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Volume 25 BULLETIN Article 3

Canada Geese of the Mississippi Flyway

With Special Reference to an Illinois Flock

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Printed by Authority of the State of Illinois

URBANA, ILLINOIS

March 1950

This paper is a contribution from the Section of Game Research and Management.

(80159—4,500—6-49) 2

FOREWORD

OF all of the geese inhabiting North America, the Canada goose stands at or near the top of the list in general recognition, and as a game bird. So well known is it that the mention of wild goose brings to the average person a mental picture of the great gray-bodied, black-necked, white-jowled "honker." Francis Kortright, in his *The Ducks, Geese and Swans of North America* says, "Sagacity, wariness, strength and fidelity are characteristics of the Canada Goose which, collectively, are possessed in the same degree by no other bird." The cold, calculating, investigative, scientific eye may occasionally cast doubt on the completeness with which some of these traits permeate the whole population (as will be noted in this report). One can, if he searches diligently, find a thriftless Scotchman.

Wide distribution, great size, and habits conspicuous to the ear and eye have all assisted in making the Canada goose a well-known bird; but most of the knowledge concerning it has been general and superficial. During some time in the year this goose may be seen from one coast to the other and from northern Canada to the Gulf of Mexico. To the average person this wide distribution might mean that the elimination of the species from any of its areas of habitation would be difficult. But every field biologist is familiar with the so-called "flyway concept" that has developed in the past few decades. This concept, backed by a large quantity of band-recovery data and general observation, is that the whole population of a migratory species may be divided into subpopulations, each having rather definite nesting and wintering areas and routes of movement, with a minimum of mixing among these subpopulation groupings.

On the basis of this thinking, the study of a migratory species breaks down into a number of geographic units, and the success or failure of one flyway population may affect but little the populations of other flyways.

This is the problem that faced those interested in the geese wintering in Illinois. From nesting grounds on the west side of James Bay in Canada, one segment of the Canade goose population moved south and west, and in recent years wintered to a very large extent at the Horseshoe Lake Game Refuge in Alexander County, Illinois. About half of the population of geese in the Mississippi flyway concentrated in a small area where excessive hunting could conceivably have affected numbers and hunting successes in a very large area both inside and outside the state. The object of the study reported herein was to ascertain the health of the Horseshoe Lake population, and this study required a broad attack both as related to the subject matter investigated and the geography involved.

Both of the authors have been far afield in this study. Mr. Smith, as Flyway Biologist for the United States Fish and Wildlife Service, has had an opportunity allowed to but a very few to observe this and other Canada goose populations. Mr. Hanson spent several years at Horseshoe Lake and parts of two summers in the James Bay nesting area

The section titled "Population Survival" represents an attempt to analyze a difficult problem with data difficult to obtain in quantity. The data available have been explored by Mr. Hanson, and certain conclusions reached. These conclusions, it is realized, may vary somewhat from the true picture, but it is felt that their inclusion is worth while as a stimulus to a fuller investigation of this problem even if there were no other values accruing.

A study such as the following must of necessity have authors. It is obvious, however, that an investigation of this magnitude is the result of the authors' efforts plus assistance from many people in numerous ways. To all who helped in any way we are deeply grateful.

HARLOW B. MILLS, *Chief*
Illinois Natural History Survey

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Evening flight of Canada geese at Horseshoe Lake.

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HORSESHOE LAKE, formed from an ancient oxbow of the Mississippi River, lies in Alexander County, Illinois, at the southwest tip of the state, fig. 1. An area, totaling 3,489.77 acres, that includes the lake and the island it surrounds, was purchased by the Illinois State Department of Conservation in 1927 for use as a wildlife refuge. Subsequent purchases in 1941, 1945, and 1946 added about 220 acres to the area, now known as the Horseshoe Lake Game Refuge.

That the plan of use for the Horseshoe Lake area was eminently successful from the standpoint of attracting wildlife soon became evident. Flocks of Canada geese that previously had wintered along the Mississippi River in the region of southern Illinois left their traditional wintering grounds for the food supply and the rest lake provided by the refuge. In recent years, for varying periods during the autumn and winter, the Horseshoe Lake Game Refuge and the countryside immediately around it have contained approximately 50 per cent of the Canada goose population wintering in the entire Mississippi River valley.

Along with the increase in numbers of Canada geese at Horseshoe Lake there were two developments of primary importance: a tremendous increase in shooting pressure on the flock and an alteration in the behavior of the geese. Once as wary as any waterfowl population in the Mississippi River valley, the goose flock using Horseshoe Lake gradually lost most of its fear of man and gunfire while near the refuge. The obvious result of the greatly increased shooting pressure and the loss of normal wariness was a tremendous increase in the kill.

Large annual kills made at Horseshoe Lake, beginning in 1939, focused the attention of wildlife administrators on the need for a long-term management program in that area. In recognition of this need, the Natural History Survey Division of the Illinois State Department of Registration and Education instituted the research program on which the present report is based. When it became evident that the Horseshoe Lake goose problem was not only of local importance, but national and international in scope, the United States Fish and Wildlife Service initiated a program of investigations to cover the entire range of the Canada goose population wintering in the Mississippi River valley; these investigations extended from the James Bay region of Canada to the coastal marshes of Louisiana.

* Flyway Biologist, United States Fish and Wildlife Service.

ACKNOWLEDGMENTS

For the generous co-operation on the research project at Horseshoe Lake by the Illinois Department of Conservation, the agency which operates and maintains the refuge, special appreciation is due officials or employees of the Department active during the period of field work:

