wood duck hunting restrictions have precluded the detection of any possible cause and effect relationships.

Population and Habitat Status

The average preseason estimate of wood duck numbers during 1962 through 1968 was 3.3 million birds. Estimates of the immature to adult ratios ranged from 1.2 to 1.3, and the sex ratios were 1.13 adult males per adult female and 1.19 immature males per immature female. The average 1962 through 1968 preseason production ratio was 1.14 immature females per adult female.

During the 1960's more than 13 million acres (5.3 million hectares) of forest habitats having potential for wood ducks were lost in eastern North America. Critical losses of the most valuable habitats occurred in southern reference areas where more than 600 thousand acres (243 thousand hectares) of bottomland hardwoods were lost annually. Overall, there was a 20 percent decrease in bottomland-hardwood forest in eastern North America during the 1960's.

Although wood duck kill rates approached 29 percent and hunting was responsible for 54 percent of total annual

mortality, productivity was more than sufficient to replace mortality. Consequently, wood duck populations increased in numbers during the 1960's. I should stress that this increase was for the entire Eastern population. Individual breeding populations could vary from such a trend, and this would not necessarily be reflected in an overall estimate. Although wood duck numbers increased during the decade of the 1960's, there was a definite trend toward decreasing forest acreages important to nesting wood ducks. This is particularly true for floodplain forests where drainage, channelization, clearing for crops, flood control, pollution, and forest management practices have acted as detrimental factors. The extensive loss of southern-forest nesting habitats was cushioned by increases in beaver populations and thus increases in wood duck brood habitats. Nevertheless, if the past trend of vanishing bottomland-hardwood forests continues; there will be a reduction in wood duck carrying capacity of many southern states.

Banding

Restrictions on banding data left a maximum of 20 thousand recoveries for analysis. The greatest number of wood ducks (63,524) was banded in the North Central Reference Area as compared to a low of 5,446 in the Southeastern Reference Area. Annual reference-area banding quotas were calculated as follows:

Reference Area	Wood Duck Banding Quota
North Central	8,300
Lake States	6,600
Southern	8,500
New York-Eastern Canada	6,300
Northeastern	7,500
Southeastern	8,500
Total	45,700

Although large numbers of wood ducks had been banded prior to 1970, much of the recovery data could not be used due to inconsistent banding efforts and season of year that banding occurred. To estimate parameters that are associated with specific wood duck populations, samples should be banded when wood ducks are on their breeding grounds. Banding intensity was also inadequate for studying population characteristics of several reference areas. Notable deficiencies were in Quebec, portions of Ontario, Maritime Provinces, several Atlantic Coastal states, and a majority of those states in the Southern and Southeastern Reference Areas. Sufficient banded samples can be obtained if banding quotas are assigned to reference areas followed by an allocation of subquotas to individual states. Until satisfactory population estimates of wood ducks can be obtained, I believe banding will continue to be the most useful technique available for monitoring survival and harvest characteristics.

Implications and Recommendations

Administratively and biologically there is a good basis for management of wood ducks within existing boundaries of the two eastern flyways; however, there are strong implications that management by reference areas would offer considerably more opportunities for differential hunting regulations and thus more intensive management of the resource. As an example, limited data show sufficient recovery and survival rate differences among geographical areas to suggest more liberal hunting regulations for wood duck populations of the deep south. However, such a liberalization should not occur while northern birds are on the wintering grounds because wood ducks from many northern populations are exposed to heavy shooting pressure and low survival rates. An experimental, early September wood-duck hunting season would be more appropriate, and such a season would also provide valuable information on the migrational behavior and early fall movement of northern birds into southern harvest areas.

In the absence of a direct census to estimate wood duck numbers, the most promising solution lies in the development of mathematical models to indirectly estimate population abundance. Ambiguous estimates of this study were the result of inadequate federal survey data and sampling vagaries. I recommend the initiation of larger and more consistent banding and hunter-survey programs to

improve sampling frames utilized by the U.S. Fish and Wildlife Service. A wood duck reward-band study should be given serious consideration in order to obtain representative reporting rate estimates. I also recommend additional investigations to determine the accuracy and precision of simultaneous equation estimates under various conditions of banding effort, hunting pressure, and reporting rate trends. Future goals should be to estimate population densities within individual reference areas, and the simultaneous equation approach is one means by which this can be accomplished.

There is, and will continue to be, a desire to show the relative importance of Eastern forest types to wood ducks. I recommend additional on-the-ground studies to define quantitatively and qualitatively forest habitats preferred by wood ducks and their broods. Individual tree characteristics that should be documented during such studies are as follows: resistance to breakage and splitting, susceptability to decay and bird damage, maximum size and longevity, other cavity formation traits, sprouting capabilities, and wood duck food-production potential. Important site qualities to be noted are basal area, soil moisture, light intensity, associated plant species, and actual use by wood ducks.

Length of the waterfowl season, "duck" bag limits, number of October hunting days, and wood duck movements

were important factors affecting hunting pressure and harvest of wood ducks, and they should be assessed whenever a change in harvest is desired. The relationships between shooting mortality, survival, and regulations could not be documented; therefore, much additional research is needed to evaluate the impact of hunting upon wood duck survival. Such research will require that hunting restrictions for wood ducks be allowed to vary as opposed to the unchanging regulations of past decades.

I recommend that banding be continued and expanded as the major method for monitoring harvest, estimating survival rates, and better defining wood duck reference areas. A larger banding effort is especially needed in reference areas of the south, in several Canadian provinces, and in numerous states along the Atlantic Coast. In order to minimize the marking of transient birds, prehunting season banding should be restricted to May 1 through August 31 in northern states and May 1 through September 30 in southern states. The importance of adequate and consistent banding cannot be over-emphasized. A large banding effort in one year, followed by little effort in the next, eliminates data from both years for the purpose of calculating survival. Also, for maximum usefulness, adequate samples of each age and sex must be marked annually.

Some of the most valuable forest habitats of the

wood duck are decreasing at an alarming rate. I strongly recommend that state and federal conservation agencies begin identifying remaining bottomland-hardwood areas that can be placed permanently under their stewardship either as wildlife management areas, wildlife refuges, or national recreation areas. These agencies should also closely monitor drainage programs proposed or being conducted by other state or federal departments to insure that waterfowl and other wildlife impacts are given consideration during initial planning phases.

LITERATURE CITED

Allen, D.L. 1962. Our wildlife legacy. Funk and Wagnalls Co., New York. 422 p.

Anderson, D.R. 1975. Population ecology of the mallard V. temporal and geographic estimates of survival, recovery, and harvest rates. U.S. Fish and Wildl. Serv. Res. Publ. 125. 110 p.

__________, and K.P. Burnham. 1976. Population ecology of the mallard VI. the effect of exploitation on survival. U.S. Fish and Wildl. Serv. Res. Publ. 128. 66 p.

__________, and C.J. Henny. 1972. Population ecology of the mallard I. a review of previous studies and the distribution and migration from breeding areas. U.S. Fish and Wildl. Serv. Res. Publ. 105. 166 p.

__________, C.F. Kimball, and F.R. Fieher. 1974. A computer program for estimating survival and recovery rates. J. Wildl. Manage. 38(2):369-370.

Arner, D.H. 1963. Production of duck food in beaver ponds. J. Wildl. Manage. 27(1):76-81.

__________, J. Baker, D. Wesley, and B. Herring. 1969. An inventory and study of beaver impounded water in Mississippi. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 23:110-128.

Atwood, E.L. 1956. Validity of mail survey on bagged waterfowl. J. Wildl. Manage. 20(1):1-16.

Aultfather, W.A. 1966. Impact of forest management and other human activities on northern wood duck habitat. Pages 32-39 in L.R. Jahn, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, D.C. 212 p.

Barden, L.S. 1968. A population analysis of Maine-banded wood ducks. M.S. thesis. Univ. Maine, Orono. 109 p.

Barr, A.J., and J.H. Goodnight. 1972. A user's guide to the Statistical Analysis System. Dep. of Statistics, North Caroline State Univ., Raleigh, N.C. 260 p.

Barrett, J.W. 1962. Regional silviculture of the United States. The Ronald Press Co., New York. 610 p.

Baskett, T.S. 1947. Nesting and production of the ring-necked pheasant in north-central Iowa. Ecol. Monog. 17(1):1-30.

Baumgartner, L.L. 1939. Fox squirrel dens. J. Mamm. 20(4):456-465.

Beard, E.B. 1953. The importance of beaver in waterfowl management of the Seney National Wildlife Refuge. J. Wildl. Manage. 17(4):398-436.

Bellrose, F.C. 1976. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, Pa. 544 p.

__________, and E.B. Chase. 1950. Population losses in the mallard, black duck, and blue-winged teal. Ill. Nat. Hist. Surv., Biol. Notes 22. 27 p.

__________, and R.D. Crompton. 1970. Migrational behavior of mallards and black ducks as determined from banding. Ill. Nat. Hist. Surv. Bull. 30-3:234 p.

__________, K.L. Johnson, and T.U. Meyers. 1964. Value of natural cavities and nesting houses for wood ducks. J. Wildl. Mange. 28(4):661-676.

Beshears, W.W., Jr. 1974. Wood ducks in Alabama. Al. Dep. of Conserv. and Nat. Res., Spec. Rep. 4, Proj. W-35--Job I-F. 45 p.

Carney, S.M., and R.L. Craft. 1968. Probable effects of changes in the daily bag limit on wood duck kill during the 1967 hunting season in the Mississippi Flyway. U.S. Fish and Wildl. Serv., Migratory Bird Populations Station, Laurel, Md., Admin. Rep. 160 (mimeographed).

__________, M.F. Sorensen, and E.M. Martin. 1975. Distribution in states and counties of waterfowl species harvested during the 1961-70 hunting seasons. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 187. 132 p.

Chamberlain, E.B., D.S. Benning, E.L. Ferguson, M.M. Smith, and J.L. Hall. 1972. Waterfowl status report. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 166. 145 p.

Chan, B.C.K. 1972. Population modeling of the wood duck in eastern North America. M.S. thesis. La. State Univ., Baton Rouge. 130 p.

Chapman, D.C., and C.O. Junge, Jr. 1956. The estimation of the size of a stratified animal population. Ann. Math. Stat. 27:375-389.

Cringan, A.T. 1971. Status of the wood duck in Ontario. Trans. North Am. Wildl. Conf. 36:296-312.

Crissey, W.F. 1955. The use of banding data in determining waterfowl migration and distribution. J. Wildl. Manage. 19(1):75-84.

Cunningham, E.R. 1968. A three year study of the wood duck on the Yazoo National Wildlife Refuge. Proc. Annu. Conf. of the Southeast. Assoc. of Game and Fish Comm. 22:145-155.

Decker, E. 1959. A 4-year study of wood ducks on a Pennsylvania marsh. J. Wildl. Manage. 23(3):310-315.

Dixon, R.M. 1963. The forest resources of Ontario. Ontario Dep. of Lands and Forests. 107 p.

Errington, P.L. 1945. Some contributions of a 15 year local study of the northern bobwhite to a knowledge of population phenomena. Ecol. Monog. 15(1):1-34.

Fowells, H.A. (ed.). 1965. Silvics of forest trees of the United States. USDA Forest Serv. Handb. 271. 762 p.

Geis, A.D. 1959. Annual and shooting mortality estimates for the canvasback. J.Wildl. Manage. 23(3):253-261.

__________. 1963. Role of hunting regulations in migratory bird management. Trans. North Am. Wildl. Conf. 28:164-172.

__________. 1966. Establishing the status of wood duck populations--success and problems. Pages 183-192 in L.R. Jahn, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, D.C. 212 p.

__________. 1972. Use of banding data in migratory game bird research and management. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 154. 47 p.

__________, and E.L. Atwood. 1961. Proportion of recovered waterfowl bands reported. J. Wildl. Manage. 25(2):154-159.

__________, and F.G. Cooch. 1972. Distribution of the duck harvest in Canada and the United States. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 151. 11 p.

__________, and W.F. Crissey. 1969. Effects of restrictive hunting regulations on canvasback and redhead harvest rates and survival. J. Wildl. Manage. 33(4):860-866.

__________, and R.I. Smith. 1962. Black duck recovery rates in relation to hunting regulations. U.S. Fish and Wildl. Serv., Migratory Bird Populations Station, Laurel, Md., Admin. Rep. 2(mimeographed).

__________, R.K. Martinson, and D.R. Anderson. 1969. Establishing hunting regulations and allowable harvest of mallards in the United States. J. Wildl. Manage. 33(4):848-859.

__________, R.I. Smith, and J.P. Rogers. 1971. Black duck distribution, harvest characteristics, and survival. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 139. 241 p.

Gigstead, G. 1938. Wood ducks in the Illinois river bottoms. Trans. North Am. Wildl. Conf. 3:603-609.

Grice, D., and J.P. Rogers. 1965. The wood duck in Massachusetts. Mass. Div. of Fisheries and Game, Final Rep. Proj. No. W-19-R. 96 p.

Hankla, D.J., and V.E. Carter. 1966. Impact of forest management and other human activities on wood duck habitat in the Southeast. Pages 29-36 in L.R. Jahn, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, D.C. 212 p.

Hansen, H.L. 1966. Silvical characteristics of tree species and decay processes as related to cavity production. Pages 65-69 in L.R. Jahn, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, D.C. 212 p.

Hardister, J.P., F.E. Hester, and T.L. Quay. 1965. Movements of juvenile wood ducks as measured by web-tagging. Proc. Annu. Conf. of the Southeast. Assoc. of Game and Fish Comm. 16:70-75.

Harlow, W.M., and E.S. Harrar. 1958. Textbook of dendrology. McGraw-Hill Book Co., New York. 561 p.

Hawkins, A.S., and F.C. Bellrose. 1941. Wood duck habitat management in Illinois. Trans. North Am. Wildl. Conf. 5:392-395.

Hein, D., and A. Haugen. 1966. Autumn roosting flight counts as an index to wood duck abundance. J. Wildl. Manage. 30(4):657-668.

Hester, F., and T. Quay. 1961. A three-year study of the fall migration and roosting-flight habits of the wood duck in east-central North Carolina. Proc. Annu. Conf. of the Southeast. Assoc. of Game and Fish Comm. 15:55-60.

Hickey, J.J. 1952. Survival studies of banded birds. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 15. 177 p.

Hill, E.F. 1976. Control methods for nuisance beaver in the southeastern United States. Pages 85-98 in C. Siebe, ed. Proc. of the 7th Vertebr. Pest Conf. 323 p.

Kaczynski, C.F. 1968. Wood duck recovery data for 1967 and preseason population estimates, 1961-67. U.S. Fish and Wildl. Serv., Migratory Bird Populations Station, Laurel, Md., Admin. Rep. 53(mimeographed).

__________, and A.D. Geis. 1961. Wood duck banding program progress report 1959 and 1960. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 59. 41 p.

Kimball, C.F., and D.R. Anderson. 1969. Wood duck band recovery data for 1968 and preseason population estimates. U.S. Fish and Wildl. Serv., Migratory Bird Populations Station, Laurel, Md., Admin. Rep. 179(mimeographed).