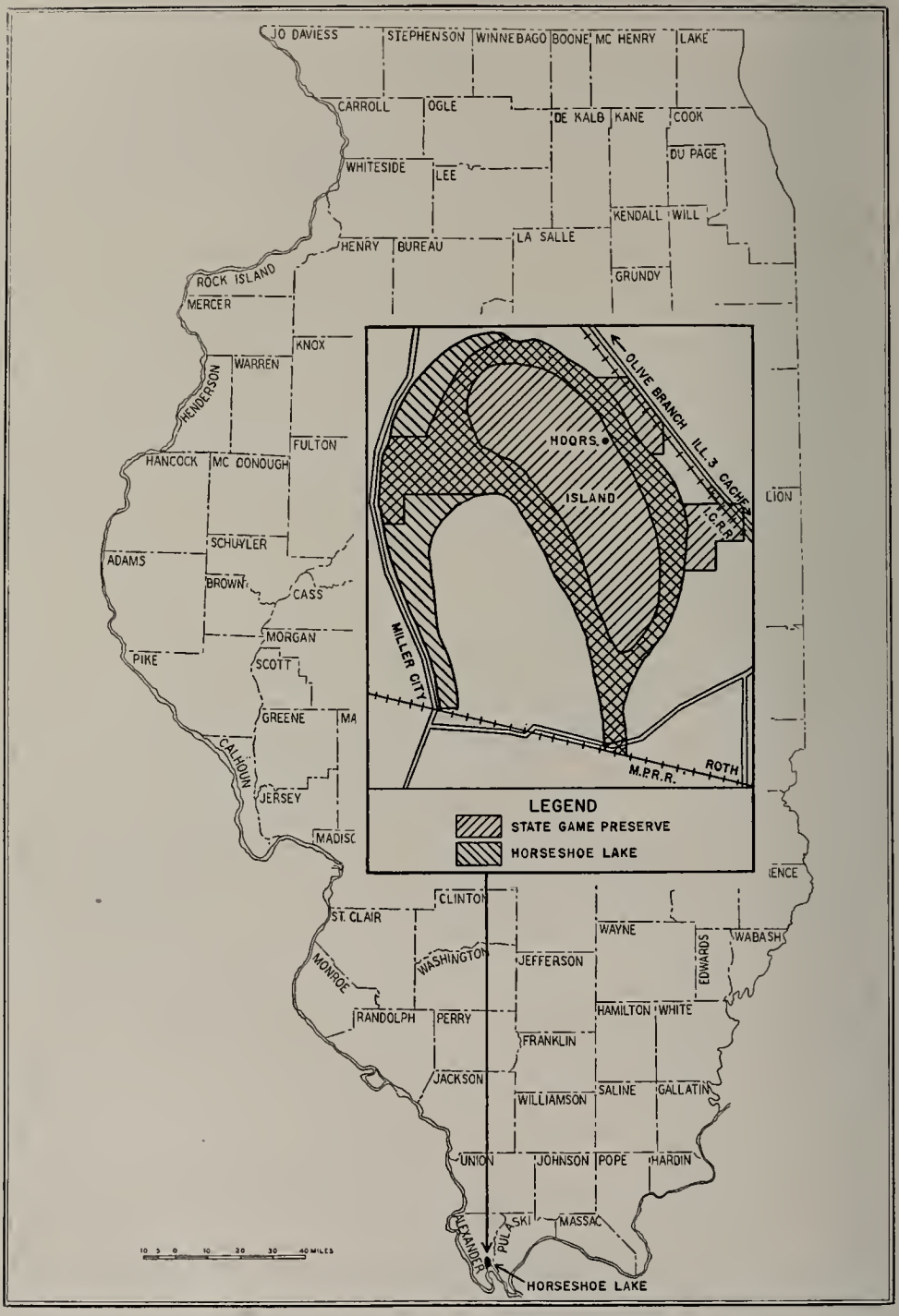

Fig. 1.—Map showing the boundaries and location of the Horseshoe Lake Game Refuge, 1946. The refuge area totaled about 3,700 acres at the end of that year. The original purchase, in 1927, involved about 3,500 acres.

Livingston E. Osborne, Director; Lewis E. Martin, Harold L. Gray, and Joe B. Davidson, members of the administrative staff; and Vernal Nave, C. E. Laughery, and Kenneth Long, refuge managers. The inception of the Canada goose study at Horseshoe Lake was in no small measure due to Paul S. Smith, formerly Chief Conservation Officer, Illinois Department of Conservation, and later Game Management Agent of the United States Fish and Wildlife Service. He was one of the first to recognize the serious consequences of the high Canada goose kills in southern Illinois and to awaken others to its dangers. The valuable co-operation given the research program by Smith was continued by his successor, Vernon C. Conover.

For their official helpfulness and personal interest in the research program, we are indebted to the late Dr. Theodore H. Frison, formerly Chief, to Dr. Leo R. Tehon, formerly Acting Chief, and to Dr. Harlow B. Mills, present Chief, of the Illinois Natural History Survey; to Dr. Clarence Cottam, Fredrick C. Lincoln, Jesse F. Thompson, Leo Couch, Dr. Gustav A. Swanson, and Richard Griffith, all of them during the period of field work with the United States Fish and Wildlife Service; to Dr. Harrison F. Lewis and T. S. Hennessey of the Dominion Wildlife Service, Canada Department of Mines and Resources; and to Dr. T. J. Orford of the Indian Affairs Branch, Canada Department of Mines and Resources.

Manly Miner, President of the Jack Miner Migratory Bird Foundation, Inc., acting in behalf of the Miner family and the Miner Foundation, was most helpful during the course of this study. For permission of the Miner family to compile and analyze the Miner goose-banding records, we are deeply appreciative.

The senior author was privileged to undertake field studies in the James Bay area in 1946 and 1947 under the auspices of the Arctic Institute of North America. For helpfulness in connection with this activity we wish to thank Dr. A. L. Washburn, Executive Director of the Institute.

In 1947, Ducks Unlimited provided the senior author with funds for an aerial reconnaissance of the breeding grounds of the Canada goose in northern Ontario and northeastern Manitoba. Appreciation is due for the support given this program by L. H. Barkhausen, B. W. Cartwright, and Arthur Bartley. Paul Queneau of Westport, Connecticut, rendered valuable assistance during these flights by operating one of the aerial cameras used and keeping a personal flight log of his observations.

We are grateful to Father John M. Cooper of the Catholic University of America for permission to quote from his unpublished report on tribal and family hunting grounds in the James Bay area and to reproduce a portion of his accompanying map, fig. 9. This report, on file in the Indian Affairs Branch, Canada Department of Mines and Resources, was made available to us through the courtesy of T. R. L. MacInnes.

Employees of the Hudson's Bay Company and other residents of the James Bay area have shown us many courtesies and contributed information. We are indebted to William B. Anderson, W. J. Cobb, Mathew Cowan, R. M. Duncan, William Faries, C. C. Forman, William Glennie, Patrick Houston, Wesley Houston, A. H. Michell, Father Leopold Morin, Thomas Rettalack, Norman Ross, Arthur Sullivan, and the late James Watt and Mrs. Watt. The above people, as well as the following, have zealously reported bands in past years: J. W. Anderson, Bishop Henri Belleau, Father Bilodeau, George S. Cotter, H. Gibbs, the Rev. Arnold C. Herbert, Brother Gerard Lavoie, the Rev. D. A. MacLachlan, Norman Mathew, L. G. Maver, P. A. C. Nichols, E. H. Riddell, the Rev. H. A. Turner, the Rev. J. H. Turner, J. B. Tyrer, and Harold Udgarden.

For information on the wintering grounds and kills of Canada geese in various states we are indebted as follows: for Michigan, Herbert J. Miller and Dr. Miles D. Pirnie; for Wisconsin, Therman Deerwester and F. R. Zimmerman; for Minnesota, Frank D. Blair; for Indiana, William B. Barnes; for Iowa, Bruce F. Stiles; for Missouri, M. O. Steen. Data for other states have been gathered largely by the authors, but Frank C. Bellrose of the Illinois Natural History Survey has furnished us with the information on Canada goose concentrations in the Illinois River valley.

From 1940 through 1943, staff members of the Illinois Natural History Survey carried out studies of a captive Canada goose flock on the Bright Land Farm near Barrington, Illinois, a program supported by the late A. L. Eustice and Mrs. Eustice, aided by Carleton A. Beckhart.

Cecil S. Williams, Dr. Elizabeth Brown Chase, Arthur S. Hawkins, and Dr. Gustav A. Swanson have read parts of the manuscript and given much helpful criticism. Dr. Chase and H. W. Bean have reviewed the statistical data. Arlone Hanson has contributed much valuable assistance in the field and in the office.

MATERIALS AND METHODS

This Canada goose study is based on data from three primary sources: data collected at Horseshoe Lake, Alexander County, Illinois; surveys by the authors on the distribution, habitat, and behavior of the population elsewhere in the Mississippi flyway; and banding records of the Jack Miner Bird Sanctuary, Kingsville, Ontario. Data from other sources have been used as indicated in the text.

Data From Horseshoe Lake

Most of the data relating to Canada geese of the Horseshoe Lake Game Refuge, prior to 1940, were obtained by Paul S. Smith when he was federal Game Management Agent. In 1940 and 1941, Arthur S. Hawkins, then Game Technician of the Illinois Natural History Survey, collaborated with Smith on an investigation of conditions at and near Horseshoe Lake. The first successful trap used at Horseshoe Lake was designed and constructed by John M. Anderson and Jacob H. Lemm of the Natural History Survey and in February, 1941, the first bandings of geese in the area were made by Hawkins, who recorded the sex and age classes of birds banded. In January and February, 1942, and in the winter of 1942–43, Dr. William H. Elder continued the trapping program begun by Hawkins. From the autumn of 1943 to the spring of 1947, the senior author was responsible for the research program at Horseshoe Lake.

In the studies at Horseshoe Lake, particular emphasis was given to trapping and banding (Hanson 1949*c*), often the only techniques whereby such vital statistics as average longevity and rate of population turnover can be obtained. These study techniques yielded data on sex and age composition of the flock, and, in connection with bag inspection, on the differential vulnerability of the sex and age classes. Sex and age criteria, flock habits and flock organization, crippling losses, and, as time permitted, diseases and parasites of Canada geese were also studied. The total numbers of Canada geese trapped and banded at Horseshoe Lake by the Illinois Natural History Survey are given in table 1.

Data From Jack Miner Sanctuary

On a number of occasions, members of the Illinois Natural History Survey staff

Table 1.—Number of Canada geese trapped at Horseshoe Lake, Alexander County, Illinois, by Illinois Natural History Survey personnel, during the fall and winter seasons of 1940–41 through 1946–47.