Ladd, W., J.P. Linduska, and M.F. Sorensen. 1974. Waterfowl wetlands in the United States: their abuse and salvation. Internat. Conf. on Wetlands and Waterfowl, Heiligenhafen Federal Republic of Germany. 25 p. (mimeographed).

Lauckhart, J.B. 1956. Calculating mortality rates for waterfowl. The Murrelet 37(3):31-34.

Leopold, F. 1951. A study of nesting wood ducks in Iowa. Condor 53(5):209-220.

Li, J.C.R. 1964. Statistical inference I. Edward Brothers Inc., Ann Arbor, Mich. 658 p.

Madson, J. 1974. Deathbeds for rivers. La. Conservationist. 26(1-2):18-23.

Manning, G.H., and H.R. Grinnell. 1971. Forest resources and utilization in Canada to the year 2,000. Dep. of the Environment, Can. Forest Ser. Publ. No. 1304. 80 p.

Martin, E.M., and A.O. Haugen. 1960. Seasonal changes in wood duck roosting flight habits. The Wilson Bull. 72(3):238-243.

Martinson, R.K. 1966. Band recovery data (1965) and pre-season population estimates for wood ducks (1960-65). U.S. Fish and Wildl. Serv., Migratory Bird Populations Station, Laurel, Md., Admin. Rep. 114 (mimeographed).

__________, A.D. Geis, and R.I. Smith. 1968. Black duck harvest and population dynamics in eastern Canada and the Atlantic Flyway. Pages 21-32 in P. Barske, ed. The black duck-evaluation, management, and research: a symposium. Atlantic Waterfowl Council and Wildl. Manage. Inst., Washington, D.C. 193 p.

McGilvrey, F.B. 1968. A guide to wood duck production habitat requirements. U.S. Fish and Wildl. Serv. Res. Publ. 60. 32 p.

McLaughlin, C.L., and D. Grice. 1952. The effectiveness of large-scale erection of wood duck boxes as a management procedure. Trans. North Am. Wildl. Conf. 17:242-259.

Moisan, G., R.I. Smith, and R.K. Martinson. 1967. The green-winged teal: its distribution, migration, and population dynamics. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 100. 247 p.

Nixon, C.M. 1968. Squirrel management guidelines for wildlife areas. Ohio Dep. of Nat. Resources Div., Inservice Document 55. 8 p.

Odum, R.R. 1970. Nest box production and brood survival of wood ducks on the Piedmont National Wildlife Refuge. Proc. Annu. Conf. of the Southeast. Assoc. of Game and Fish Comm. 24:108-117.

Overton, W.S., and D.E. Davis. 1969. Estimating the number of animals in wildlife populations. Pages 403-455 in R.H. Giles, ed. Wildlife management techniques, 3rd ed., revised. Wildl. Soc., Washington, D.C. 623 p.

Prince, H.H. 1968. Nest sites used by wood ducks and common goldeneyes in New Brunswick. J. Wildl. Manage. 32(3):489-500.

Seber, G.A.F. 1970. Estimating time-specific survival and reporting rates for adult birds from band returns. Biometrika 57(2):313-318.

__________. 1972. Estimating survival rates from bird-band returns. J. Wildl. Manage. 36(2):405-413.

Shaw, S.P., and C.G. Gredine. 1956. Wetlands of the United States, their extent and their value to waterfowl and other wildlife. U.S. Fish and Wildl. Serv. Circular 39. 67 p.

Shroeder, L.D., M.F. Sorensen, and S.M. Carney. 1974. Waterfowl harvest and hunter activity in the United States during the 1973 hunting season. U.S. Fish and Wildl. Serv., Migratory Bird Populations Station, Laurel, Md., Unnumbered Admin. Rep. (mimeographed).

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., New York. 312 p.

Smith, R.I., and A.D. Geis. 1961. Pre-hunting season banding of mallards and black ducks--progress report 1959 and 1960. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 60. 29 p.

__________, S.V. Goddard, and A.D. Geis. 1963. Analysis of some wood duck bandings and report on the 1962 wood duck banding program. U.S. Fish and Wildl. Serv., Migratory Bird Populations Station, Laurel, Md., Admin. Rep. 21(mimeographed).

Snedecor, G.W., and W.G. Cochran. 1967. Statistical methods. Iowa State Univ. Press, Ames. 593 p.

Society of American Foresters. 1954. Forest cover types of North America (exclusive of Mexico). Society of American Foresters, Washington, D.C. 67 p.

Speake, D.W. 1956. Waterfowl use of creeks, beaver swamps, and small impoundments in Lee County, Alabama. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 9:178-185.

Stearns, F. 1966. Present and future status of forests along surface waters of the north central states. Pages 5-22 in L.R. Jahn, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, D.C. 212 p.

Stewart, P.A. 1958. Local movements of wood ducks (Aix sponsa). Auk 75(2):157-168.

Stewart, R.E., A.D. Geis, and C.E. Evans. 1958. Distribution of populations and hunting kill of the canvasback. J. Wildl. Manage. 22(4):333-370.

Sutherland, D.E. 1971. A 1965 waterfowl population model. U.S. Fish and Wildl. Serv., Flyway Habitat Manage. Unit Proj. Rep. 4. 126 p.

Tabberer, D.K. 1969. The wood duck roost count as an index to wood duck abundance in Louisiana. M.S. thesis. La. State Univ., Baton Rouge. 77 p.

Uhlig, H.G. 1956. The gray squirrel in West Virginia. West Virginia Conserv. Comm. Div. of Game Manage. Bull. 3. 83 p.

U.S. Fish and Wildlife Service. 1961. Waterfowl status report. U.S. Fish and Wildl. Serv. Spec. Sci. Rep.--Wildl. 61. 122 p.

__________. 1975. Final environmental statement for the issuance of annual regulations permitting the sport hunting of migratory birds. USDI. 71 p.

U.S. Forest Service. 1958. Timber resources for America's future. USDA Forest Res. Rep. 14. 713 p.

__________. 1965. Timber trends in the United States. USDA Forest Res. Rep. 17. 235 p.

__________. 1972. Forest statistics for the United States, by state and region, 1970. USDA Forest Serv. 96 p.

__________. 1973a. The outlook for timber in the United States. USDA Forest Res. Rep. 20. 367 p.

__________. 1973b. Silvicultural systems for the major forest types of the United States. USDA Handb. 445. 114 p.

Webster, C.G., and F.B. McGilvrey. 1966. Providing brood habitat for wood ducks. Pages 70-75 in L.R. Jahn, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, D.C. 212 p.

Weier, R.W. 1966. A survey of wood duck nest sites on Mingo National Wildlife Refuge in southeast Missouri. Pages 91-112 in L.R. Jahn, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, D.C. 212 p.

Woodward, D.K., and J.D. Hair. 1976. Status of beaver in South Carolina as determined by a postal survey of landowners. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 19 p. (in press).

Yancey, R.K. 1970. Our vanishing delta hardwoods. La. Conservationist. 22(3-4):26-31.

APPENDIX A

Estimating Wood Duck Abundance, Harvest Derivation and Harvest Distribution

TABLE 4.2.--Acres and wood duck values of commercial forests by forest type[1]

Location	Elm-Ash-Cottonwood Acres	Elm-Ash-Cottonwood Value	Maple-Beech-Birch Acres	Maple-Beech-Birch Value	Aspen-Birch Acres	Aspen-Birch Value	Oak-Hickory Acres	Oak-Hickory Value	Spruce-Fir Acres	Spruce-Fir Value	Oak-Gum-Cypress Acres	Oak-Gum-Cypress Value
Mississippi Flyway												
Alabama	94	10.0	. . .	6.0	. . .	7.0	5,106	2.0	. . .	3.0	2,271	10.0
Arkansas	476	8.0	. . .	6.0	. . .	6.0	7,878	0.5	. . .	0.5	4,077	10.0
Illinois	1,442	8.0	14	5.0	9	6.0	2,232	1.0	. . .	1.0	17	10.0
Indiana	942	8.0	397	5.0	38	6.0	2,240	1.0	. . .	1.0	129	10.0
Iowa	1,219	8.0	78	5.0	20	6.0	1,278	1.0	. . .	1.0	. . .	10.0
Kentucky	1,508	8.0	812	5.0	. . .	6.0	7,402	0.5	. . .	1.0	137	10.0
Louisiana	647	10.0	. . .	7.0	. . .	7.0	1,767	2.0	. . .	3.0	5,967	10.0
Michigan	1,166	8.0	5,568	5.0	5,744	6.0	2,142	1.0	2,559	1.0	. . .	10.0
Minnesota	2,045	10.0	1,049	7.0	6,972	8.0	1,080	2.0	4,555	3.0	. . .	10.0
Mississippi	511	10.0	. . .	6.0	. . .	7.0	4,237	2.0	. . .	3.0	3,431	10.0
Missouri	2,179	8.0	85	5.0	. . .	6.0	11,333	0.5	. . .	1.0	410	10.0
Ohio	1,243	8.0	600	5.0	5	6.0	2,915	1.0	. . .	1.0	54	10.0
Tennessee	224	8.0	202	4.0	. . .	4.0	9,743	0.5	. . .	0.5	675	10.0
Wisconsin	1,494	10.0	3,013	7.0	5,166	8.0	2,948	2.0	1,637	3.0	. . .	10.0
Atlantic Flyway												
Connecticut	298	8.0	110	5.0	94	5.0	1,375	1.0	. . .	1.0	. . .	10.0
Delaware	. . .	8.0	. . .	4.0	. . .	5.0	76	0.5	. . .	0.5	96	10.0
Florida	. . .	10.0	. . .	6.0	. . .	7.0	2,503	2.0	. . .	3.0	5,049	10.0
Georgia	. . .	10.0	. . .	6.0	. . .	7.0	4,028	2.0	. . .	3.0	5,145	10.0
Maine	303	8.0	5,112	5.0	1,444	5.0	275	1.0	8,383	1.0	. . .	10.0
Maryland	24	8.0	81	4.0	. . .	5.0	1,353	0.5	3	0.5	461	10.0
Massachusetts	285	8.0	563	5.0	285	5.0	1,325	1.0	28	1.0	. . .	10.0
New Hampshire	119	8.0	1,301	5.0	443	5.0	603	1.0	1,055	1.0	. . .	10.0
New Jersey	128	8.0	38	4.0	130	5.0	838	0.5	9	0.5	165	10.0
New York	869	8.0	5,520	4.0	1,724	5.0	1,890	0.5	735	0.5	[illegible]	10.0
North Carolina	. . .	8.0	251	4.0	. . .	4.0	5,657	0.5	15	0.5	3,343	10.0

TABLE 42.--Continued

Location	FOREST TYPES											
	Elm-Ash-Cottonwood		Maple-Beech-Birch		Aspen-Birch		Oak-Hickory		Spruce-Fir		Oak-Gum-Cypress	
	Acres	Value	Acres	Value	Acres	Value	Acres	Value	Acres	Value	Acres	Value
Pennsylvania	252	8.0	3,896	4.0	1,205	5.0	8,611	0.5	4	0.5	55	10.0
Rhode Island	78	8.0	. . .	5.0	27	5.0	314	1.0	. . .	1.0	. . .	10.0
South Carolina	. . .	10.0	. . .	6.0	. . .	7.0	1,989	2.0	. . .	3.0	3,097	10.0
Vermont	73	8.0	2,237	5.0	287	5.0	71	1.0	628	1.0	. . .	10.0
Virginia	. . .	8.0	53	4.0	. . .	4.0	8,763	0.5	. . .	0.5	959	10.0
West Virginia	611	8.0	2,338	3.0	. . .	5.0	7,477	0.5	27	0.5	148	10.0
Central Flyway												
Texas	80	10.0	. . .	6.0	. . .	7.0	2,016	2.0	. . .	3.0	1,826	10.0

[1]Forest acreages were derived from "Timber Trends in the United States," U. S. Forest Service, Forest Resource Report No. 17, and are expressed in thousands.

TABLE 43.--Estimating wood duck indices from forest values[1]

	FOREST TYPES						
	Elm-Ash-Cottonwood	Maple-Beech-Birch	Aspen-Birch	Oak-Hickory	Spruce-Fir	Oak-Gum-Cypress	Population Index
Location[2]	Forest Value	Forest Value	Forest Value	Forest Value	Forest Value	Forest Value	Sum
Mississippi Flyway							
Alabama	940	. . .	. . .	10,212	. . .	22,710	33,862
Arkansas	3,808	. . .	. . .	3,939	. . .	40,770	48,517
Illinois	11,536	70	54	2,232	. . .	170	14,062
Indiana	7,536	1,985	228	2,240	. . .	1,290	13,279
Iowa	9,752	546	120	1,278	. . .	. . .	11,696
Kentucky	12,064	4,060	. . .	3,701	. . .	1,370	21,195
Louisiana	6,470	. . .	. . .	3,534	. . .	59,670	69,674
Michigan	9,328	27,840	34,464	2,142	2,559	. . .	76,333
Minnesota	20,450	7,343	55,776	2,160	13,665	. . .	99,394
Mississippi	5,110	. . .	. . .	8,474	. . .	34,310	47,894
Missouri	17,432	425	. . .	5,666	. . .	4,100	27,623
Ohio	9,943	3,000	29	2,914	. . .	539	16,425
Tennessee	2,240	808	. . .	4,871	. . .	6,750	14,669
Wisconsin	14,940	21,091	41,328	5,896	4,911	. . .	88,166
Atlantic Flyway							
Connecticut	2,384	550	470	1,375	. . .	. . .	4,779
Delaware	. . .	. . .	. . .	38	. . .	960	998
Florida	. . .	. . .	. . .	5,006	. . .	50,490	55,496
Georgia	. . .	. . .	. . .	8,416	. . .	51,450	59,856
Maine	2,424	25,560	7,220	275	8,383	. . .	43,862
Maryland	192	324	. . .	676	2	4,610	5,804
Massachusetts	2,280	2,815	570	1,325	28	. . .	7,018
New Hampshire	952	6,505	2,215	603	1,055	. . .	11,330
New Jersey	1,024	152	650	419	4	1,650	3,899
New York	6,952	22,080	8,620	945	368	60	39,025

TABLE 43.--Continued

	FOREST TYPES						
	Elm-Ash-Cottonwood	Maple-Beech-Birch	Aspen-Birch	Oak-Hickory	Spruce-Fir	Oak-Gum-Cypress	Population Index
Location[2]	Forest Value	Forest Value	Forest Value	Forest Value	Forest Value	Forest Value	Sum
North Carolina	. . .	1,004	. . .	2,828	8	33,430	37,270
Pennsylvania	2,016	15,584	6,025	4,305	2	550	28,482
Rhode Island	624	135	314	. . .	. . .	. . .	1,073
South Carolina	. . .	. . .	. . .	3,978	. . .	30,970	34,948
Vermont	584	11,185	1,435	71	628	. . .	13,903
Virginia	. . .	212	. . .	4,381	. . .	9,590	14,183
West Virginia	4,888	7,014	. . .	3,738	14	1,480	17,134
Central Flyway							
Texas	800	. . .	. . .	4,032	. . .	18,260	23,092

[1]Forest values are the product of acres(x)wood-duck values in Appendix Table 42.

[2]Canadian forest values were estimated as [63 million acres(x) a value of 2.0], which equals to a population index of 126 thousand.

TABLE 44.--Wood duck harvest data used in determining an adjusted harvest for immatures and adults (see text for procedures)[1]

	Distribution of Harvest (%)[2]						Immatures		Adults	
	Immatures			Adults			Original harvest	Adjusted harvest	Original harvest	Adjusted harvest
	1	2	3	1	2	3				
Connecticut	0.4	0.5	0.4	0.4	0.3	0.2	1,641	1,752	873	582
Delaware	T	0.3	0.2	0.1	0.4	0.2	291	855	223	767
Florida	3.5	5.6	5.6	4.1	8.4	8.3	13,126	21,100	9,352	19,191
Georgia	2.4	4.8	4.9	3.1	8.3	9.4	9,194	18,388	7,097	20,299
Maine	0.7	1.4	3.4	0.9	0.7	1.8	2,829	9,122	2,007	2,990
Maryland	0.2	0.1	0.2	0.2	0.2	0.2	819	624	446	492
Massachusetts	0.8	1.2	0.4	0.8	1.6	0.8	3,171	3,079	1,962	2,734
New Hampshire	0.6	1.9	0.8	0.6	1.2	0.6	2,288	5,515	1,325	2,166
New Jersey	1.0	1.5	0.8	1.4	1.5	0.8	3,909	4,372	2,484	2,648
New York	4.7	3.3	3.0	3.3	3.2	3.2	17,698	11,818	7,560	7,486
North Carolina	3.2	3.9	3.9	3.4	4.5	4.1	11,950	14,808	9,028	9,922
Pennsylvania	3.4	2.8	3.2	2.6	2.3	2.5	12,892	11,457	5,914	5,577
Rhode Island	T	T	T	T	T	T	87	644	74	25
South Carolina	3.8	5.8	5.2	5.2	7.3	6.3	14,261	20,843	11,854	15,652
Vermont	0.6	1.2	0.9	0.4	0.8	0.8	2,460	4,209	1,053	1,850
Virginia	0.9	1.0	1.1	1.0	0.6	0.6	3,400	3,956	2,250	1,333
West Virginia	0.2	0.1	0.4	0.2	0.3	0.6	603	1,142	430	1,022
Alabama	1.8	3.3	3.3	2.4	4.5	4.9	6,774	12,490	5,492	10,670
Arkansas	2.8	3.6	3.8	4.7	4.1	4.4	10,822	13,900	10,796	9,723
Illinois	4.0	4.0	2.2	3.7	3.3	1.7	15,197	11,619	8,604	5,800
Indiana	1.0	1.3	0.7	0.9	1.2	0.9	4,142	3,899	2,145	2,433
Iowa	3.7	3.1	2.4	2.5	2.5	1.5	14,067	10,461	5,821	4,546
Kentucky	0.6	0.3	0.4	0.1	0.4	0.6	216	127	170	1,245
Louisiana	10.0	8.6	10.4	12.4	9.8	12.3	38,082	35,949	28,504	25,448
Michigan	3.2	2.9	5.2	3.2	1.7	3.0	12,249	15,376	7,455	5,453

TABLE 44.--Continued

	Distribution of Harvest (%)						Immatures		Adults	
	Immatures			Adults			Original harvest	Adjusted harvest	Original harvest	Adjusted harvest
	1	2	3	1	2	3				
Minnesota	11.3	5.2	5.8	8.6	2.3	2.7	42,847	20,778	19,891	5,832
Mississippi	2.4	3.9	4.3	3.6	6.4	6.5	9,156	15,346	8,377	14,908
Missouri	1.4	1.9	1.4	1.3	1.7	1.4	5,313	6,231	2,920	3,567
Ohio	3.6	2.8	1.5	3.2	2.1	1.3	13,681	8,271	7,439	3,961
Tennessee	1.0	0.9	0.9	1.7	1.3	1.5	3,818	3,423	3,901	3,194
Wisconsin	7.2	6.9	8.0	8.1	3.9	5.0	27,288	28,142	18,567	10,291
Texas	2.0	3.9	4.1	2.7	3.8	4.1	7,875	15,050	6,154	9,159
Ontario	15.5	10.4	8.7	11.0	7.5	6.0	58,574	36,088	25,240	15,498
Quebec	2.1	1.7	2.6	1.9	1.7	1.7	8,042	8,120	4,465	3,979
Total	100.0	100.1	100.0	99.8	99.8	99.9	378,762	378,954	229,873	230,443

[1]1 = Harvest survey; 2 = Population model data; 3 = Forest data.

[2]Rounded to nearest decimal — original computations involved data with five decimal places.

Table 45.--States requiring a proration of recovery rates based on recovery distributions of adjacent state(s)

Prorated State	Adjacent State(s)
Arkansas	Louisiana Mississippi Tennessee
Connecticut	Massachusetts Vermont
Delaware*	Massachusetts
Florida	Alabama South Carolina
Georgia	Alabama South Carolina
Kentucky	Tennessee
Maryland*	Massachusetts
New Hampshire	Maine Vermont
New Jersey	Massachusetts
Pennsylvania	New York West Virginia
Quebec	Maine Ontario Vermont
Rhode Island*	Massachusetts
Texas	Louisiana
Virginia	North Carolina

*ONLY immature direct recovery rates were prorated.

TABLE 46.--Direct recovery rate matrix utilized for adjusted simultaneous equation population estimates of adult wood ducks[1]

RECOVERED IN:	WOOD DUCKS BANDED IN:							
	Illinois	Iowa	Minnesota	Missouri	Wisconsin	Indiana	Michigan	Ohio
Illinois	0.01659	0.00526	0.00086	0.01043	0.00136	0.00083	0.00124	. . .
Iowa	0.00207	0.02829	0.00173	. . .	0.00213	. . .	. . .	. . .
Minnesota	0.00078	0.00066	0.01009	0.00035	0.00271	. . .	0.00062	. . .
Missouri	0.00363	0.00263	0.00086	0.00939	0.00077	. . .	. . .	. . .
Wisconsin	0.00078	0.00263	0.00288	0.00035	0.02016	. . .	. . .	. . .
Indiana	. . .	. . .	0.00058	. . .	0.00058	0.01075	0.00062	. . .
Michigan	. . .	. . .	0.00086	. . .	0.00019	0.00083	0.01551	0.00188
Ohio	. . .	0.00066	. . .	. . .	0.00039	. . .	0.00186	0.02023
Connecticut	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Maine	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Massachusetts	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Vermont	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
West Virginia	. . .	. . .	. . .	. . .	. . .	. . .	0.00062	. . .
Pennsylvania	. . .	. . .	. . .	. . .	. . .	. . .	0.00062	. . .
Rhode Island	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Delaware	. . .	. . .	. . .	. . .	0.00019	. . .	. . .	. . .
Maryland	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New Hampshire	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New Jersey	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New York	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Ontario	. . .	. . .	. . .	. . .	. . .	. . .	0.00186	0.00094
Quebec	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Alabama	0.00233	0.00066	0.00173	0.00035	0.00174	0.00331	0.00186	0.00518
Arkansas	0.00311	0.00526	0.00490	0.00313	0.00465	0.00165	0.00124	. . .
Kentucky	0.00026	. . .	0.00029	. . .	. . .	0.00083	0.00062	0.00047
Louisiana	0.00933	0.01184	0.01009	0.00696	0.00814	0.00993	0.00806	0.00141
Mississippi	0.00389	0.00263	0.00403	0.00452	0.00446	0.00910	0.00248	0.00282
Tennessee	0.00078	0.00066	0.00029	0.00070	0.00058	0.00083	0.00186	0.00047
Texas	0.00415	0.00263	0.00548	0.00313	0.00213	0.00165	. . .	. . .
Florida	0.00052	0.00066	0.00029	0.00035	0.00155	0.00248	0.00496	0.00282
Georgia	. . .	. . .	0.00058	0.00035	0.00097	0.00331	0.00310	0.00329
North Carolina	0.00052	. . .	. . .	. . .	0.00019	. . .	0.00124	. . .
South Carolina	. . .	. . .	. . .	. . .	0.00078	0.00083	0.00186	0.00282
Virginia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

TABLE 46.--Continued

	Connecticut	Maine	Massachusetts	Vermont	West Virginia	Pennsylvania	Rhode Island	Delaware
Illinois	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Iowa	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Minnesota	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Missouri	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Wisconsin	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Indiana	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Michigan	. . .	. . .	. . .	. . .	0.00707	0.00354	. . .	. . .
Ohio	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Connecticut	0.02887	0.00063	. . .	. . .	. . .	. . .	. . .	. . .
Maine	0.00063	0.02572	. . .	0.00125	. . .	. . .	. . .	. . .
Massachusetts	0.00094	0.00188	0.02321	0.00188	. . .	. . .	. . .	0.00068
Vermont	. . .	. . .	. . .	0.03453	. . .	. . .	. . .	. . .
West Virginia	. . .	. . .	. . .	. . .	0.01415	0.00236	. . .	. . .
Pennsylvania	0.00094	. . .	. . .	0.00188	0.00236	0.01943	. . .	. . .
Rhode Island	. . .	. . .	. . .	. . .	. . .	. . .	0.00370	. . .
Delaware	. . .	0.00125	0.00068	0.00063	. . .	. . .	. . .	0.02321
Maryland	0.00031	0.00125	. . .	0.00063	. . .	. . .	. . .	. . .
New Hampshire	0.00031	0.00063	. . .	0.00063	. . .	. . .	. . .	. . .
New Jersey	0.00012	0.00314	. . .	0.00251	. . .	0.00034	. . .	. . .
New York	0.00157	0.00188	. . .	0.00314	. . .	0.00069	. . .	. . .
Ontario	. . .	. . .	. . .	. . .	0.00236	0.00392	. . .	. . .
Quebec	0.00012	0.00125	. . .	0.00314	. . .	. . .	. . .	. . .
Alabama	0.00094	0.00063	. . .	0.00188	0.01179	0.00692	0.00185	. . .
Arkansas	. . .	. . .	. . .	. . .	. . .	0.00034	0.00185	. . .
Kentucky	. . .	. . .	. . .	. . .	0.00236	0.00118	. . .	. . .
Louisiana	. . .	0.00063	. . .	. . .	0.00236	0.00152	. . .	. . .
Mississippi	. . .	. . .	. . .	. . .	. . .	0.00069	. . .	. . .
Tennessee	0.00031	. . .	. . .	0.00063	. . .	0.00152	. . .	. . .
Texas	. . .	. . .	. . .	. . .	0.00236	0.00069	. . .	. . .
Florida	0.00447	0.00439	0.00580	0.00314	0.00472	0.00476	0.00924	0.00580
Georgia	0.00575	0.00753	0.00774	0.00377	0.00472	0.00407	0.00554	0.00774
North Carolina	0.00609	0.00564	0.00967	0.00251	. . .	0.00343	0.00554	0.00967
South Carolina	0.01194	0.00690	0.01257	0.01130	0.00707	0.00628	0.01109	0.01257
Virginia	0.00627	0.00188	. . .	0.00125	. . .	0.00034	. . .	. . .

TABLE 46.--Continued

	Maryland	New Hampshire	New Jersey	New York	Ontario	Quebec	Alabama	Arkansas
Illinois	. . .	. .	. . .	. . .	. . .	. . .	. . .	. . .
Iowa	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Minnesota	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Missouri	. . .	. . .	. . .	. . .	0.00122	0.00041	. . .	. . .
Wisconsin	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Indiana	. . .	. . .	. . .	. . .	0.00244	0.00081	. . .	. . .
Michigan	. . .	. . .	. . .	. . .	0.00122	0.00041	. . .	. . .
Ohio	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Connecticut	. . .	0.00031	. . .	. . .	. . .	0.00021	. . .	. . .
Maine	. . .	0.00095	. . .	. . .	. . .	0.00313	. . .	. . .
Massachusetts	. . .	0.00188	. . .	. . .	0.00122	0.00166	. . .	. . .
Vermont	. . .	0.00063	. . .	. . .	. . .	0.00125	. . .	. . .
West Virginia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Pennsylvania	. . .	0.00095	. . .	0.00069	0.00244	0.00144	. . .	. . .
Rhode Island	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Delaware	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Maryland	0.02321	0.00031	. . .	. . .	. . .	0.00021	. . .	. . .
New Hampshire	. . .	0.03012	. . .	. . .	. . .	0.00042	. . .	. . .
New Jersey	. . .	0.00282	0.02321	0.00069	. . .	0.00188	. . .	. . .
New York	. . .	0.00251	. . .	0.02471	0.00489	0.00330	. . .	. . .
Ontario	. . .	. . .	. . .	0.00549	0.03056	. . .	. . .	. . .
Quebec	. . .	0.00220	. . .	. . .	. . .	0.03027	. . .	. . .
Alabama	0.00324	0.00125	. . .	0.00206	0.00122	0.00124	0.02184	0.00178
Arkansas	. . .	. . .	. . .	0.00069	. . .	. . .	. . .	0.02071
Kentucky	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00012
Louisiana	. . .	0.00031	. . .	0.00069	0.00122	0.00062	0.00273	0.00276
Mississippi	. . .	. . .	. . .	0.00137	0.00244	0.00082	0.00273	0.00251
Tennessee	. . .	0.00031	. . .	0.00069	. . .	0.00021	0.00182	0.00287
Texas	. . .	. . .	. . .	0.00137	0.00122	0.00041	. . .	0.00084
Florida	0.00324	0.00376	0.00580	0.00480	0.00490	0.00414	0.00364	0.00072
Georgia	0.00324	0.00565	0.00774	0.00343	0.00367	0.00491	0.00273	0.00172
North Carolina	0.00324	0.00408	0.00967	0.00686	0.00611	0.00476	. . .	. . .
South Carolina	0.00647	0.00910	0.01257	0.00549	0.00611	0.00810	. . .	. . .
Virginia	0.00324	0.00157	. . .	0.00069	0.00122	0.00145	. . .	. . .