Season of Trapping	Geese Banded	Returns Retrapped *	Total Individuals	Repeats and Returns Retrapped*	Total Annual Catch
1940–41	315	0	315	11	326
1941–42	402	6	408	24	432
1942–43	1,036	18	1,054	147	1,201
1943–44	2,329	133	2,462	2,139	4,601
1944–45	853	248	1,101	1,567	2,668
1945–46	310	231	541	543	1,084
1946–47	502	215	717	289	1,006
Total	*5,747*	*851*	*6,598*	*4,720*	*11,318*

*A *return* is a goose trapped and banded at Horseshoe Lake that is retrapped at Horseshoe Lake in any year following the year of banding. A *repeat* is a goose trapped and banded at Horseshoe Lake that is retrapped at Horseshoe Lake in the year of banding, or a return that is retrapped more than once in any year.

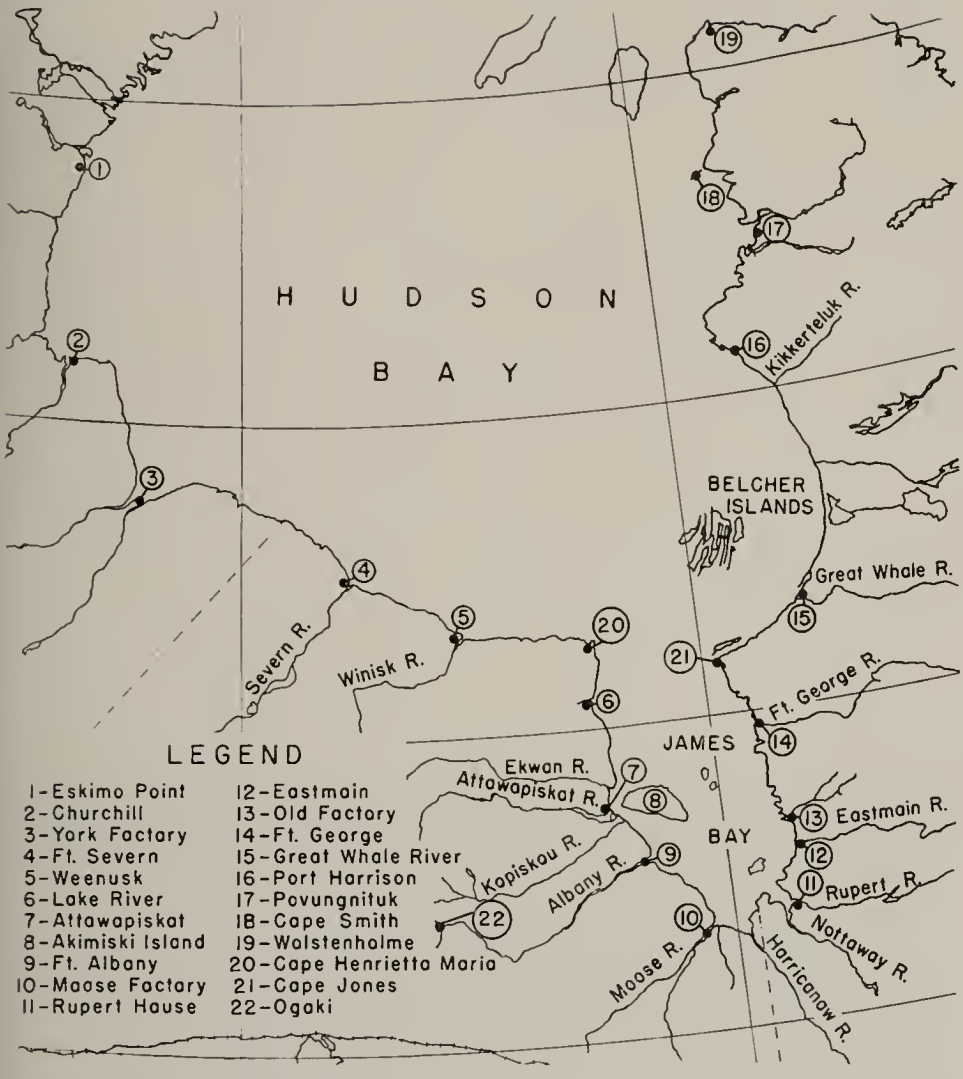

Fig. 2.—Map of the Hudson-James Bay range of Canada geese that winter in the Mississippi River valley. The main breeding range of this goose population is between the Severn and the Albany rivers.

have visited the Jack Miner Bird Sanctuary at Kingsville, Ontario, to study trapping operations. The first traps built at Horseshoe Lake, although set on land, were modeled after the water trap perfected by the Miners. In May, 1945, the authors visited Kingsville to obtain background material requisite for compiling and interpreting Miner band-recovery data. The Miner records consisted of the original reports of band recoveries from hunters in the United States and Canada, and from missionaries and fur traders in the far north, who reported recoveries made by the natives. The senior author was responsible for the compilation of these original data, which are filed in Ottawa at the Dominion Wildlife Service, Canada Department of Mines and Resources.

Between 1915 and the spring of 1944, approximately 31,000 Canada geese were banded at the Miner Sanctuary. From these bandings approximately 3,900 rec-

Table 2.—Number of Canada geese banded at the Jack Miner Bird Sanctuary, Kingsville, Ontario, during the fall trapping seasons, 1927–1944.

YEAR	GEESE BANDED	YEAR	GEESE BANDED
1927	50	1936	660
1928	558	1937	1,741
1929	225	1938	604
1930	578	1939	1,606
1931	1,091	1940	1,182
1932	1,129	1941	1,235
1933	1,490	1942	1,167
1934	468	1943	1,294
1935	170	1944	984
Total			*16,232*

ords of recoveries had been received by 1944. Although exact records are not available for the early years, it is estimated that about one-half of the 31,000 geese were banded in the autumn months, table 2, when many geese of the Mississippi flyway migrate through the Kingsville region. A comparatively small number of the geese of this flyway migrate through Kingsville in spring. Recovery records from fall-banded geese for which sufficient data are available have been analyzed for use in this paper.

Because of their sheer mass and the span of years they cover, data from the Miner bandings are outstanding in the annals of wildlife study. That the bandings have not yielded findings commensurate with their size is understandable, as they were begun at a time when little was known about sexing and aging of Canada geese.

Because Jack Miner did not serially number his bands, some of the potential values of his bandings will never be realized. Prior to 1932, his bands were marked with symbols to represent only the season and year in which they were used. For example, "25 S" meant 1925 spring; "25 F" meant 1925 fall. Since 1932, all bands have been stamped with an additional letter to signify the date of banding, and, since the fall or autumn of 1946, all bands have also been serially numbered.

Fig. 3.—Noon stop on the Albany River, June 1947. Canoe and plane are the only means of travel in much of the breeding range of the Mississippi Valley geese.

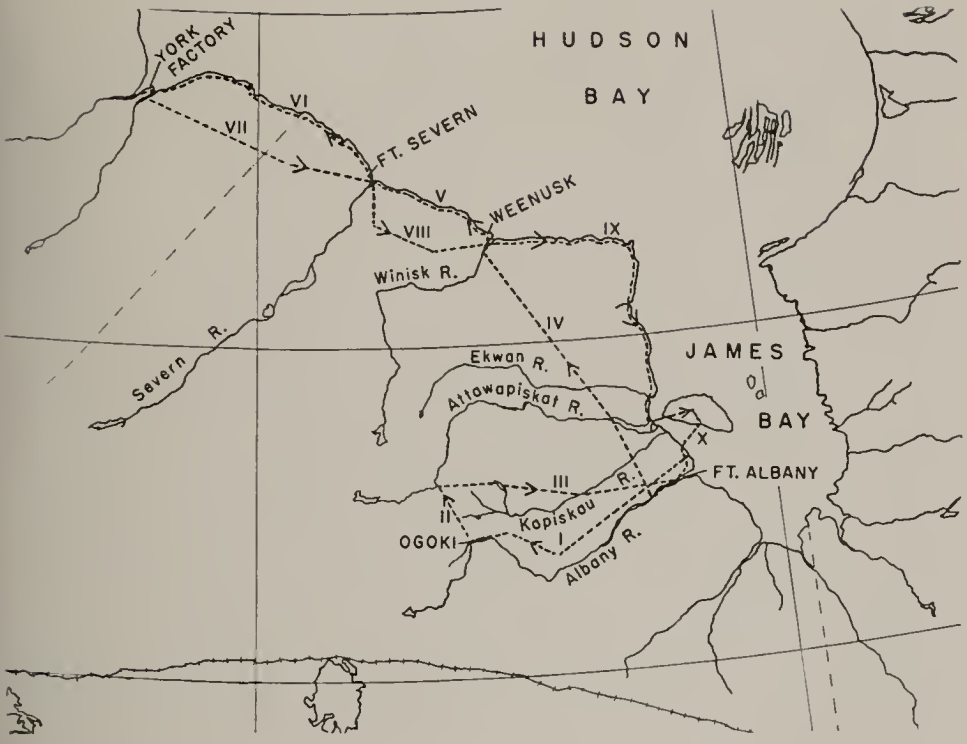

Fig. 4.—Map showing flight routes of an aerial reconnaissance of the breeding grounds of Canada geese south of Hudson Bay and west of James Bay in 1947. Roman numerals designate the various flights discussed in the text.

Recovery records for the first 8 years are incomplete, as many of the letters reporting bands were given to newspapers and never returned. In some cases only news clippings with incomplete data served to preserve early records.

Data From Other Areas

Field studies on Canada goose concentrations away from Horseshoe Lake were begun by the junior author in 1942. Beginning in 1943, he inventoried by plane many of the wintering concentrations from Horseshoe Lake to Louisiana. He devoted the summer of 1943 to a survey of the south and east coast areas of James Bay, from Moose Factory, Ontario, to Fort George, Quebec, fig. 2. The following summer he made a reconnaissance of the west coast from Moose Factory to Cape Henrietta Maria.

The senior author made a brief preliminary trip to James Bay in the summer of 1946, visiting Moose Factory, Rupert House, and Fort Albany, and ascending Little Partridge Creek via canoe. In 1947, he spent from mid-May to September investigating the breeding grounds inland from the west coast of James Bay; he used both canoe, fig. 3, and plane for these surveys. The aerial reconnaissance in 1947 included stops at Weenusk, Fort Severn, and York Factory. Approximately 375 aerial photographs were taken on this aerial survey, the itinerary of which is shown in fig. 4.

Data From Questionnaires

Approximate'y 40 questionnaires regarding goose-breeding grounds and kills were distributed to fur trade posts in the Canadian Eastern Arctic in 1947, through the courtesy of the administration of the Northwest Territories, Canada Department of Mines and Resources. Replies to the questionnaires have been summarized and the data included in this report.

THE FLYWAY CONCEPT

Over a decade ago, Lincoln (1935) presented the concept that the routes taken by North American birds in migration fall into major flyways or lanes of travel. Recoveries of banded birds have demonstrated the validity of the flyway concept with respect to waterfowl as well as many other kinds of birds. Lincoln named the Atlantic, the Mississippi, the Central, and the Pacific flyways as the principal ones of North America.

The limits of the waterfowl flyways vary somewhat with each species and may change to some degree from year to year, depending on weather, surface water, and food conditions. In most species the populations of one flyway merge almost imperceptibly with those of adjoining flyways. Consequently, the flyway taken in any one year by an individual bird breeding in an area where two flyways meet may be due in part to chance.

The adherence of ducks and geese to their ancestral flyways has been demonstrated experimentally by removing individuals from one flyway to another. With relatively few exceptions, the transported individuals have been recorded later in their original flyways. One of the early experiments of this kind with ducks was begun in 1918 by McIlhenny (1940), who, in co-operation with Dr. Arthur A. Allen of Cornell University and the United States Bureau of Biological Survey, shipped ducks and coots trapped during the winter in Louisiana, which is in the Mississippi flyway, to points in the Atlantic and Pacific flyways. Most of the released individuals that were later recovered or retrapped were taken in the Mississippi flyway.

Perhaps the earliest test of this kind with Canada geese was made by Jack Miner; complete data on the test were found in the files of the Dominion Wildlife Service. In the spring of 1934, 25 geese trapped at the Miner Sanctuary, from flocks that had wintered on the Atlantic Coast and were in migration to their breeding grounds along the east coast of James and Hudson bays, were released among a concentration of blue and snow geese at Grant Lake, Manitoba, a locality far west of their own migration routes. Three of these geese were later reported shot, two of them in their own flyway: one in the vicinity of Poplar Branch, North Carolina, in the fall of 1934; the other near Lake St. John, Quebec, in the fall of 1940. The third was recovered in northern Manitoba in the spring of 1934, too soon after release for the record to be significant.

The chief deviations from flyway consciousness are among young birds that have not yet nested (Lincoln 1934). Williams & Kalmbach (1943) showed that the migratory behavior of young Canada geese when raised in or transported to a new area is similar to the behavior of geese native to that area.

As pointed out by Lincoln (1935), the adherence of waterfowl to their ancestral flyways has particular administrative significance in connection with conserving the continental waterfowl resources. "It indicates," Lincoln writes, "that if the birds should be exterminated in any one of the four major flyways now definitely recognized, it would at best be a long time before that region could be repopulated, even though birds of the species affected should continue over other flyways to return to their great breeding grounds of the North."

This hypothesis is of special significance as applied to the management of Canada geese. Members of a species with a fairly low breeding potential, they would probably require several years to regain their numbers in any one flyway after having been once seriously depleted. Thus, it is to the hunter's best interests that the yearly kills in each flyway be kept within reasonable bounds.

EASTERN POPULATIONS

A brief review of the distribution and taxonomy of Canada goose populations in eastern North America is relevant to an understanding of the data later presented concerning the Mississippi flyway population.

The Canada geese using the Atlantic and Mississippi flyways, as defined by Lincoln (1935), have been recognized as belonging to two distinct major populations, based on taxonomy (Todd 1938)

Fig. 5.—Extreme examples of plumage variation in Canada geese of the flock wintering at Horseshoe Lake in southern Illinois. The majority of the geese at Horseshoe Lake approach the dark-colored goose, left above, considered to be *Branta canadensis interior;* but a few resemble the individual at the right. The latter is more like *Branta canadensis canadensis* of the North Atlantic coast. The goose on the left is a yearling female; that on the right, a yearling male.

and location of the breeding grounds: the North Atlantic population and the Hudson-James bay population. The North Atlantic population constitutes a distinct management unit. The study reported here indicates that the Hudson-James bay population is not homogeneous but consists of four subpopulations, each of which constitutes a separate management unit having a fairly distinct range of its own. These subpopulations are here designated by terms suggestive of their wintering grounds or migration routes: the South Atlantic, the Southeast, the Mississippi Valley, and the Eastern Prairie.* The ranges of these subpopulations are shown in fig. 6.

Todd (1938) noted what he considered significant plumage differences among Canada geese collected in the eastern half of the United States and proposed a new subspecies, *Branta canadensis interior,* for the darker colored birds that breed and migrate in an area west of the range of the nominate subspecies, *Branta canadensis canadensis.* Fig. 5 shows two Canada geese trapped at Horseshoe Lake with plumages that illustrate some of the differences between these two races.

"Typical *canadensis,* as represented by breeding examples from Newfoundland and by winter birds from the South Atlantic coast, is a comparatively light-colored bird," according to Todd (1938). "In breeding dress the anterior under parts are buffy white, and this pale color runs up on the sides of the lower neck (behind the black) to form a conspicuous light-colored area on the upper back. In the new race this feature is wanting. The feather-edgings of the new

* Name and recognition of the Eastern Prairie population as a separate population from Cecil S. Williams of the United States Fish and Wildlife Service, 1946.