TABLE 46.--Continued

	Kentucky	Louisiana	Mississippi	Tennessee	Texas	Florida	Georgia	North Carolina
Illinois	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Iowa	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Minnesota	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Missouri	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Wisconsin	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Indiana	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Michigan	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Ohio	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Connecticut	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Maine	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Massachusetts	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Vermont	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
West Virginia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Pennsylvania	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Rhode Island	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Delaware	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Maryland	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New Hampshire	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New Jersey	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New York	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Ontario	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Quebec	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Alabama	0.00287	. . .	0.00224	0.00287	. . .	0.00232	0.00186	. . .
Arkansas	0.00287	. . .	. . .	0.00287	. . .	. . .	. . .	. . .
Kentucky	0.01112	. . .	. . .	0.00036	. . .	. . .	. . .	. . .
Louisiana	0.00717	0.03529	0.00112	0.00717	. . .	0.00170	0.00169	. . .
Mississippi	0.00753	. . .	0.01571	0.00753	. . .	0.00033	0.00033	. . .
Tennessee	0.00036	. . .	. . .	0.01112	. . .	0.00278	0.00277	. . .
Texas	0.00251	. . .	. . .	0.00251	0.03529	. . .	. . .	. . .
Florida	0.00215	. . .	. . .	. . .	. . .	0.02374	0.00465	. . .
Georgia	0.00179	. . .	0.00337	0.00215	. . .	0.00270	0.02374	. . .
North Carolina	. . .	. . .	. . .	0.00179	. . .	0.00050	0.00050	0.01635
South Carolina	. . .	. . .	. . .	. . .	. . .	0.00283	0.00133	0.00701
Virginia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

TABLE 46.--Continued

	South Carolina	Virginia
Illinois	. . .	. . .
Iowa	. . .	. . .
Minnesota	. . .	. . .
Missouri	. . .	. . .
Wisconsin	. . .	. . .
Indiana	. . .	. . .
Michigan	. . .	. . .
Ohio	. . .	. . .
Connecticut	. . .	. . .
Maine	. . .	. . .
Massachusetts	. . .	. . .
Vermont	. . .	. . .
West Virginia	. . .	. . .
Pennsylvania	. . .	. . .
Rhode Island	. . .	. . .
Delaware	. . .	. . .
Maryland	. . .	. . .
New Hampshire	. . .	. . .
New Jersey	. . .	. . .
New York	. . .	. . .
Ontario	. . .	. . .
Quebec	. . .	. . .
Alabama	0.00100	. . .
Arkansas	. . .	. . .
Kentucky	. . .	. . .
Louisiana	0.00067	. . .
Mississippi	0.00067	. . .
Tennessee	0.00033	. . .
Texas	. . .	. . .
Florida	0.00566	. . .
Georgia	0.00266	. . .
North Carolina	0.00100	. . .
South Carolina	0.02564	0.00701
Virginia	. . .	0.01635

[1] Banded May-August, 1950-68 for northern reference-area states and May-September, 1950-68 for southern reference-area states.

TABLE 47.--Direct recovery rate matrix utilized for adjusted simultaneous equation population estimates of immature wood ducks[1]

RECOVERED IN:	WOOD DUCKS BANDED IN:							
	Illinois	Iowa	Minnesota	Missouri	Wisconsin	Indiana	Michigan	Ohio
Illinois	0.02472	0.00455	0 00130	0.00910	0.00291	0.00504	0.00209	. . .
Iowa	0.00128	0.02748	0.00621	0.00024	0.00733	. . .	. . .	. . .
Minnesota	0.00015	0.00278	0.02289	. . .	0.01176	. . .	. . .	. . .
Missouri	0.00589	0.00240	0.00163	0.01600	0.00186	0.00100	. . .	. . .
Wisconsin	0.00022	0.01139	0.01340	. . .	0.03809	0.00050	0.00628	. . .
Indiana	0.00007	0.00012	. . .	. . .	. . .	0.01966	0.00419	. . .
Michigan	0.00015	0.00012	. . .	. . .	0.00023	0.00151	0.04926	0.00058
Ohio	. . .	0.00012	0.00032	. . .	0.00023	. . .	. . .	0.03580
Connecticut	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Maine	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Massachusetts	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New York	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Ontario	. . .	. . .	. . .	. . .	0.00023	. . .	0.00209	0.00029
Vermont	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
West Virginia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00029
Pennsylvania	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Rhode Island	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Alabama	0.00173	0.00101	0.00130	0.00049	0.00058	0.00302	0.00314	0.00293
Arkansas	0.00529	0.00405	0.00359	0.00541	0.00337	0.00302	0.00419	. . .
Florida	0.00090	0.00088	0.00065	0.00024	0.00023	0.00403	0.00209	0.00587
Georgia	0.00052	0.00050	. . .	. . .	0.00023	0.00201	0.00314	0.00587
Kentucky	0.00030	0.00012	. . .	. . .	. . .	0.00100	. . .	0.00029
Louisiana	0.00945	0.00747	0.00948	0.00787	0.00722	0.00655	0.00733	0.00410
Mississippi	0.00219	0.00405	0.00130	0.00221	0.00232	0.00504	0.00419	0.00322
North Carolina	. . .	. . .	0.00065	. . .	0.00011	0.00050	. . .	0.00088
South Carolina	0.00015	0.00025	0.00032	. . .	0.00011	0.00050	0.00209	0.00440
Tennessee	0.00068	0.00113	0.00098	0.00073	0.00093	0.00100	. . .	0.00117
Delaware	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Texas	0.00431	0.00595	0.00686	0.00467	0.00477	0.00201	. . .	0.00146
Maryland	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Virginia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00029
New Hampshire	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New Jersey	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Quebec	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

TABLE 47.--Continued

	Connecticut	Maine	Massachusetts	New York	Ontario	Vermont	West Virginia	Pennsylvania
Illinois	0.00012	. . .	. . .	. . .	. . .	0.00024	. . .	. . .
Iowa	. . .	. . .	. . .	. . .	0.00097	. . .	. . .	. . .
Minnesota	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Missouri	. . .	. . .	. . .	. . .	. . .	0.00024	. . .	. . .
Wisconsin	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Indiana	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Michigan	. . .	. . .	. . .	0.00023	0.00097	. . .	. . .	0.00011
Ohio	0.00012	. . .	. . .	0.00047	. . .	0.00024	0.00496	0.00272
Connecticut	0.03290	0.00265	. . .	. . .	. . .	. . .	0.00099	. . .
Maine	0.00024	0.05644	. . .	. . .	. . .	0.00048	. . .	. . .
Massachusetts	0.00012	0.00066	0.02577	. . .	. . .	0.00024	. . .	. . .
New York	0.00316	0.00066	. . .	0.03597	0.00097	0.00632	. . .	0.00107
Ontario	0.00048	. . .	. . .	0.00309	0.05268	0.00097	. . .	0.00154
Vermont	. . .	. . .	. . .	0.00023	. . .	0.04012	. . .	0.00011
West Virginia	. . .	. . .	. . .	. . .	. . .	. . .	0.01092	. . .
Pennsylvania	0.00121	0.00066	. . .	0.00214	0.00195	0.00243	. . .	0.03597
Rhode Island	. . .	. . .	. . .	0.00023	. . .	. . .	. . .	0.00011
Alabama	0.00146	0.00132	0.00171	0.00095	0.00292	0.00121	0.00794	0.00444
Arkansas	. . .	. . .	. . .	0.00023	0.00097	. . .	0.00099	0.00061
Florida	0.00281	0.00597	0.00343	0.00548	0.00195	0.00218	0.00496	0.00548
Georgia	0.00317	0.00597	0.00343	0.00500	0.00487	0.00291	0.00595	0.00548
Kentucky	. . .	. . .	. . .	. . .	. . .	. . .	0.00099	0.00049
Louisiana	0.00036	. . .	. . .	0.00119	0.00195	0.00072	0.00297	0.00268
Mississippi	0.00036	. . .	. . .	0.00119	0.00195	0.00072	0.00297	0.00196
North Carolina	0.00684	0.00730	0.00859	0.00595	0.00292	0.00510	0.00198	0.00397
South Carolina	0.00696	0.00597	0.00687	0.01000	0.00487	0.00705	0.00695	0.00847
Tennessee	0.00024	0.00066	. . .	0.00047	. . .	0.00048	. . .	0.00023
Delaware	. . .	0.00066	. . .	0.00023	. . .	. . .	. . .	0.00011
Texas	0.00012	. . .	. . .	. . .	. . .	0.00024	. . .	. . .
Maryland	0.00012	0.00132	. . .	0.00023	. . .	0.00024	. . .	0.00011
Virginia	0.00085	0.00199	. . .	0.00238	0.00097	0.00170	. . .	0.00011
New Hampshire	0.00012	0.00132	. . .	0.00047	. . .	0.00024	. . .	0.00023
New Jersey	0.00183	0.00332	0.00171	0.00095	0.00195	0.00194	. . .	0.00047
Quebec	0.00449	0.00066	. . .	0.00071	0.00097	0.00899	. . .	0.00035

TABLE 47.--Continued

	Rhode Island	Alabama	Arkansas	Florida	Georgia	Kentucky	Louisiana	Mississippi
Illinois	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Iowa	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Minnesota	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Missouri	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Wisconsin	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Indiana	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Michigan	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Ohio	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Connecticut	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Maine	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Massachusetts	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New York	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Ontario	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Vermont	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
West Virginia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Pennsylvania	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Rhode Island	0.02577	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Alabama	0.00171	0.01254	0.00176	. . .	. . .	0.00290	0.00061	0.00178
Arkansas	. . .	0.00209	0.01488	0.00130	0.00130	0.00259	0.00370	0.00178
Florida	0.00343	0.00418	0.00109	0.01807	0.00481	0.00207	0.00061	0.00059
Georgia	0.00343	0.00365	0.00068	0.00468	0.01807	0.00145	. . .	0.00059
Kentucky	. . .	. . .	0.00013	. . .	. . .	0.01067	. . .	. . .
Louisiana	. . .	0.00418	0.00658	0.00260	0.00260	0.01378	0.03028	0.00595
Mississippi	. . .	0.00470	0.00269	0.00300	0.00300	0.00622	0.00185	0.01370
North Carolina	0.00859	0.00104	0.00269	0.00091	0.00091	0.00010	. . .	. . .
South Carolina	0.00687	0.00104	. . .	0.00052	0.00052	0.00031	. . .	. . .
Tennessee	. . .	. . .	0.00086	. . .	. . .	0.00041	. . .	. . .
Delaware	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Texas	. . .	. . .	0.00320	. . .	. . .	0.00352	0.00370	0.00238
Maryland	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Virginia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New Hampshire	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
New Jersey	0.00171	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Quebec	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

TABLE 47.--Continued

	North Carolina	South Carolina	Tennessee	Delaware	Texas	Maryland	Virginia	New Hampshire
Illinois	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00012
Iowa	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Minnesota	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Missouri	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00012
Wisconsin	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Indiana	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Michigan	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Ohio	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00012
Connecticut	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00144
Maine	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00024
Massachusetts	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00045
New York	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00349
Ontario	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00048
Vermont	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00024
West Virginia	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Pennsylvania	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00154
Rhode Island	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Alabama	. . .	0.00129	0.00290	0.00171	0.00061	0.00171	. . .	0.00127
Arkansas	. . .	0.00051	0.00259	. . .	0.00370	. . .	. . .	. . .
Florida	0.00838	0.00544	0.00207	0.00343	0.00006	0.00343	0.00838	0.00408
Georgia	0.00335	0.00570	0.00145	0.00343	. . .	0.00343	0.00335	0.00408
Kentucky	. . .	. . .	0.00041	. . .	. . .	. . .	. . .	. . .
Louisiana	0.00167	0.00103	0.01378	. . .	0.00370	. . .	. . .	0.00036
Mississippi	0.00167	0.00129	0.00622	. . .	0.00185	. . .	0.00167	0.00036
North Carolina	0.01845	0.00077	0.00010	0.00859	. . .	0.00859	0.00815	0.00620
South Carolina	. . .	0.02359	0.01067	0.00687	. . .	0.00687	0.00838	0.00651
Tennessee	. . .	. . .	0.01067	. . .	. . .	. . .	. . .	0.00057
Delaware	. . .	. . .	. . .	0.25773	. . .	. . .	. . .	0.00033
Texas	. . .	. . .	0.00352	. . .	0.03028	. . .	. . .	0.00012
Maryland	. . .	. . .	. . .	. . .	. . .	0.02577	. . .	0.00078
Virginia	. . .	. . .	. . .	. . .	. . .	. . .	0.01845	0.00184
New Hampshire	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.04283
New Jersey	. . .	. . .	. . .	0.00171	. . .	0.00171	. . .	0.00263
Quebec	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.00483

TABLE 47.--Continued

	New Jersey	Quebec
Illinois	. . .	0.00008
Iowa	. . .	0.00032
Minnesota	. . .	. . .
Missouri	. . .	0.00008
Wisconsin	. . .	. . .
Indiana	. . .	. . .
Michigan	. . .	0.00032
Ohio	. . .	0.00008
Connecticut	. . .	0.00096
Maine	. . .	0.00016
Massachusetts	. . .	0.00030
New York	. . .	0.00265
Ontario	. . .	0.00032
Vermont	. . .	0.00299
West Virginia	. . .	. . .
Pennsylvania	. . .	0.00168
Rhode Island	. . .	. . .
Alabama	0.00171	0.00182
Arkansas	. . .	0.00032
Florida	0.00343	0.00337
Georgia	0.00343	0.00771
Kentucky	. . .	. . .
Louisiana	. . .	0.00089
Mississippi	. . .	0.00089
North Carolina	0.00859	0.00511
South Carolina	0.00687	0.00596
Tennessee	. . .	0.00038
Delaware	. . .	0.00022
Texas	. . .	0.00008
Maryland	. . .	0.00052
Virginia	. . .	0.00135
New Hampshire	. . .	. . .
New Jersey	0.02577	0.00240
Quebec	. . .	0.04975

[1]Banded May-August, 1950-65 for northern reference-area states and May-September, 1950-68 for southern reference-area states.

TABLE [illegible].--Weighting factors for immature and adult wood ducks as determined from four estimates of wood duck abundance

State	FHMP		Simultaneous Equation		Forest		Row Sum	
	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Illinois	11.508	5.875	[illegible]	3.810	2.697	[illegible]	6.122	3.506
Iowa	11.583	4.312	[illegible]	1.800	4.516	1.029	9.842	2.379
Minnesota	15.123	24.747	[illegible]	31.684	16.889	[illegible]	17.717	24.313
Missouri	6.993	9.766	[illegible]	11.017	6.661	5.345	10.308	8.726
Wisconsin	7.192	7.926	14.125	10.037	9.058	6.075	10.158	8.015
Indiana	13.685	16.381	[illegible]	11.803	4.543	[illegible]	10.644	10.493
Michigan	14.020	32.918	27.447	42.307	26.755	38.171	30.424	37.765
Ohio	11.086	9.917	[illegible]	4.100	4.552	2.444	7.789	5.495
Connecticut	43.011	52.209	[illegible]	6.032	25.694	19.143	23.206	25.811
Maine	7.113	19.378	14.886	19.956	18.352	16.257	13.384	15.531
Massachusetts	16.938	39.024	11.484	28.996	4.755	6.547	11.892	24.956
Vermont	4.065	3.605	4.347	3.932	3.768	1.671	4.124	3.069
West Virginia	6.803	4.040	30.723	24.657	23.312	8.654	20.046	12.459
Pennsylvania	81.272	111.446	[illegible]	208.663	100.643	85.784	70.463	135.299
Rhode Island	3.490	2.927	3.173	5.583	1.873	1.047	2.845	3.186
Delaware	3.388	7.805	4.689	0.794	0.676	0.974	2.918	3.191
Maryland	23.404	13.393	5.515	3.609	12.349	8.637	14.756	8.546
New Hampshire	8.224	8.167	5.432	5.263	3.727	2.051	5.794	5.160
New Jersey	12.195	28.293	14.144	20.002	2.642	3.804	9.660	17.366
New York	12.606	8.265	14.157	8.675	12.299	4.605	14.354	7.183
Ontario	83.565	110.734	44.227	66.249	61.843	56.497	63.205	77.827
Quebec	15.565	11.332	7.917	9.742	16.079	14.684	13.187	11.921
Alabama	25.478	32.410	50.643	82.065	30.812	17.711	35.645	44.059
Arkansas	23.400	15.994	[illegible]	1.797	33.391	11.246	28.257	9.679
Kentucky	4.303	1.659	4.882	0.000	7.560	2.297	5.588	1.285
Louisiana	45.588	27.194	50.352	28.142	102.462	43.042	66.127	32.799
Mississippi	49.383	33.969	154.422	33.647	53.753	28.542	85.855	32.053