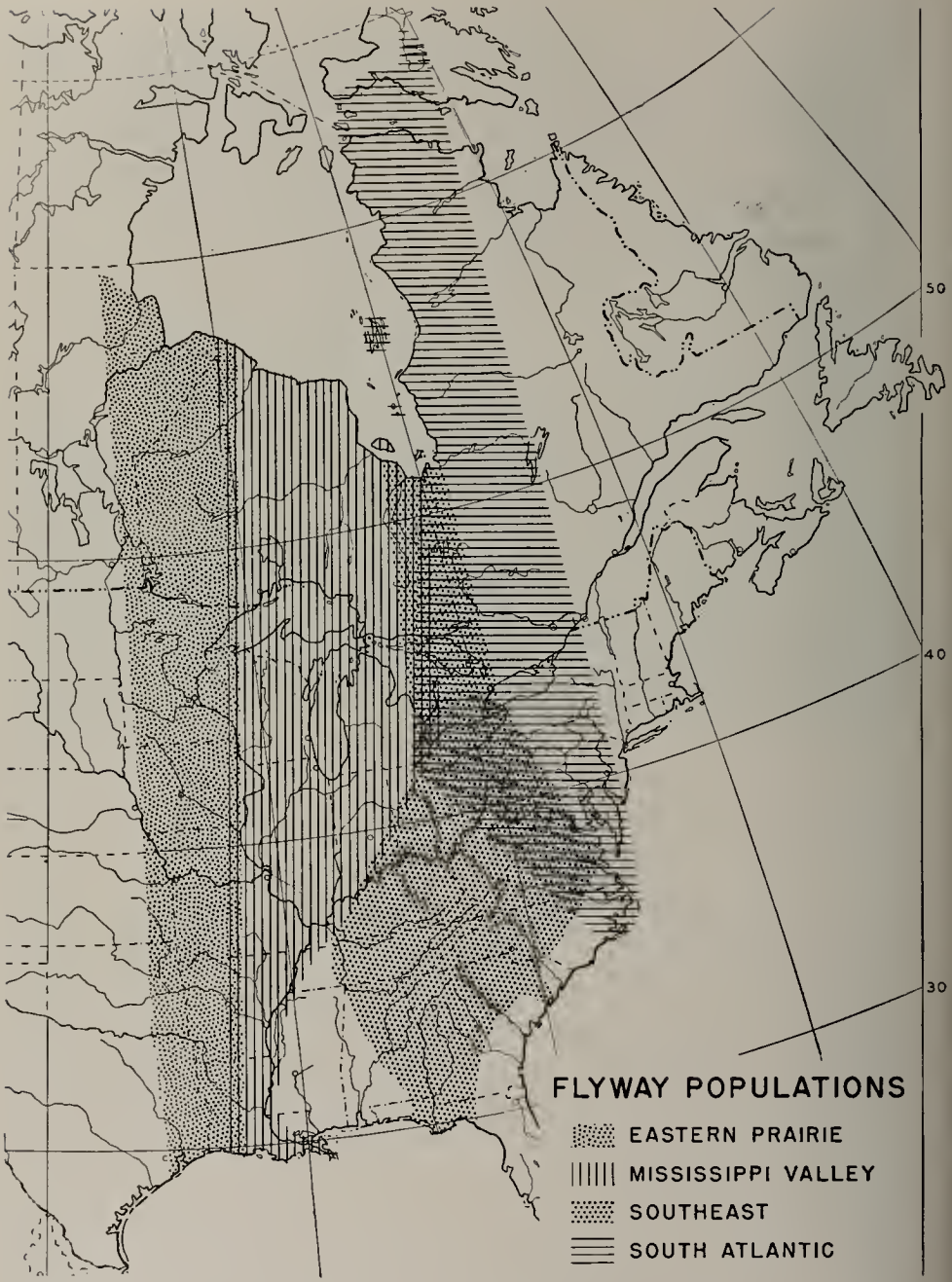

Fig. 6.—Map showing roughly the main ranges of the four populations of Canada geese nesting in the Hudson-James bay region. The range of the Mississippi Valley geese overlaps the range of the Southeast population chiefly in fall; the range of the South Atlantic population overlaps the range of the Southeast population chiefly in spring. The western limits of the range of the Eastern Prairie population extend farther west than indicated here. The eastern limits of the range of the South Atlantic population probably extend farther east in some areas than indicated.

race are generally darker, while the under-plumage is conspicuously so."

Official recognition was given to the race *interior* by its inclusion in the *Twentieth Supplement to the American Ornithologists' Union Check-List of North American Birds* (Wetmore 1945). Appendix B contains a brief summary of the latest classification of the Canada geese of the genus *Branta,* with notes regarding recognition of various kinds by the Indians.

North Atlantic Population

The Canada geese of the North Atlantic, which breed in Newfoundland, eastern Quebec, and Labrador north to the northern limit of trees (Austin 1932), are those recognized by Todd (1938) as *Branta canadensis canadensis.* In the autumn, they migrate down the Atlantic Coast and winter principally from Port Joli and Port l'Hebert, Nova Scotia (Tufts 1932, Lloyd 1923), to Martha's Vineyard, Massachusetts, and south probably as far as New Jersey. Skins examined by us at the Chicago Natural History Museum indicate that some of these geese winter as far south as the coast of North Carolina, where they mingle with South Atlantic geese.

Low (1935), in a report on 64 Canada geese banded at Cape Cod, Massachusetts, presented convincing evidence that the flight of geese along the North Atlantic Coast is a distinct entity. Twenty-five of the 26 geese later recovered or recaptured were taken between Newfoundland and New Jersey. One was recovered in Florida.

Hudson-James Bay Populations

The Canada geese that breed inland from both coasts of Hudson and James bays, fig. 2, as far north on the west coast as Churchill, Manitoba, and probably as far north on the east coast as Baffin Island, which lies just north of Cape Wolstenholme, conform to the description given by Todd (1938) for *Branta canadensis interior.* While the distribution of geese breeding around the two bays is more or less continuous, available data indicate that this population is a heterogeneous one and is composed of the four segments or subpopulations previously named: the South Atlantic, the Southeast, the Mississippi Valley, and the Eastern Prairie. Each has its own breeding range, migration routes, and wintering areas, figs. 6 and 7. The existence of two of the population divisions that nest in the Hudson Bay area, one wintering along the central Atlantic Coast and the other in the Mississippi River valley, was first pointed out by Manly Miner (1931). This discovery, based on band recoveries, was due in part to the fortuitous location of the Miner Sanctuary, fig. 12, which lies about midway between the migration routes of these populations and thus permits banding of both populations.

South Atlantic Population.—This population is distributed in winter along the Atlantic Coast from southern New Jersey to Chesapeake Bay, Back Bay (Virginia), Pamlico Sound, and Currituck Sound, and Hyde and Dare counties, North Carolina. Recoveries from geese migrating through the Miner Sanctuary in the spring, and banded there in that season, reveal that Lake Mattamuskeet in Hyde County, North Carolina, has in recent years become the most important wintering area of this population.

A portion of the birds in this population stop at the Miner Sanctuary while en route to their breeding grounds, which are on the Belcher and probably the Twin Islands and in suitable localities along the east coast of James and Hudson bays, and inland probably to the height of land, as suggested by Todd (1938). Band recoveries indicate that the breeding range may include a portion of southern Baffin Island, fig. 7. Large numbers of recoveries reported from a post or small area may actually have been taken along extensive areas of the coast. For instance, recoveries plotted as from the Belcher Islands in fig. 7 also include the recoveries from the east coast of Hudson Bay from Cape Jones to Nastapoka Falls; recoveries represented as from the Port Harrison area actually include the recoveries made along the east coast of Hudson Bay from the Kikkerteluk River area to the Povungnituk area.

Southeast Population.—The existence and range of the Southeast population was revealed when band recoveries

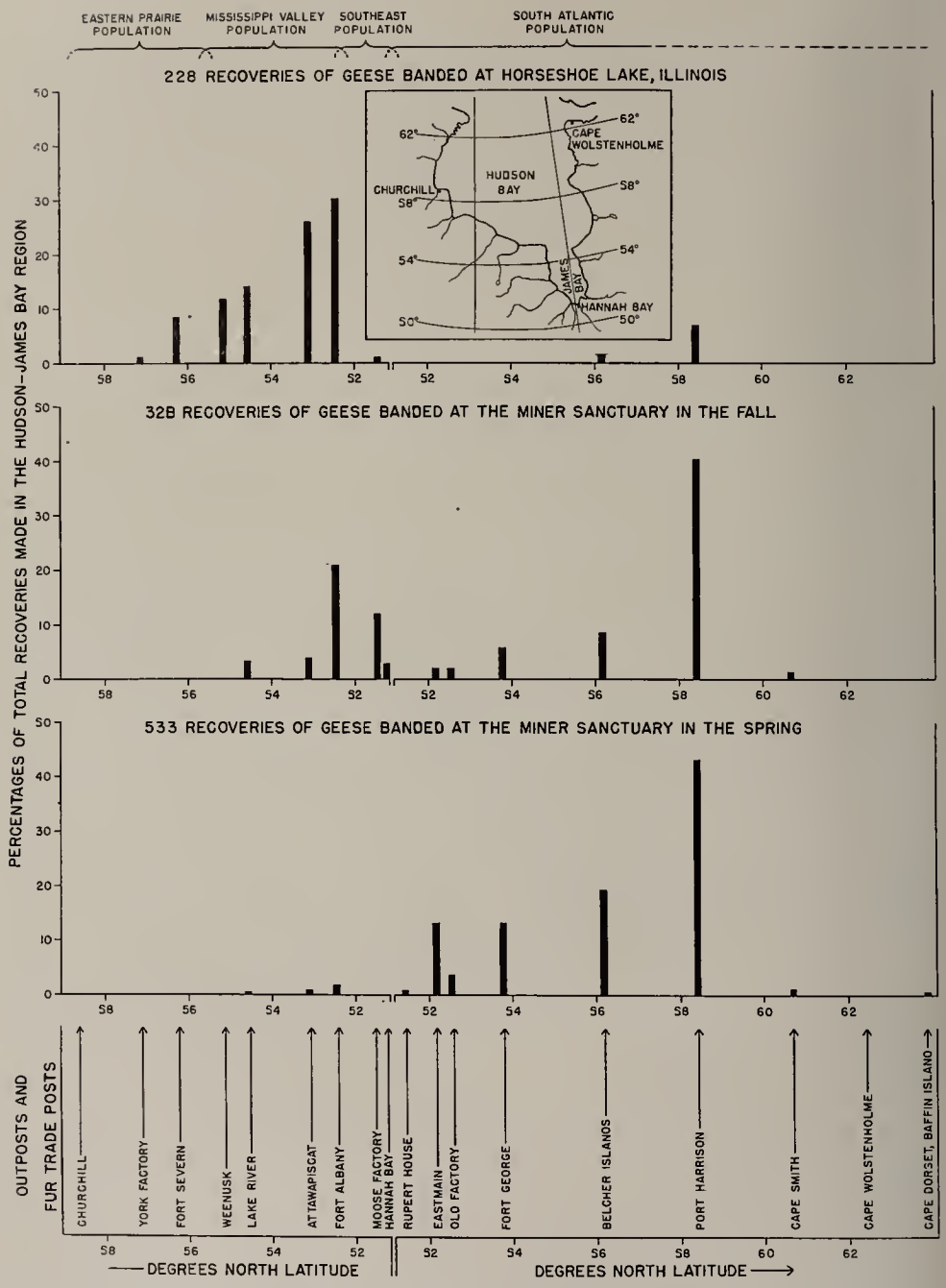

Fig. 7.—Band recoveries in the Hudson-James bay region from Canada geese banded at the Horseshoe Lake Game Refuge and at the Jack Miner Bird Sanctuary. Shown here are the percentages of the total recoveries from the Hudson-James bay region for various outposts and fur-trade posts. In some cases, large numbers of recoveries reported from a post or small area have actually been taken along extensive areas of the coast line. For instance, recoveries plotted as from the Belcher Islands also include recoveries from the east coast of Hudson Bay.

from the Miner autumn-banded geese were plotted as to exact locality. These recoveries show that the autumn flight of geese through the Kingsville, Ontario, area is not homogeneous, but is composed of two populations of geese: the Southeast population and the Mississippi Valley population, figs. 6 and 7. The Southeast population breeds inland from the south coast of James Bay and winters in the inland regions of the southeastern states. A detailed discussion of the range of the Southeast population is presented in Appendix A.

Mississippi Valley Population.—The range of the Canada goose population that winters in the valley of the Mississippi River extends in autumn and winter from western Michigan west through the eastern portions of those states lying immediately west of the Mississippi River and south in the valley of this river to the coast of the Gulf of Mexico. The main winter range south of Cairo, Illinois, does not extend greatly beyond the immediate valley of the Mississippi River except in Arkansas and Louisiana. The Mississippi Valley population, which is given primary consideration in this paper, breeds inland from the west coast of James Bay and the south coast of Hudson Bay, figs. 6 and 7.

Eastern Prairie Population.—The eastern range limits of the Eastern Prairie population seemingly merge with the western range limits of the Mississippi Valley population on the breeding grounds in the muskeg between Fort Severn and Fort York and on the wintering grounds in western Louisiana, figs. 6 and 7. The eastern range limits of the Eastern Prairie geese in migration are apparently in central parts of Minnesota, Iowa, Missouri, Arkansas, and Louisiana. We do not have the data at hand to discuss the western limits of the range of this population, nor are they of concern in this paper.

HUDSON-JAMES BAY BREEDING RANGE

The Canada goose has long been a staple food item for the natives of North America. To the white man in the United States and Canada, it has been a highly prized hunting trophy as well as an esteemed table bird. Formerly the species nested over much of the upper Mississippi River valley (McClanahan 1940), but, subjected to intensive hunting pressure, it was soon extirpated as a breeding bird from most of this country. Probably the only reason that there are still Canada geese to winter in the Mississippi River valley is that much of the country adjacent to Hudson and James bays in northern Ontario, where most of this migratory population breeds, is relatively inaccessible to man in summer.

Limits of Range

The general limits of the range of the Canada goose in the Hudson-James bay area have not been adequately summarized in previous publications. The existence of only two of the four populations that nest adjacent to these bays has been recognized previously, and the limits of their ranges have not been well defined. For these reasons, in addition to presenting new data on the Canada goose breeding range in the region of Hudson and James bays, we review pertinent references in the literature.

Until the race *Branta canadensis interior* was recognized by the American Ornithologists' Union (Wetmore 1945), most of the writers who mentioned the Canada goose either made no distinction between the two races of *Branta canadensis,* or they referred to birds of both races as belonging to the race *canadensis.* References in the literature prior to 1945 to either of these races should be interpreted in the light of the recent decision by the A.O.U.

The sequence of the following citations is in general according to the geographic position of the localities concerned: from north to south on the west side of the bays and from south to north on the east side.

The northern limit of the breeding range of *Branta canadensis interior* west of Hudson Bay coincides roughly with the northern limit of trees as delineated by the distribution of black spruce and white spruce, fig. 8. Taverner & Sutton (1934) found that at Churchill, Manitoba, which is "precisely at the limit of tree growth, where the spruce forest dies out on the

Fig. 8.—Map showing subsurface geological structures south and west of Hudson and James bays. Approximate limit of trees from official Canadian map. The principal nesting range of the Mississippi Valley Canada goose population lies within the shaded area.

arctic tundra and both types of biological association are in contact," the goose they referred to as *Branta canadensis canadensis* "is a common transient, which breeds sparingly in the vicinity."

Preble (1902) recorded that when he was in the region west of James Bay and Hudson Bay considerable numbers of *Branta canadensis* were reported as nesting on an island in Lake Winnipeg. He saw or had reliable reports of young geese along the Fox, the Churchill, and other rivers of the region.

Bell (1880) stated that *Anser canadensis* "breeds in considerable numbers along the Churchill River."

Grinnell & Palmer (1941) reported that "birds [*Branta canadensis*] were seen and heard at intervals from June 6 on" in the vicinity of Churchill.

Allen (1945) recorded nests and nesting pairs of *Branta canadensis* near Churchill.