TABLE 48.--Continued

State	FHMUP		Simultaneous Equation		Forest		Row Sum	
	Adult	Immature	Adult	Immature	Adult	Immature	Adult	Immature
Tennessee	4.661	2.281	0.000	0.396	5.260	1.521	3.307	1.399
Texas	23.529	17.305	26.631	10.379	33.959	14.272	28.040	13.986
Florida	29.254	492.611	45.198	255.699	27.058	273.379	33.837	340.563
Georgia	14.627	260.000	88.581	462.980	29.184	239.424	44.131	320.801
North Carolina	93.458	92.282	188.827	154.069	87.079	62.534	123.122	102.961
South Carolina	13.320	18.154	4.443	16.187	11.638	9.063	9.800	14.468
Virginia	52.632	27.174	26.390	93.130	74.647	38.541	51.223	52.948

TABLE 49 .--Reporting rates used in conjunction with simultaneous equation population estimates

Flyway States	Reporting Rate
Mississippi Flyway	
Alabama	0.365
Arkansas	0.262
Illinois	0.284
Indiana	0.333
Iowa	0.290
Kentucky	0.299
Louisiana	0.246
Michigan	0.290
Minnesota	0.296
Mississippi	0.304
Missouri	0.317
Ohio	0.188
Tennessee	0.199
Wisconsin	0.317
Atlantic Flyway	
Connecticut	0.171
Delaware	0.333
Florida	0.304
Georgia	0.370
Maine	0.336
Maryland	0.320
Massachusetts	0.269
New Hampshire	0.249
New Jersey	0.295
New York	0.273
North Carolina	0.341
Pennsylvania	0.269
Rhode Island	0.269
South Carolina	0.286
Vermont	0.332
Virginia	0.299
West Virginia	0.474
Canada	0.188
Central Flyway	
Texas	0.241

EXAMPLE 1.--Estimating wood duck population densities by simultaneous equations

Given the following:

(1) Three states with unknown population densities, populations x, y, z

(2) Total wood duck harvest within each state determined from harvest surveys and wing collection surveys

x = 189,700   y = 88,000   z = 60,400

(3) Direct recovery rates within and between each state as determined from summer banding and hunter recoveries

x to x = 0.070	x to y = 0.020	x to z = 0.010
y to x = 0.040	y to y = 0.060	y to z = 0.030
z to x = 0.000	z to y = 0.020	z to z = 0.080

(4) Reporting rates for each state, x = 0.300   y = 0.320   z = 0.350, provided by U. S. Fish and Wildlife Service

(5) Harvest rates calculated by dividing direct recovery rates by the appropriate reporting rates

x to x = 0.233	x to y = 0.063	x to z = 0.029
y to x = 0.133	y to y = 0.188	y to z = 0.086
z to x = 0.000	z to y = 0.063	z to z = 0.229

Then:

Formulate simultaneous equations with as many equations and unknowns as there are states

0.233(x) + 0.133(y) + 0.000(z) = 189,700 wood ducks harvested

0.063(x) + 0.188(y) + 0.063(z) = 88,000 wood ducks harvested

0.029(x) + 0.086(y) + 0.229(z) = 60,400 wood ducks harvested

Matrix Form

$$\begin{matrix} 0.233 & 0.133 & 0.000 \\ 0.063 & 0.188 & 0.063 \\ 0.029 & 0.086 & 0.229 \end{matrix} \quad (x) \quad \begin{matrix} x \\ y \\ z \end{matrix} \quad = \quad \begin{matrix} 189{,}700 \\ 88{,}000 \\ 60{,}400 \end{matrix}$$

Solution

x = 700,000 wood ducks   y = 200,000 wood ducks   z = 100,000 wood ducks

EXAMPLE 2.--Using weighted band recovereis to indicate breeding area derivation and distribution of harvest (hypothetical data)

Birds Recovered in Louisiana (derivation of harvest):

Breeding Area:	No. of Recoveries (A)	Weighting Factor (B)	Weighted Recovery (A X B)	Origin of Harvest (in %)
Northeastern	10	1,000	10,000	2.7
N.E.-E.Canada	15	1,500	22,500	6.1
Southeastern	13	2,000	26,000	7.1
Lake States	20	1,200	24,000	6.5
Southern	50	2,400	120,000	32.7
North Central	55	3,000	165,000	44.9
Totals	163		367,500	100.0

Birds Banded in Lake States Reference Area (distribution of harvest)

Recovered in	No. of Recoveries from (A) Michigan	(B) Ohio	(C) Indiana	Weighting factor (D) Michigan	(E) Ohio	(F) Indiana	Weighted Recoveries (AD)+(BE)+CF)	Distribution of harvest (%)
Mich.	20	8	3	3,000	2,000	1,500	80,500	17.5
Ohio	8	30	9	↓	↓	↓	97,500	21.2
Ind.	7	12	25				82,500	17.9
Ala.	5	9	7				43,500	9.5
Miss.	6	10	7				48,500	10.5
Tenn.	6	9	9				49,500	10.8
Ark.	3	3	4				21,000	4.6
La.	4	8	6				37,000	8.0
Totals	59	89	70				460,000	100.0

APPENDIX B

Determining Survival Rates and Banding Quotas

TABLE 50.—Reference area survival rates and direct recovery rates used in determining banding quotas[1]

Reference Area	Adult Male		Adult Female		Immature Male		Immature Female	
	Survival Rate	Recovery Rate	Survival Rate	Recovery Rate	Survival Rate	Recovery Rate	Survival Rate	Recovery Rate
North Central	0.538	0.0531	0.464	0.0474	0.414	0.0726	0.448	0.0665
Lake States	0.517	0.0519	0.509	0.0460	0.394	0.0785	0.432	0.0599
Southern	0.582	0.0357	0.540	0.0258	0.547	0.0465	0.600	0.0250
N.Y.-E.Canada	0.485	0.0659	0.460	0.0620	0.340	0.0914	0.327	0.0767
Northeastern	0.518	0.0666	0.451	0.0568	0.378	0.0827	0.315	0.0718
Southeastern[2]	0.536	0.0436	0.500	0.0297	0.500	0.0493	0.500	0.0258

[1]Survival estimates are geometric averages derived from composite, selected-recent survival calculations.

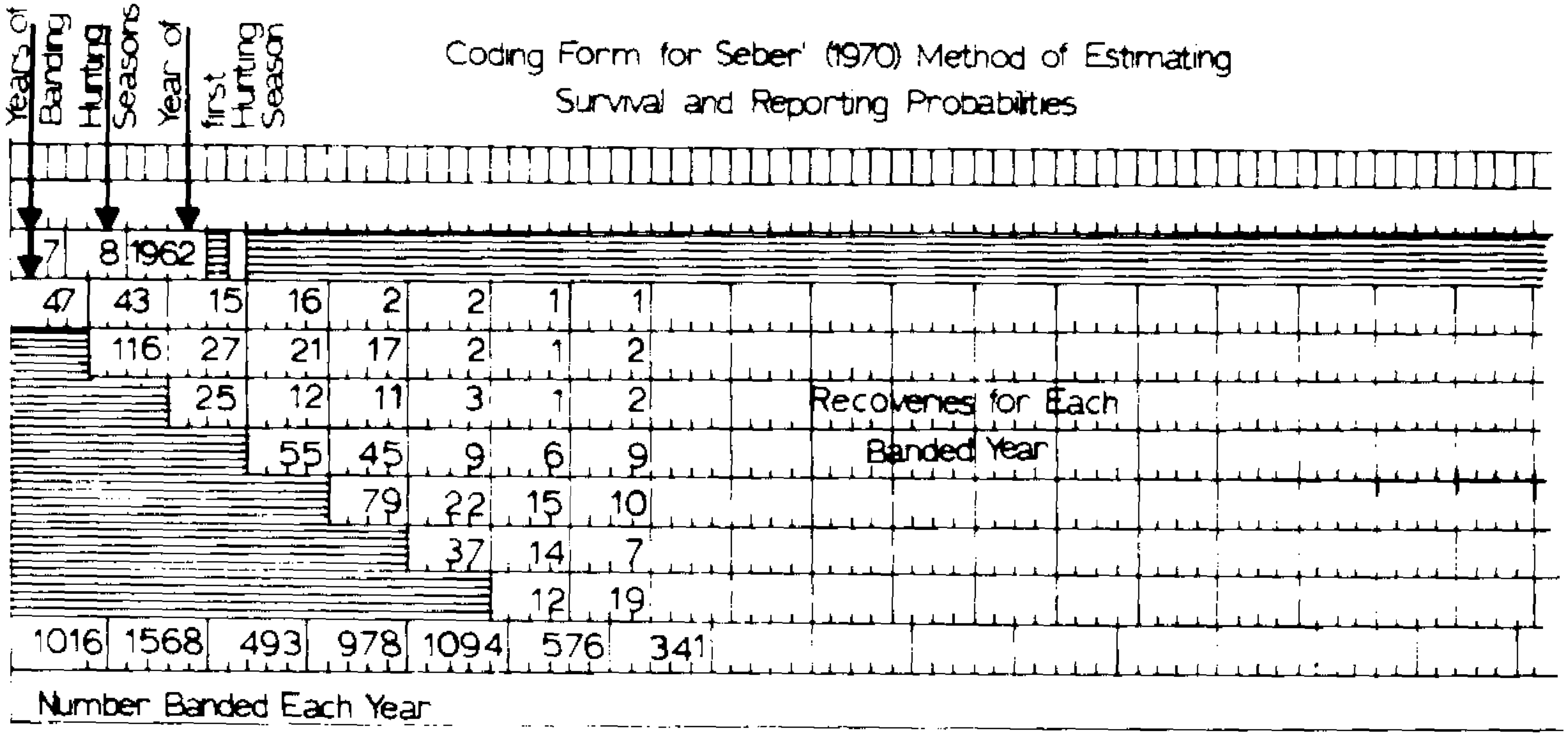
[2]A survival rate of 0.500 was assumed for adult females, immature males, and immature females.

EXAMPLE 3.--Coding adult wood duck banding and recovery data for survival estimates

Given the recovery data for adult males banded in Wisconsin during 1962-68, the following tabulation was constructed:

Year Banded	No. Banded	Recovered In 1962	1963	1964	1965	1966	1967	1968	1969
1962	1016	47	43	15	16	2	2	1	1
1963	1568	0	116	27	21	17	2	1	2
1964	493	0	0	25	12	11	3	1	2
1965	978	0	0	0	55	45	9	6	9
1966	1094	0	0	0	0	79	22	15	10
1967	576	0	0	0	0	0	37	14	7
1968	341	0	0	0	0	0	0	12	19

Coded as follows:



EXAMPLE 4.--Coding immature wood duck banding and recovery data for survival estimates

Given the recovery data for immature males banded in Wisconsin during 1962-68, the following tabulation was constructed using immature data in conjunction with adult information from Example 3:

Age Sex	Year Banded	No. Banded	Recovered In							
			1962	1963	1964	1965	1966	1967	1968	1969
IM	1962	355	26	8	6	1	0	3	0	0
AM	1963	1586	--	116	27	21	17	2	1	2
	Coding and solving the above data will give an estimate of the 1962 survival rate									
IM	1963	790	--	66	11	10	8	3	0	0
AM	1964	493	--	--	25	12	11	3	1	2
	Coding and solving the above data will give an estimate of the 1963 survival rate									

1962 coded as follows:

Coding Form for Seber's (1970) Method of Estimating
Survival and Reporting Probabilities

2	8	1962					
26	8	6	1	0	3	0	0
	116	27	21	17	2	1	2
355	1586						

EXAMPLE 5. --Determining adult numbers to be banded when survival rates and direct recovery rates are known, and a coefficient of variation between 10 and 20 percent is desired for the survival statistic

Data for Adult Females of the Southern Reference Area:
Survival rate from Table 50 = 0.540
Direct recovery rate from Table 50 = 0.0258
X, number to be banded

Let X = 2,200 and then construct a table of recoveries utilizing the known survival rate and direct recovery rate figures.
Computations for banding year 1960 are as follows:

No. alive in 1960		Survival Rate		No. alive in 1961		Survival Rate		No. alive in 1962		No. alive in 1965
2,200	X	0.540	equals to	1,188	X	0.540	equals to	641	---------------	101

After repeating this procedure for each banding year, determine the numbers recovered for each year after banding as follows:

No. alive in 1960		Direct recovery rate		No. recovered in 1960
2,200	X	0.0258	equals to	57

No. alive in 1961		Direct recovery rate		No. of 1960 banded birds recovered in 1961
1,188	X	0.0258	equals to	31

Data are then summarized in the following tabular form and coded for survival estimates as shown in Example 3:

		Recoveries							
Year Banded	No. Banded	1960	1961	1962	1963	1964	1965	Survival estimate	Coeff. of variation
1960	2,200	57	31	16	9	5	3	54.2	15.2
1961	2,200	--	57	31	16	9	5	53.9	14.7
1962	2,200	--	--	57	31	16	9	57.4	15.2
1963	2,200	--	--	--	57	31	16	55.9	16.5
1964	2,200	--	--	--	--	57	31	58.4	20.4
1965	2,200	--	--	--	--	--	57	--	--

EXAMPLE 6.--Determining immature numbers to be banded when survival rates and direct recovery rates are known, and a coefficient of variation between 10 and 20 percent is desired for the survival statistic

Data for Immature Females of the Southern Reference Area:

- Survival rate from Table 5C = 0.600
- Direct recovery rate from Table 5C = 0.025.
- Banding and recovery data for adult females from Example 5
- X, number of immatures to be banded

Let X = 2,200 and then construct a table of recoveries utilizing the known survival rate and direct recovery rate figures for immatures. Computations for banding year 1960 are as follows:

No. alive in 1960		Survival rate		No. alive in 1961		Survival rate		No. alive in 1962		No. alive in 1965
2,200	X	0.600	equals to	1,320	X	0.600	equals to	792	------------	171

After repeating this procedure for each banding year, determine the numbers recovered for each year after banding as follows:

No. alive in 1960		Direct recovery rate		No. recovered in 1960
2,200	X	0.0250	equals to	55

No. alive in 1961		Direct recovery rate		No. of 1960 banded birds recovered in 1961
1,320	X	0.0250	equals to	33

Data are summarized in the following tabular form and coded for survival estimates using adult female data from Example 5 and coding procedures of Example 4:

Age Sex	Year Banded	No. Banded	Recoveries 1960	1961	1962	1963	1964	1965	Immature survival estimate	Coefficient of variation
IF	1960	2,200	55	33	19	12	7	4	62.8	14.8
AF	1961	2,200	--	57	31	16	9	5		
IF	1961	2,200	--	55	33	19	12	7	61.5	15.6
AF	1962	2,200	--	--	57	31	16	9		

APPENDIX C

Statistical Tests

TABLE [illegible]. --Results of the Maximum R^2 Improvement Technique by age-sex classes in the North Central Reference Area, 1962-68[1]