Traverner (1931) wrote: ". . . . it [*Branta canadensis candensis*] is the common breeding goose of James and Hudson bays for most of the east coast and the west side at least as far as

Churchill, probably stopping somewhere south of cape Eskimo where it appears to be replaced by *leucopareia.*" From the barren grounds north of Churchill, the lesser Canada goose, *Branta leucopareia leucopareia* is the common representative of the genus *Branta.**

Hørring (1937) examined parts of 10 individuals, mainly from Baker Lake, a locality 385 miles nearly due north of Churchill, which he assigned to the race *leucopareia.*

A female goose taken May 20, 1937, at Eskimo Point, on the coast of Hudson Bay north of Churchill, appeared to Shortt & Peters (1942) "to be of the form *leucopareia.*"

Specimens taken along the Thelon River, which is in the districts of Mackenzie and Keewatin, Northwest Territories, were "referred by P. A. Taverner to *B. c. leucopareia*" (Clarke 1940).

There are numerous references in the literature regarding the occurrence of the Canada goose south of Hudson Bay and west of James Bay. Richardson (1851) quoted a report of George Barnston, an officer of the Hudson's Bay Company at "Martin's Falls," a post on the Albany River 200 miles inland from James Bay, in which mention is made of "geese and ducks hatching" in the vicinity.

Bell (1887), describing his exploration of the Attawapiskat River, wrote: "The Canada goose breeds in considerable numbers in the open swamps behind the wooded borders of the lower section of the river, and the young birds, ready to fly, were congregating in flocks, all along the lower stretch, in the end of August and the beginning of September."

Baillie & Harrington (1937) wrote: "The Canada Goose breeds fairly commonly along the coasts of James and Hudson bays, between Moose river and Churchill."

South of James Bay the principal breeding range of the Canada goose may not extend more than 60 miles inland from the coast. In 1926, a mining party led by B. C. Lamble explored the country between Timmins, Ontario, and James Bay. During the trip they "saw many broods of Canada geese, but none farther south than Kesagami Lake, Latitude 50° 30′" (letter to Jack Miner from B. C. Lamble, August 5, 1926).

In regard to the status in other parts of Ontario of the bird they regarded as *Branta canadensis canadensis,* Baillie & Harrington (1937) stated: "Recent maps indicate, perhaps correctly, that this bird may breed in the whole of northern Ontario, north of Lake Superior and the southern end of James Bay.

"The several instances of this bird nesting in southern and central Ontario almost undoubtedly concern injured or semi-domesticated individuals."

Bell (1883), who was undoubtedly intimately familiar with most of the province of Ontario, stated that "between the great lakes and James' Bay, only chance pairs lag behind in their northward flight to hatch their broods."

Inland from many parts of the east coast of Hudson and James bays, and on the islands along the coast and to the north, suitable habitat for nesting Canada geese is less extensive than inland from the west coast. Consequently, nesting on the east side of the bays is relatively concentrated although, in the interior of northern Quebec (Ungava), more widely scattered nesting is found.

The late James Watt, former manager of the Hudson's Bay Company post at Rupert House, wrote the junior author (letter of December 25, 1943) that "While travelling in the interior [south and east of James Bay] surveying beaver lands and counting lodges I have seen as many as 15 to 20 nesting [Canada] geese in a day's travel—all with broods of young geese, and . . . . taking into consideration the immense territory and number of lakes and inland waterways, the number of geese that nest inland must be large."

A. P. Low (1896) wrote: The Canada goose "breeds in marshes throughout the northern interior [of Quebec], and is seen along the rivers with young broods about July 1st; . . . . . several large broods seen on Burnt Lakes, Romaine River; not common at Lake Mistassini, but abundant on East Main River—especially on lower part, where the river is cut out of clays, with good bottomlands; breeds in large numbers on the islands of James Bay."

* See Appendix B for discussion of recent revision by Hellmayr & Conover (1948).

In reply to the questionnaire sent out in 1947, Roy Jefferies, Post Manager at Eastmain for the Hudson's Bay Company, in collaboration with an Indian, stated that Canada geese nested in a swamp about 10 miles south of Eastmain.

It is common knowledge in the James Bay area that considerable concentrations of nesting geese are found on the Twin Islands in James Bay, particularly the South Twin, and on the Belcher Islands in Hudson Bay, fig. 2. Nesting pairs are also found on Charlton Island and a number of smaller islands along the east coast of James Bay.

In the summer of 1947, Donald F. Coates and Donald B. Coombs (personal communication), observers for the Geodetic Service of Canada, visited the following islands in James Bay: North Bear, Bear, South Bear, Bare, Grey Goose, Walter, North Twin, Weston, and Charlton. They found Canada geese on only three of these islands. On Grey Goose, their guide shot two geese but they found little evidence of breeding pairs; on Weston, they saw about 20 pairs, in one instance 6 adults and 21 goslings together on one pond; and on Salt Lake, at the northern tip of Charlton, they observed 1 pair and 6 goslings.

Bell (1883) found that Canada geese "breed on the islands along the east coast of Hudson's Bay . . . . . it is said that very few Canada geese breed northward of Hudson's Strait."

Manning (1946) mentioned "a considerable number of geese in the Mistake Bay area at the end of July." (Mistake Bay is between Povungnituk and Port Harrison, fig. 2.) He "saw 10 or 15 of them, and all belonged to the large form." He identified them as *Branta canadensis interior.*

In a recent letter (to the senior author, April 11, 1947), T. H. Manning states that he believes the chief breeding ground of Canada geese in this area is between Cape Dufferin (near Port Harrison) and the Cape Smith Range. "I do not . . . think that they often nest on the coastal islands. They may nest on the King George and Sleeper Islands, but the Ottawa Islands are high, rocky and barren, and unsuitable. I have no direct evidence, but I should think they nest throughout the interior between Hudson and Ungava bays."

The Reverend H. S. Shepherd, missionary at Port Harrison, Quebec, for 2 years, stated in the questionnaire sent out in 1947 that scattered nesting of Canada geese is found over a large area of the interior inland from Port Harrison, but that the total number is not great.

Low (1902) found that, in the country about 12 miles south of the Digges Islands,* "The many small ponds and swamps that occur between the boulder ridges are favorite breeding places for grey geese." Farther south, about 30 miles north of the Povungnituk River, Low also found large numbers of Canada geese about 10 miles inland from the mouth of the Sorehead River.

In the Povungnituk area, W. A. Tolboom, a post manager, reported by questionnaire in 1947 that nesting is well scattered over a wide area and that generally speaking all nests are found on islands, on lakes or shores of lakes, seldom on rivers, and very seldom on coastal islands.

Manning's surmise regarding goose nesting over the Ungava Peninsula is substantiated by Rousseau's (1948) finding that the Canada goose is one of the few prevalent forms of wildlife between Povungnituk and Payne Bay post on Ungava Bay.

A few individuals of the Canada goose nest on the arctic islands north of the Canadian mainland. Sutton (1932) reported that Eskimos have occasionally found nests of *Branta canadensis canadensis* on Southampton Island.

Shortt & Peters (1942) reported an immature "specimen referable to *B. canadensis canadensis*" taken August 17, 1938, at Lake Harbour, southern Baffin Island.

Soper (1946) reported that *Branta canadensis canadensis* breeds on Baffin Island along the southern coast of Foxe Peninsula, and from at least Amadjuak Bay to Gabriel Strait along the coast of Hudson Strait.

Mississippi Valley Population.—The limits of the breeding range of each

* Small islands lying off the extreme tip of Ungava, northern Quebec.

of the four populations of *Branta canadensis interior* around Hudson and James bays have been deduced from band recoveries, coupled with a knowledge of the suitable nesting country, figs. 6 and 7. In ascertaining the true distribution of each of these populations, we were fortunate that the Miner banding records, as well as the Horseshoe Lake records, could be analyzed. An interpretation of either the Horseshoe Lake records or the Miner records alone would undoubtedly have led to erroneous conclusions, whereas the two sets of data considered together supplemented each other.