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
ADULT MALES							
Best 1 variable x3							
Source							
Regression	1	0.001164	21.72**	0.813			
Error	5	0.000054					
Total	6						
Source							
Mean (intercept)						-0.018175	
x3					.001164	0.005895	4.66**
Best 2 variables, x1, x3							
Source							
Regression	2	0.000597	9.99*	0.833			
Error	4	0.000060					
Total	6						
Source							
Mean (intercept)						-0.014347	
x3					0.001164	0.007127	3.22*
x1					0.000029	-0.000520	-0.70

TABLE [illegible]--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial SS[3]	B Values	T Test[4]
Best 3 variables x1, x3, x4 or x2, x3, x4							
Source							
Regression	3	0.000410	6.12	0.860			
Error	3	0.000067					
Total	6						
Source							
Mean (intercept)						-0.013432	
x3					0.001164	0.007004	2.82
x2					0.000029	-0.000086	0.61
x4					0.000038	0.006950	0.51
Best 4 variables x1, x2, x3, x4							
Source							
Regression	4	0.000311	3.29	0.868			
Error	2	0.000094					
Total	6						
Source							
Mean (intercept)						-0.012268	
x3					0.001164	0.008257	1.80
x1					0.000029	0.006909	0.36
x4					0.000034	0.009399	0.73
x2					0.000016	-0.000632	-0.42

TABLE 51.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial SS[1]	B Values	T Test[4]
ADULT FEMALES							
Best 1 variable x3							
Source							
Regression	1	0.001325	41.72**	0.893			
Error	5	0.000032					
Total	6						
Source							
Mean (intercept)						-0.028546	
x3					0.001325	0.006289	6.46**
Best 2 variables x3, x4							
Source							
Regression	2	0.000667	17.72*	0.898			
Error	4	0.000038					
Total	6						
Source							
Mean (intercept)						-0.027354	
x3					0.001325	0.006866	4.22*
x4					0.000008	-0.002287	-0.47

TABLE 51. --Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial SS[3]	B Values	T Test[4]
Best 3 variables x2, x3, x4 or x1, x2, x3							
Source							
Regression	3	0.000452	10.47*	0.913			
Error	3	0.000043					
Total	6						
Source							
Mean (intercept)						-0.028992	
x3					0.001325	0.004788	1.64
x1					0.000002	-0.008987	-0.81
x2					0.000028	0.000683	0.80
Best 4 variables x1, x2, x3, x4							
Source							
Regression	4	0.000351	8.75	0.946			
Error	2	0.000040					
Total	6						
Source							
Mean (intercept)						-0.031054	
x3					0.001325	0.003669	1.23
x4					0.000008	-0.009325	-1.11
x2					0.000002	0.001310	1.31
x1					0.000068	-0.016347	-1.30

TABLE 51.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
IMMATURE MALES (3)							
Best 1 variable x3							
Source							
Regression	1	0.001380	16.66*	0.769			
Error	5	0.000083					
Total	6						
Source							
Mean (intercept)						-0.000794	
x3					0.001380	0.006418	4.08*
Best 2 variables x3, x4							
Source							
Regression	2	0.000722	8.21*	0.804			
Error	4	0.000088					
Total	6						
Source							
Mean (intercept)						0.002492	
x3					0.001380	0.008010	3.22*
x4					0.000063	-0.006307	-0.84

TABLE [illegible]. --Continued

Combinations	DF	Mean Squares	F Test	R^2	Partial SS	B Values	T Test
Best 3 variables x2, x3, x4							
Source							
Regression	3	0.000521	6.76	0.871			
Error	3	0.000077					
Total	6						
Source							
Mean (intercept)						-0.004167	
x3					0.001380	0.006380	2.39
x4					0.000063	-0.015078	-1.52
x2					0.000120	0.000115	1.25
Best 4 variables x1, x2, x3, x4							
Source							
Regression	4	0.000397	3.85	0.885			
Error	2	0.000103					
Total	6						
Source							
Mean (intercept)						-0.005842	
x3					0.001380	0.004577	0.96
x4					0.000063	-0.018601	-1.38
x2					0.000120	0.000902	0.56
x1					0.000025	-0.009939	-0.49

TABLE [illegible]--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
IMMATURE FEMALES							
Best 1 variable x3							
Source							
Regression	1	0.001302	24.76**	0.832			
Error	5	0.000052					
Total	6						
Source							
Mean (intercept)						-0.007158	
x3					0.001302	0.006233	4.98**
Best 2 variables x2, x3 or x1, x2							
Source							
Regression	2	0.000685	14.09*	0.876			
Error	4	0.000049					
Total	6						
Source							
Mean (intercept)						-0.012790	
x2					0.001169	0.001330	2.28
x1					0.000202	-0.016262	-2.06

TABLE [illegible].--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Best 3 variables x1, x2, x4							
Source							
Regression	3	0.000506	[illegible].30**	0.970			
Error	3	0.000016					
Total	6						
Source							
Mean (intercept)						-0.017206	
x2					0.001169	0.0019[illegible]	5.04*
x1					0.000202	-0.0231[illegible]	-4.58*
x4					0.000148	-0.015284	-3.07
Best 4 variables x1, x2, x3, x4							
Source							
Regression	4	0.000380	16.83	0.971			
Error	2	0.000022					
Total	6						

TABLE 5[illegible]. --Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial SS[3]	B Values	T Test[4]
Source							
Mean (intercept)						-0.17399	
x3					0.001301	0.000640	0.29
x2					0.000065	0.001777	2.37
x4					0.000040	-0.014577	-2.31
x1					0.000113	-0.021116	-2.24

[1]Regression of the dependent variable y (direct recovery rate) on independent variables x1(average total hunting days in a reference area), x2(total hunting days in flyway), x3(total October hunting days), and x4 (average duck bag-limit for states in the flyway) as shown in Table 34.

[2]Degress of freedom are represented by DF.

[3]Depicts the partial sums of squares.

[4]T test for Ho : B = 0 Ha : B ≠ 0.

*p ≤ 0.05

**p ≤ 0.01

TABLE 52.--Comparison of direct recovery rates and regulation variables for wood ducks banded in Illinois, Minnesota, Wisconsin, and Vermont

Location and Age - Sex	Year	Direct Recovery Rate	Regulation Variables[1]				
			X1	X2	X3	X4	X5
Minnesota							
Adult Males	1962	.0275	25	350	19	2.0	--
	1963	.0849	35	481	27	4.0	--
	1964	.0491	40	548	29	4.0	--
	1965	.0494	40	552	23	4.0	--
	1966	.0692	45	622	24	4.0	--
	1967	.0437	40	553	25	4.0	--
	1968	.0378	27	400	15	3.0	--
Wisconsin							
Adult Males	1959	.0699	50	615	25	3.5	1.0
	1960	.0551	50	606	25	3.5	1.0
	1961	.0363	30	397	18	2.5	1.0
	1962	.0472	25	350	19	2.0	2.0
	1963	.0740	35	481	27	4.0	2.0
	1964	.0507	40	548	22	4.0	2.0
	1965	.0562	40	552	23	4.0	2.0
	1966	.0722	45	622	24	4.0	2.0
	1967	.0642	40	553	25	4.0	1.2
	1968	.0352	30	400	20	3.0	2.0
Immature Males	1959	.0718					
	1960	.0935					
	1961	.0469	Same variables for Adult Males 1959-1968				
	1962	.0732					
	1963	.0835					
	1964	.0922					

TABLE 52 .--Continued

Location and Age - Sex	Year	Direct Recovery Rate	Regulation Variables[1] X1	X2	X3	X4	X5
	1965	.0855					
	1966	.1435					
	1967	.0935	Same variables for Adult Males 1959-1968				
	1968	.0559					
Immature Females	1959	.0942					
	1960	.0893					
	1961	.0454					
	1962	.0426					
	1963	.0848	Same variables for Adult Males 1959-1968				
	1964	.0962					
	1965	.0910					
	1966	.1082					
	1967	.0869					
	1968	.0386					
Vermont							
Adult Males	1954	.0914	60	990	22	4.0	1.0
	1957	.0708	70	1174	22	4.0	1.0
	1958	.1265	60	997	22	4.0	1.0
	1960	.0748	50	798	25	3.5	1.9
	1961	.0821	40	732	18	2.5	1.9
	1963	.0642	45	795	17	3.5	2.0
	1964	.0909	50	795	22	3.5	2.0
	1965	.0864	50	786	16	3.5	2.0
	1966	.0732	55	875	24	3.5	2.0
	1967	.0738	45	786	25	3.5	2.0

TABLE 52.--Continued

Location and Age - Sex	Year	Direct Recovery Rate	Regulation Variables[1]				
			X1	X2	X3	X4	X5
Immature Males	1950	.0704	40	640	12	4.0	0.9
	1951	.1244	45	737	20	4.0	1.0
	1952	.0900	55	924	25	4.0	1.0
	1953	.1304	55	978	27	4.0	1.0
	1954	.0850	60	990	22	4.0	1.0
	1955	.1026	70	1188	27	4.0	1.0
	1956	.1232	70	1190	27	4.0	1.0
	1957	.0643	70	1174	22	4.0	1.0
	1958	.1534	60	997	22	4.0	1.0
	1959	.1354	60	912	22	3.5	1.9
	1960	.0839	50	798	25	3.5	1.9
	1961	.0622	40	732	18	2.5	1.9
	1962	.0909	40	769	20	2.5	2.0
	1963	.0682	45	795	17	3.5	2.0
	1964	.0693	50	795	22	3.5	2.0
	1965	.0890	50	786	16	3.5	2.0
	1966	.1306	55	875	24	3.5	2.0
	1967	.1236	45	786	25	3.5	2.0
	1968	.0868	50	751	20	3.5	2.0
Immature Females	1950	.0594					
	1951	.0876					
	1952	.0918					
	1953	.0886					
	1954	.0856	Same variables as Immature Males 1950-68				
	1955	.1003					
	1958	.1099					
	1959	.1163					

TABLE 52 .--Continued

Location and Age - Sex	Year	Direct Recovery Rate	Regulation Variables[1]				
			X1	X2	X3	X4	X5
Immature Females	1960	.0947	Same variables as Immature Males 1950-68				
	1961	.0793					
	1962	.0891					
	1963	.0630					
	1964	.0827					
	1965	.0782					
	1966	.1224					
	1967	.1107					
	1968	.1061					
Illinois							
Immature Males	1960	.0470	40	606	4	3.5	1.0
	1962	.0506	25	350	6	2.0	2.0
	1963	.0726	35	481	0	4.0	2.0
	1964	.0584	40	548	1	4.0	2.0
	1965	.0534	40	552	2	4.0	2.0
	1966	.0785	45	622	10	4.0	2.0
	1967	.0551	40	553	3	4.0	1.2
	1968	.0355	30	400	0	3.0	2.0

[1]Regulation variable X1 (average total hunting days in the state), X2 (total hunting days in flyway), X3 (total October hunting days) X4 (average duck bag-limit for states in flyway), and X5 (wood duck limit).

TABLE 53.--Results of the Maximum R^2 Improvement Technique by age-sex classes in Illinois, Minnesota, Wisconsin, and Vermont[1]

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial SS[3]	B Values	T Test[4]
Minnesota-Adult Male 1962-68							
Best 1 Variable X 4							
Source							
Regression	1	0.001041	4.26	0.460			
Error	5	0.000244					
Total	6						
Source							
Mean (intercept)						-0.008123	2.06
X4					0.001041	0.016738	
Best 2 Variables X2, X4							
Source							
Regression	2	0.000553	1.91	0.489			
Error	4	0.000289					
Total	6						
Source							
Mean (intercept)						0.000295	
X4					0.001041	0.024759	1.30
X2					0.000065	-0.000074	-0.48
Best 3 Variables X1, X2,X4							
Source							
Regression	3	0.000392	1.08	0.520			
Error	3	0.000362					
Total	6						

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Source							
Mean (intercept)						0.014201	
X4					0.001041	0.024800	1.16
X2					0.000065	-0.000490	-0.51
X1					0.000071	0.005397	0.44
Best 4 Variables X1, X2, X3, X4							
Source							
Regression	4	0.000295	0.54	0.521			
Error	2	0.000542					
Total	6						
Source							
Mean (intercept)						0.023526	
X4					0.001041	0.026744	0.69
X2					0.000065	-0.000666	-0.24
X1					0.000071	0.007712	0.21
X3					0.000003	-0.000495	-0.07
Wisconsin-Adult Male 1959-68 Best 1 Variable X3							
Source							
Regression	1	0.001386	28.62**	0.782			
Error	8	0.000048					
Total	9						
Source							
Mean (intercept)						-0.039053	
X3					0.001386	0.004173	5.35**

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial SS[3]	B Values	T Test[4]
Best 2 Variables X3,X5							
Source							
Regression	2	0.000702	13.29*	0.792			
Error	7	0.000053					
Total	9						
Source							
Mean (intercept)						-0.044783	
X3					0.001386	0.004222	5.15**
X5					0.000018	0.002852	0.58
Best 3 Variables X1, X2, X3							
Source							
Regression	3	0.000489	9.53*	0.826			
Error	6	0.000051					
Total	9						
Source							
Mean (intercept)						-0.042645	
X3					0.001386	0.003789	3.13*
X2					0.000005	0.000126	1.24
X1					0.000074	-0.001351	-1.21
Best 4 Variables X1, X2, X3, X4							
Source							
Regression	4	0.000416	18.91*	0.938			
Error	5	0.000022					
Total	9						

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Source							
Mean (intercept)						-0.064002	
X3					0.001386	0.005638	5.62**
X2					0.000005	0.000383	3.53*
X1					0.000074	-0.003717	-3.45*
X4					0.000198	-0.017892	-2.99*
Best 5 Variables X1, X2, X3, X4, X5							
Source							
Regression	5	0.000333	12.14*	0.940			
Error	4	0.000027					
Total	9						
Source							
Mean (intercept)						-0.064914	
X3					0.001386	0.005635	5.03**
X5					0.000018	0.000562	0.11
X2					0.000013	0.000378	2.94*
X4					0.000055	-0.017988	-2.68
X1					0.000193	-0.003644	-2.65
Wisconsin-Immature Male 1959-1968 Best 1 Variable X2							
Source							
Regression	1	0.002911	7.03*	0.468			
Error	8	0.000414					
Total	9						

TABLE 53--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial SS[3]	B Values	T Test[4]
Source							
Mean (intercept)						-0.008674	
X2					0.0029112	0.000181	2.65*
<u>Best 2 Variables X1, X2</u>							
Source							
Regression	2	0.002205	8.52*	0.709			
Error	7	0.000259					
Total	9						
Source							
Mean (intercept)						-0.032548	
X2					0.002911	0.000681	3.17*
X1					0.001499	-0.006045	-2.41*
<u>Best 3 Variables X1,X2, X4</u>							
Source							
Regression	3	0.001611	6.96*	0.777			
Error	6	0.000231					
Total	9						
Source							
Mean (intercept)						-0.033435	
X2					0.002911	0.001037	3.12*
X1					0.001499	-0.008906	-2.80*
X4					0.000424	-0.020658	-1.35

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Best 4 Variables, X1, X2, X4, X5							
Source							
Regression	4	0.001287	6.00*	0.828			
Error	5	0.000214					
Total	9						
Source							
Mean (intercept)						-0.062492	
X2					0.002911	0.000894	2.62*
X1					0.001499	-0.006682	-1.87
X4					0.000424	-0.023920	-1.60
X5					0.000316	0.017384	1.21
Best 5 Variables X1, X2, X3, X4, X5							
Source							
Regression	5	0.001082	5.31	0.869			
Error	4	0.000204					
Total	9						
Source							
Mean (intercept)						-0.100748	
X2					0.002911	0.001019	2.91*
X1					0.001499	-0.008254	-2.20
X4					0.000424	-0.036431	-1.99
X5					0.000316	0.017069	1.22
X3					0.000258	0.003434	1.12

TABLE 53 .--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Wisconsin Immature Female 1959-1968							
Best 1 Variable X2							
Source							
Regression	1	0.005063	56.68**	0.876			
Error	8	0.000089					
Total	9						
Source							
Mean (intercept)						-0.044531	
X2					0.005063	0.000238	7.53**
Best 2 Variables X1, X2							
Source							
Regression	2	0.002714	54.22**	0.939			
Error	7	0.000050					
Total	9						
Source							
Mean (intercept)						-0.056302	
X2					0.005063	0.000485	5.13**
X1					0.000364	-0.00298	-2.70*
Best 3 Variables X1, X2, X3							
Source							
Regression	3	0.001834	39.88**	0.952			
Error	6	0.000046					
Total	9						

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Source							
Mean (intercept)						-0.072494	
X2					0.005063	0.000445	4.64**
X1					0.000364	-0.002891	-2.72*
X3					0.000074	0.001454	1.27
Best 4 Variables X1, X2, X3, X5							
Source							
Regression	4	0.001380	26.76**	0.955			
Error	5	0.000052					
Total	9						
Source							
Mean (intercept)						-0.078348	
X2					0.005063	0.000401	3.16*
X1					0.000364	-0.002261	-1.46
X3					0.000074	0.001362	1.11
X5					0.000018	0.004130	0.59
Best 5 Variables X1, X2, X3, X4, X5							
Source							
Regression	5	0.001105	17.39**	0.956			
Error	4	0.000064					
Total	9						
Source							
Mean (intercept)						-0.081655	

TABLE 53--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
X2					0.005063	0.000434	2.21
X1					0.000364	-0.002551	-1.22
X3					0.000074	0.001613	0.95
X5					0.000018	0.004377	0.56
X4					0.000004	-0.002477	-0.24
Vermont Adult Males 1954-67							
Best 1 Variable X5							
Source							
Regression	1	0.000704	2.70	0.252			
Error	8	0.000260					
Total	9						
Source							
Mean (intercept)						0.114955	
X5					0.000704	-0.018776	-1.64
Best 2 Variables X2, X5							
Source							
Regression	2	0.000695	3.48	0.499			
Error	7	0.000199					
Total	9						
Source							
Mean (intercept)						0.294777	
X5					0.000704	-0.054573	-2.51*
X2					0.000686	-0.000137	-1.85

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial SS[3]	B Values	T Test[4]
Best 3 Variables X1, X2, X5							
Source							
Regression	3	0.000596	3.58	0.642			
Error	6	0.000166					
Total	9						
Source							
Mean (intercept)						0.336706	
X5					0.000704	-0.063249	-3.07*
X2					0.000686	-0.000343	-2.30
X1					0.000399	0.002900	1.55
Best 4 Variables X1, X2, X3, X5							
Source							
Regression	4	0.000448	2.24	0.642			
Error	5	0.000199					
Total	9						
Source							
Mean (intercept)						0.338313	
X5					0.000704	-0.063085	-2.78*
X2					0.000686	-0.000344	-2.10
X1					0.000399	0.002939	1.40
X3					0.000001	-0.000138	-0.09

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Best 5 Variables X1, X2, X3, X4, X5							
Source							
Regression	5	0.000358	1.44	0.642			
Error	4	0.000249					
Total	9						
Source							
Mean (intercept)						0.337437	
X5					0.000704	-0.063005	-2.45
X2					0.000686	-0.000343	-1.81
X1					0.000399	0.002914	1.06
X3					0.000002	-0.000143	-0.08
X4					0.000000	0.000389	0.02
Vermont-Immature Males 1950-68							
Best 1 Variable X3							
Source							
Regression	1	0.003394	5.37*	0.240			
Error	17	0.000632					
Total	18						
Source							
Mean (intercept)						0.025242	
X3					0.003394	0.003399	2.32*
Best 2 Variables, X3, X4							
Source							
Regression	2	0.001898	2.94	0.268			
Error	16	0.000647					
Total	18						

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Source							
Mean (intercept)						-0.005578	
X3					0.003394	0.003052	1.97
X4					0.000402	0.010566	0.79
Best 3 Variables X2, X3, X4							
Source							
Regression	3	0.001378	2.06	0.292			
Error	15	0.000667					
Total	18						
Source							
Mean (intercept)						-0.007724	
X3					0.003394	0.003965	1.95
X4					0.000402	0.015327	1.01
X2					0.000337	-0.000039	-0.71
Best 4 Variables X1, X2, X3, X5							
Source							
Regression	4	0.001060	1.50	0.300			
Error	14	0.000707					
Total	18						
Source							
Mean (intercept)						0.056558	
X3					0.003394	0.004343	2.00
X5					0.000109	-0.011632	-0.76

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial SS[3]	B Values	T Test[4]
X2					0.000263	-0.000143	-1.00
X1					0.000475	0.001742	0.82
Best 5 Variables X1, X2, X3, X4, X5							
Source							
Regression	5	0.000854	1.12	0.302			
Error	13	0.000759					
Total	18						
Source							
Mean (intercept)						0.031336	
X3					0.003394	0.004223	1.81
X4					0.000402	0.006019	0.19
X2					0.000337	-0.000118	-0.60
X1					0.000082	0.001315	0.42
X5					0.000056	-0.007329	-0.27
Vermont-Immature Females 1950-68							
Best 1 Variable X3							
Source							
Regression	1	0.002078	11.12**	0.426			
Error	15	0.000187					
Total	16						
Source							
Mean (intercept)						0.032036	
X3					0.002078	0.002805	3.33**

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Best 2 Variables X3, X5							
Source							
Regression	2	0.001197	6.73**	0.490			
Error	14	0.000178					
Total	16						
Source							
Mean (intercept)						0.014973	
X3					0.002078	0.002949	3.56**
X5					0.000315	0.008936	1.33
Best 3 Variables X1, X2, X3							
Source							
Regression	3	0.000932	5.80**	0.572			
Error	13	0.000160					
Total	16						
Source							
Mean (intercept)						0.031098	
X3					0.002078	0.003197	2.92*
X1					0.000093	0.002111	2.09*
X2					0.000623	-0.000136	-1.97
Best 4 Variables X1, X2, X3, X4							
Source							
Regression	4	0.000814	6.01**	0.667			
Error	12	0.000135					
Total	16						

TABLE 53.--Continued

Combinations	DF^2	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Source							
Mean (intercept)						0.061934	
X3					0.002078	0.003039	3.02**
X1					0.000093	0.002945	2.86*
X2					0.000623	-0.000159	-2.46*
X4					0.000463	-0.014119	-1.85
Best 5 Variables X1, X2, X3, X4, X5							
Source							
Regression	5	0.000654	4.46*	0.670			
Error	11	0.000147					
Total	16						
Source							
Mean (intercept)						0.077967	
X3					0.002078	0.003152	2.80*
X5					0.000315	-0.003355	-0.28
X1					0.000315	0.003181	2.34*
X2					0.000321	-0.000176	-1.95
X4					0.000238	-0.017176	-1.28
Illinois Immature Males 1960-68 Best 1 Variable X4							
Source							
Regression	1	0.000371	2.34	0.280			
Error	6	0.000159					
Total	7						

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Source							
Mean (intercept)						0.020792	
X4					0.000371	0.009992	1.53
Best 2 Variables X3, X4							
Source							
Regression	2	0.000361	3.00	0.545			
Error	5	0.000120					
Total	7						
Source							
Mean (intercept)						0.008687	
X4					0.000371	0.011474	1.99
X3					0.000351	0.002099	1.71
Best 3 Variables X1, X3, X4							
Source							
Regression	3	0.000378	7.97*	0.856			
Error	4	0.000047					
Total	7						
Source							
Mean (intercept)						0.028504	
X4					0.000371	0.047791	3.72*
X3					0.000351	0.005467	3.96*
X1					0.000412	-0.004343	-2.95*

TABLE 53--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
Best 4 Variables X1, X2, X3, X4							
Source							
Regression	4	0.000291	5.41	0.878			
Error	3	0.000054					
Total	7						
Source							
Mean (intercer)						0.032598	
X4					0.000371	0.055677	3.19*
X3					0.000351	0.006000	3.66*
X1					0.000412	-0.007094	-1.73
X2					0.000028	0.000131	0.72
Best 5 Variables, X1, X2, X3, X4, X5							
Source							
Regression	5	0.000248	5.83	0.936			
Error	2	0.000043					
Total	7						
Source							
Mean (intercept)						0.004439	
X4					0.000371	0.054650	3.52
X3					0.000351	0.005636	3.79
X1					0.000412	-0.009475	-2.34

TABLE 53.--Continued

Combinations	DF[2]	Mean Squares	F Test	R^2	Partial[3] SS	B Values	T Test[4]
X2					0.000028	0.000322	1.50
X5					0.000076	0.012691	1.34

[1]Regression of the dependent variable Y (direct recovery rate) on independent variables X_1 (average total hunting days in the state), X_2 (total hunting days in flyway), X_3 (total October hunting days), X_4 (average duck bag-limit for states in flyway), and X_5 (wood duck limit) as shown in Table 52.

[2]Degrees of freedom.

[3]Depicts the partial sums of squares.

[4]T test for H_0: $B=0$ Ha: $B \neq 0$.

$*p \leq 0.05$
$**p \leq 0.01$

APPENDIX D

Wood Duck Banding and Recovery Data

TABLE 54.--Number of wood ducks banded during any banding period, 1950-69 (only normal wild birds were tabulated)

	NUMBERS BANDED[1]										
Banded In	AM	AF	IM	IF	LM	LF	LU	UM	UF	UU	TOTAL
Alabama	1,249	1,111	1,347	1,047	470	445	154	151	183	1	6,158
Arkansas	2,817	1,934	1,206	1,019	11	7	6	130	93	2	7,225
British Columbia	11	20	17	17	11	19	3	0	1	0	99
California	15	21	7	10	1	0	0	1	1	0	56
Colorado	1	1	0	0	0	0	0	1	0	0	3
Connecticut	146	110	179	161	73	62	103	0	1	1	836
Delaware	69	63	43	40	14	13	0	19	12	1	274
Florida	1,199	876	182	160	17	18	4	44	44	0	2,544
Georgia	1,651	1,199	472	463	35	24	76	36	63	5	4,024
Idaho	1	1	2	4	0	0	0	0	0	0	8
Illinois	2,645	3,712	10,463	9,050	1,229	1,137	160	64	470	78	29,008
Indiana	2,204	1,472	2,573	2,288	622	417	325	0	48	29	9,978
Iowa	1,733	1,232	6,440	5,546	1,643	1,802	138	19	89	9	18,651
Kansas	35	28	104	64	0	0	0	2	3	0	236
Kentucky	502	265	203	279	167	175	220	19	13	7	1,850
Louisiana	693	632	1,089	1,145	205	185	101	546	450	3	5,049
Maine	1,920	680	1,544	1,227	493	459	38	7	7	83	6,458
Manitoba	304	9	19	15	0	0	0	0	0	0	347
Maryland	1,149	1,275	2,292	1,921	272	270	42	6	5	30	7,262
Massachusetts	690	1,130	594	525	389	385	34	36	15	5	3,803
Michigan	2,573	722	1,338	1,014	852	744	198	30	12	29	7,512
Minnesota	5,281	1,702	4,037	3,347	406	444	21	3	15	8	15,264
Mississippi	1,781	1,612	1,344	1,224	186	190	45	560	439	5	7,386
Missouri	2,532	2,762	3,312	2,789	625	675	558	135	131	14	13,533
Montana	3	0	0	1	0	0	0	0	0	0	4

TABLE 54.--Continued

	NUMBERS BANDED[1]										
Banded In	AM	AF	IM	IF	LM	LF	LU	UM	UF	UU	TOTAL
Nebraska	0	1	0	0	0	0	0	0	0	0	1
Nevada	2	3	9	8	0	0	0	0	0	0	22
New Brunswick	302	74	116	100	110	129	1	0	1	2	835
New Hampshire	60	106	156	124	27	22	0	0	0	2	497
New Jersey	508	155	182	99	1	0	6	1	2	0	954
New Mexico	0	0	1	0	0	0	0	0	0	0	1
New York	2,439	1,631	5,429	4,727	218	255	47	113	141	17	15,017
North Carolina	484	580	375	401	130	92	60	175	134	3	2,434
North Dakota	123	9	46	40	0	0	0	0	0	0	218
Nova Scotia	38	3	3	3	0	2	0	0	0	0	49
Ohio	2,113	2,825	4,331	3,769	1,498	1,582	802	113	413	129	17,575
Oklahoma	23	19	0	0	0	0	0	1	0	0	43
Ontario	1,654	465	1,229	1,022	138	80	27	5	5	2	4,627
Oregon	270	1,245	1,234	1,146	8	4	0	17	30	0	3,954
Pennsylvania	154	238	220	215	11	12	22	2	6	0	880
Prince Edward Island	19	2	2	0	0	0	0	0	0	0	23
Quebec	164	47	73	50	14	13	0	1	0	1	363
Rhode Island	126	589	158	114	4	1	0	3	2	0	997
Saskatchewan	2	0	1	0	0	0	0	0	0	0	3
South Carolina	2,531	1,675	2,374	1,647	61	40	119	71	110	2	8,630
South Dakota	29	6	1	1	0	1	0	0	0	0	38
Tennessee	2,880	2,289	6,429	6,312	238	294	24	381	371	36	19,254
Texas	24	14	0	0	0	0	0	22	16	1	77
Utah	0	0	1	0	0	0	0	0	0	0	1
Vermont	2,559	1,585	4,708	4,639	383	428	16	1	1	5	14,325

TABLE 54.--Continued

Banded In	NUMBERS BANDED[1]										
	AM	AF	IM	IF	LM	LF	LU	UM	UF	UU	TOTAL
Virginia	372	300	201	191	0	1	0	6	10	1	1,082
Washington	166	127	165	133	11	6	10	12	11	2	643
West Virginia	817	632	1,092	1,096	346	333	4	7	8	1	4,336
Wisconsin	8,600	2,425	8,676	7,277	478	453	184	41	48	12	28,194
Wyoming	0	0	0	0	0	0	0	0	1	0	1
Total	57,663	39,614	76,019	66,470	11,397	11,219	3,548	2,781	3,405	526	272,642

[1]A (Adult), I (Immature), U (Unknown), M (Male), F (Female).

TABLE 55.--All hunting season recoveries of normal wild wood ducks banded May-August, 1950-68

State or Province	NUMBER BANDED[1]								All Hunting Season Recoveries
	AM	AF	IM	IF	UM	UF	UU	Total	
Alabama	244	299	1,237	1,010	0	0	1	2,791	175
Arkansas	27	21	37	42	0	0	0	127	7
Connecticut	98	75	162	142	0	1	1	479	43
Delaware	18	37	40	32	0	0	0	127	18
Florida	41	33	124	118	0	0	0	316	15
Georgia	31	44	131	100	2	4	3	315	14
Illinois	1,433	2,493	8,198	7,348	5	77	69	19,623	1,833
Indiana	759	450	1,650	1,127	0	7	5	3,998	359
Iowa	968	591	5,813	5,449	4	17	12	12,854	1,521
Kentucky	28	32	454	470	0	1	1	986	39
Louisiana	248	328	817	843	0	5	1	2,242	157
Maine	1,151	461	1,319	1,158	5	6	7	4,107	571
Maryland	122	194	365	298	0	2	0	981	79
Massachusetts	238	814	967	931	1	2	18	2,971	325
Michigan	1,273	344	1,368	1,126	21	3	25	4,160	495
Minnesota	2,950	659	2,122	1,822	0	1	4	7,558	820
Mississippi	251	407	705	728	1	5	0	2,097	111
Missouri	1,313	1,626	2,769	2,526	0	0	11	8,245	737
New Hampshire	13	91	75	48	0	0	1	228	13
New Jersey	1	1	10	4	0	1	0	17	5
New York	1,042	514	2,538	2,219	42	39	6	6,400	747
North Carolina	82	252	457	389	27	23	1	1,231	79
Ohio	601	1,529	3,765	3,596	50	69	63	9,673	848
Ontario	668	179	713	532	3	2	2	2,099	263
Pennsylvania	34	86	137	100	0	0	0	357	36
Quebec	55	9	46	24	0	0	0	134	20
Rhode Island	6	538	30	31	2	1	0	608	45

TABLE 55.--Continued

State or Province	NUMBER BANDED[1] AM	AF	IM	IF	UM	UF	UU	Total	All Hunting Season Recoveries
South Carolina	729	558	1,042	706	37	63	1	3,136	264
Tennessee	866	833	3,969	3,946	82	61	26	9,783	759
Texas	3	8	0	0	21	14	1	47	3
Vermont	754	961	2,483	2,548	0	0	0	6,746	820
Virginia	51	71	170	170	1	5	0	468	32
West Virginia	163	261	843	842	0	0	0	2,109	203
Wisconsin	4,235	1,065	5,332	4,335	135	137	5	15,244	1,748
Total	20,496	15,864	49,888	44,760	439	546	264	132,257	13,204

[1]A (Adult, I (Immature), U (Unknown), M (Male), F (Female).

TABLE 56.--Number of wood ducks banded May-September, 1950-63, irregardless of status at time of banding

State or Province	NUMBER BANDED[1] AM	AF	IM	IF	UM	UF	UU	Total
Alabama	591	513	1,540	1,269	0	0	1	3,914
Arkansas	80	76	104	103	0	0	1	364
Connecticut	116	85	208	178	0	1	1	589
Delaware	32	43	50	42	0	0	1	168
Florida	59	40	150	149	0	0	0	398
Georgia	82	73	202	156	3	9	4	529
Illinois	2,169	3,115	10,354	9,051	24	274	79	25,066
Indiana	1,768	1,155	2,671	2,163	0	11	23	7,791
Iowa	1,555	1,075	7,807	7,053	19	90	12	17,611
Kentucky	120	88	542	624	0	1	1	1,376
Louisiana	310	375	991	1,055	11	23	1	2,766
Maine	1,828	580	2,013	1,674	6	7	84	6,192
Maryland	197	280	621	498	0	2	0	1,598
Massachusetts	496	998	1,234	1,180	36	15	18	3,977
Michigan	2,223	635	1,975	1,588	30	8	29	6,488
Minnesota	4,665	1,366	3,869	3,095	2	12	10	13,019
Mississippi	358	533	998	974	83	76	0	3,022
Missouri	1,946	2,266	3,373	3,089	60	59	12	10,805
New Hampshire	60	106	192	156	0	0	2	516
New Jersey	128	51	59	59	1	2	0	300
New York	2,025	1,270	4,836	4,255	56	75	8	12,525
North Carolina	144	302	512	478	28	23	2	1,489
Ohio	1,405	2,208	5,576	5,104	92	303	129	14,817
Ontario	1,353	394	1,132	888	5	5	3	3,780
Pennsylvania	102	181	215	182	0	0	0	680
Quebec	121	19	65	37	1	0	1	244
Rhode Island	27	550	83	70	2	2	0	734

TABLE 56.--Continued

State or Province	NUMBER BANDED[1] AM	AF	IM	IF	UM	UF	UU	Total
South Carolina	1,883	1,157	2,359	1,681	45	80	2	7,207
Tennessee	1,439	1,355	5,073	5,146	226	235	47	13,521
Texas	3	8	0	0	22	16	1	50
Vermont	2,376	1,532	4,810	4,794	1	1	4	13,518
Virginia	79	111	239	231	3	6	1	670
West Virginia	321	414	1,327	1,332	0	0	1	3,395
Wisconsin	7,587	2,289	8,527	7,122	162	163	9	25,859
Total	37,648	25,243	73,707	65,476	918	1,499	487	204,978

[1]A (Adult), I (Immature), U (Unknown), M (Male), F (Female).

TABLE [illegible].--Direct and indirect recoveries of normal wild wood ducks banded May-September, 1950-68, and later shot or found dead

Banded in	Direct Recoveries*					All Recoveries					Number Banded				
	AM	AF	IM	IF	Total	AM	AF	IM	IF	Total	AM	AF	IM	IF	Total
Alabama	22	17	48	17	104	48	23	90	23	184	588	511	1,079	834	3,012
Arkansas	3	1	2	2	8	7	3	3	4	17	75	75	90	94	334
Connecticut	7	4	8	8	27	12	5	16	9	42	101	85	133	116	435
Delaware	4	1	2	4	11	7	3	6	4	20	32	42	36	29	139
Florida	3	1	2	0	6	3	1	6	3	13	58	38	102	101	299
Georgia	1	0	4	3	8	1	1	8	5	15	82	73	133	117	405
Illinois	121	136	549	427	1,233	234	224	913	645	2,016	2,159	3,055	8,987	7,865	22,066
Indiana	79	38	129	82	328	179	75	226	149	629	1,768	1,155	2,158	1,871	6,952
Iowa	84	83	498	375	1,040	166	117	764	598	1,645	1,524	1,066	6,116	5,247	13,953
Kentucky	7	1	7	3	18	10	5	16	11	42	92	66	114	184	456
Louisiana	14	11	42	24	91	24	20	72	59	175	308	372	765	853	2,298
Maine	115	30	146	110	401	214	49	205	155	623	1,814	576	1,502	1,196	5,088
Maryland	8	5	12	7	32	19	13	32	15	79	196	274	387	285	1,142
Massachusetts	30	64	37	21	152	66	112	68	46	292	496	980	541	484	2,501
Michigan	126	34	106	56	322	235	52	147	75	509	2,220	633	1,160	845	4,858
Minnesota	229	47	231	170	677	456	81	365	257	1,159	4,570	1,315	3,407	2,614	11,906
Mississippi	10	10	35	13	68	21	26	60	30	137	358	533	852	826	2,569
Missouri	88	91	151	107	437	189	168	284	184	825	1,941	2,206	2,721	2,399	9,267
New Hampshire	3	2	5	10	20	9	2	10	14	35	60	106	156	124	446
New Jersey	9	6	1	0	16	17	7	4	1	29	128	51	30	33	242
New York	118	68	348	271	805	227	110	531	399	1,267	1,934	1,239	4,552	3,917	11,642
North Carolina	5	5	12	13	35	10	11	24	25	70	144	284	280	316	1,024
Ohio	70	98	263	200	631	147	181	397	290	1,015	1,404	2,204	3,582	3,073	10,263
Ontario	86	23	95	64	268	153	36	129	90	408	1,264	353	970	800	3,387
Pennsylvania	6	9	15	11	41	9	13	18	15	55	102	181	175	157	615
Quebec	6	3	7	4	20	14	4	11	6	35	121	19	52	30	222
Rhode Island	0	21	5	1	27	1	36	6	5	48	25	548	77	66	716

TABLE (continued)

Banded In	Direct Recoveries[1] AM	AF	IM	IF	Total	All Recoveries AM	AF	IM	IF	Total	Number Banded AM	AF	IM	IF	Total
South Carolina	81	34	112	41	268	181	77	246	87	591	1,858	1,145	2,270	1,586	6,859
Tennessee	65	46	227	201	539	126	80	425	337	968	1,436	1,353	4,823	4,823	12,435
Texas	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Vermont	187	94	408	360	1,049	334	161	558	495	1,548	2,295	1,395	4,196	4,125	12,011
Virginia	2	2	11	3	18	7	7	18	7	39	79	111	188	180	558
West Virginia	21	20	53	51	145	41	38	96	85	260	321	414	981	999	2,715
Wisconsin	438	124	755	489	1,806	563	211	1,000	760	2,534	7,534	2,199	7,913	6,592	24,238
Total	2,048	1,129	4,276	3,198	10,651	4,330	1,952	6,754	4,888	17,624	37,087	24,658	60,528	52,781	175,054

[1]A (Adult), I (Immature), M (Male), F (Female).

TABLE 58.--Number of normal wild wood ducks banded December-March, 1950-68

State or Province	NUMBER BANDED[1]							
	AM	AF	IM	IF	UM	UF	UU	Total
Alabama	538	523	0	0	0	3	0	1,064
Arkansas	904	600	0	0	126	84	0	1,714
Connecticut	0	1	0	0	0	0	0	1
Delaware	12	8	0	0	0	0	0	20
Florida	1,018	774	2	0	9	9	0	1,812
Georgia	1,293	786	30	34	13	19	1	2,176
Illinois	82	58	0	0	18	27	0	185
Indiana	4	8	0	0	0	0	0	12
Iowa	0	1	14	4	0	0	0	19
Kentucky	141	76	17	12	18	11	0	275
Louisiana	234	150	14	10	222	176	1	807
Maryland	47	35	0	0	3	1	0	86
Massachusetts	9	5	0	2	0	0	0	16
Michigan	5	3	0	0	0	0	0	8
Minnesota	2	0	0	0	0	0	0	2
Mississippi	883	631	23	18	23	17	0	1,595
Missouri	15	16	0	0	2	2	0	35
New Jersey	3	1	0	0	0	0	0	4
New York	13	7	0	1	3	2	0	26
North Carolina	157	97	55	54	120	86	0	569
Ohio	25	6	3	0	4	9	0	47
Ontario	5	2	0	0	0	0	0	7
Pennsylvania	2	1	0	0	1	0	0	4
Rhode Island	9	4	0	2	0	0	0	15
South Carolina	461	339	2	5	22	27	0	856
Tennessee	370	215	10	0	52	63	0	710

TABLE 58.--Continued

State or Province	NUMBER BANDED[1]							
	AM	AF	IM	IF	UM	UF	UU	Total
Texas	24	12	0	0	0	0	0	36
Vermont	0	5	0	0	0	1	0	6
Virginia	95	47	1	0	0	0	0	143
West Virginia	140	78	0	0	4	5	0	227
Wisconsin	4	1	0	0	0	0	0	5
Total	6,495	4,490	171	142	640	542	2	12,482

[1]A (Adult), I (Immature), U (Unknown), M (Male), F (Female).

APPENDIX E

Common and Scientific Names of Plants

TABLE 59.--Common and scientific names of plants[1]

Common name	Scientific name
American elm	Ulmus americana L.
ash	Fraxinus spp. L.
aspen	Populus spp. L.
balsam fir	Abies balsamea (L.) Mill.
basswood	Tilia americana L.
beech	Fagus grandifolia Ehrh.
bitternut hickory	Carya cordiformis (Wangenh) K. Koch.
black ash	Fraxinus nigra Marsh.
blackjack oak	Quercus marilandica Muenchh.
black cherry	Prunus serotina Ehrh.
blackgum	Nyssa sylvatica Marsh.
black locust	Robinia pseudoacacia L.
black oak	Quercus velutina Lam.
black spruce	Picea mariana (Mill.) B.S.P.
black walnut	Juglans nigra L.
blue beech	Carpinus caroliniana Walt.
box elder	Acer negundo L.
bur oak	Quercus macrocarpa Michx.
cherrybark oak	Quercus falcata var. pagodaefolia Ell.
chestnut oak	Quercus prinus L.
cottonwood	Populus spp. L.
cypress	Taxodium distichum (L.) Rich.
eastern hemlock	Tsuga canadensis L. (Carr.)
elms	Ulmus spp. L.
green ash	Fraxinus pennsylvanica Marsh.
jack pine	Pinus banksiana Lamb.
mockernut hickory	Carya tomentosa Nutt.
oaks	Quercus spp. L.
pignut hickory	Carya glabra Mill. (Sweet)
pin oak	Quercus palustris Muenchh.
pines	Pinus spp. L.
post oak	Quercus stellata Wangenh.
red maple	Acer rubrum L.
red pine	Pinus resinosa L.
river birch	Betula nigra L.
rock elm	Ulmus racemosa Thom.
sassafras	Sassafras albidum Nutt.
scarlet oak	Quercus coccinea Muenchh.
shagbark hickory	Carya ovata (Mill.) K. Koch.
silver maple	Acer saccharinum L.
southern red oak	Quercus falcata Michx.
sugar maple	Acer saccharum L.
swamp white oak	Quercus bicolor Willd.

TABLE 59.--Continued

Common name	Scientific name
sweetgum	*Liquidambar styraciflua* L.
sycamore	*Platanus occidentalis* L.
trembling aspen	*Populus tremuloides* Michx.
tupelo	*Nyssa aquatica* L.
white birch	*Betula papyrifera* Marsh.
white cedar	*Chamaecyparis thyoides* (L.) B.S.P.
white pine	*Pinus strobus* L.
white spruce	*Picea glauca* (Moench) Voss
willows	*Salix nigra* Marsh.
yellow birch	*Betula alleghaniensis* Britton
yellow poplar	*Liriodendron tulipifera* L.

[1]From Harlow and Harrar (1958).

VITA

Emory Frank Bowers was born in Royston, Georgia, on May 5, 1942. He attended public schools in Toccoa, Georgia, and graduated from Toccoa High School in June 1960.

Entering the University of Georgia during September 1960, he graduated with a Bachelor of Science degree in Forestry in June 1964. He began graduate studies at the University of Georgia during July 1964 and received a Master of Science degree in Wildlife Management in June 1967. An additional year of graduate study in zoology was obtained at Southern Illinois University during the period January 1966 to January 1967.

In November 1967 he entered the United States Army and served in the Corps of Engineers and Medical Corps until September 1969.

He entered the Graduate School of Louisiana State University in September 1969. In November 1970, he married the former JoAnne Borne of Baton Rouge, Louisiana. He is currently employed as a Biologist with the Tennessee Valley Authority--a position held since December 1972.