Band-recovery data from the Hudson-James bay area are in large measure dependent upon the native Indians. When interviewed through interpreters, the Indians are usually able to furnish the exact date and place of each band recovery. However, if only the name of the post is known at which a band is secured, the location of the recovery can be approximated, as usually the native groups from the various fur trade posts, including even individual families, use the same hunting grounds year after year. The approximate boundaries of the hunting grounds of the various bands of Indians on the west and south coasts of James Bay is shown in fig. 9, which is copied from a portion of a map prepared by the Reverend John M. Cooper to ac-

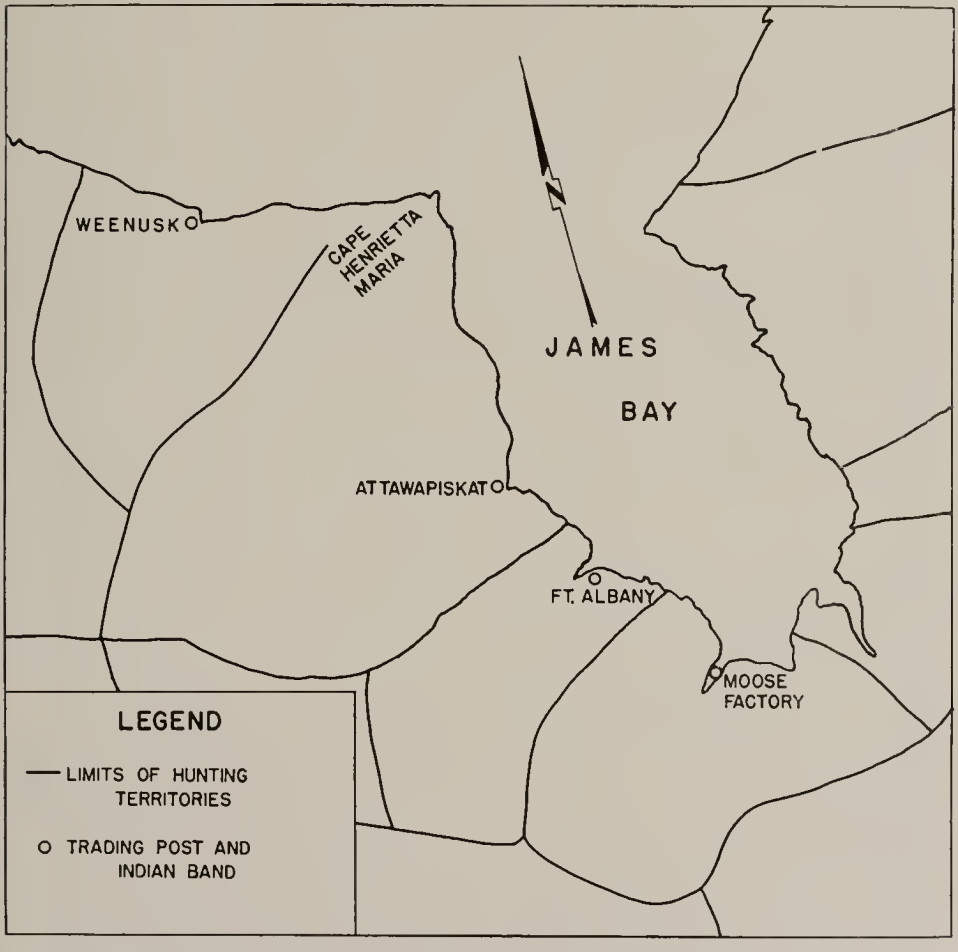

Fig. 9.—Map showing limits of the trapping and hunting grounds of the various bands of Cree Indians west and south of Hudson and James bays. (After Cooper 1933.)

Table 3.—Canadian breeding grounds of the Mississippi Valley Canada goose population, as indicated by spring and summer band recoveries from the Horseshoe Lake flock, 1941–1947.

River or Island	Unknown Except by Post or River	Number of Recoveries and Approximate Point of Recovery											Total
		Number of Miles Inland by River From Coast of Hudson or James Bay*											
		0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99	100–109	150	
Severn River	13	3					1			1				18
Winisk River	5	4	1				1		2				12	25
Sutton River		2												2
Kinusheo River	2													2
Lake River	32													32
Nowashe Creek	3			1										4
Swan River	5													5
Neatalkau River							3							3
Ekwan River						5	1		1			1		8
Attawapiskat River	16	2	3		2	3	1	1			3			31
Akimiski Island	4													4
Kapiskau River							3		1					4
Albany River	1	12		1	6	8	14	6	1	1				50
Stooping River	1								1					2
Kinoje River	5													5
Nettichi River	2	2												4
Lawapiskau River	1													1
Total	*90*	*25*	*4*	*2*	*8*	*16*	*24*	*7*	*6*	*2*	*3*	*1*	*12*	*200*

*Nearly all distances given by the Indians were in multiples of 10. Most of the band recoveries were from the 30–59-mile zone inland from the coast.

company his unpublished report to the Indian Affairs Branch in Ottawa. Father Cooper's map is based on his field studies of 1927, 1932, and 1933 in the vicinity of James Bay.

According to Father Cooper, the boundary lines of hunting territories generally are represented by natural landmarks, such as heights of land, chains of lakes, or watersheds. Hunting rights to each foot of land are owned by some Indian and are acquired only through inheritance or donation. Territory is generally inherited in the male line and most family territories have been in the same family line for generations. As to the accuracy of these boundaries, Father Cooper writes: "These limits are and can be only approximate as we have not adequate and detailed maps based on surveys of the whole area. . . . . The Moose Indian grounds and to a certain extent the Rupert House grounds are plotted as of a generation ago. Some changes through inheritance and through the dying out of certain families, particularly around Lake Kesagami, have occurred, but in the main the present Indian families still hunt each where the father and grandfathers hunted."

Band recoveries from the Canadian breeding grounds of geese banded at Horseshoe Lake are summarized in table 3. These recoveries, important in revealing the location and extent of the breeding range of most of the Mississippi Valley geese, do not, however, take into account geese that nest in the United States, where several efforts to establish breeding flocks on federal, state, and private refuges are making increasingly important contributions to the Mississippi Valley population.

Most of the Horseshoe Lake bands recovered in Canada were taken in the muskeg country lying inland from the coasts of James and Hudson bays between the Kinoje* and Severn River watersheds, fig. 30. Band recoveries indicate that during the breeding season this enormous section of muskeg country, roughly triangular in outline, contains the bulk of the geese that winter in southern Ontario, Michigan, Wisconsin, Indiana, Illinois, eastern portions of Minnesota, Iowa, Missouri, Arkansas, Louisiana (Delta), western Kentucky, western Tennessee, and western Mississippi. The barren grounds of Cape Henrietta Maria and the coastal marshes probably do not contain breeding birds, but nesting occurs on Akimiski Island, figs. 2 and 30, which lies in James Bay a few miles east of the mouth of the Attawapiskat River.

Of the tremendous area of muskeg outlined above, only a relatively small portion is either suitable for, or attractive to, nesting geese. Field observations, as well as band recoveries, indicate that the main breeding range of *Branta canadensis interior* south of Hudson Bay and west of James Bay is within an enormous area of muskeg, the limits of which coincide roughly with the area underlaid with sedimentary rocks of the Paleozoic era, fig. 8. These rocks, of the Ordovician, Silurian, and Devonian periods, are covered by a mantle of glacial drift over which the flat muskeg is superimposed. According to Bell (1887), "The drift (principally boulder-clay) which overspreads the palaeozoic basin westward of James' Bay appears to be a continuous sheet varying probably between thirty and ninety feet as far as can be judged by the sections along the rivers."

Ells (1912) believes that fairly uniform timber and land conditions prevail concentrically from James Bay except for minor variations, depending on primary and secondary drainage.

> Thus, if we have a 5 ft. muskeg at a distance of thirty miles south of James Bay, I would look for a similar condition East and West along a belt roughly parallel with the shores of the Bay. . . . . This assumption I have based on the fundamental principle that the country adjacent to James Bay on the South and West side is gradually being elevated . . . . . As we leave the shores of James Bay, the depth of the muskeg should gradually increase . . . . Eight miles to the west of Moose Factory the depth of moss and muck is 2 ft. to 3 ft.; 10 miles further south the depth is 2 ft. to 4 ft.; and 40 miles, 4½ to 5 ft.; at 60-80 miles, 5½ to 6 ft.; and at 90 miles the depth is 6 to 8 feet.

Evidence that the main breeding grounds of the Mississippi Valley Canada

* A small river that flows into James Bay 8 miles south of the Albany River.

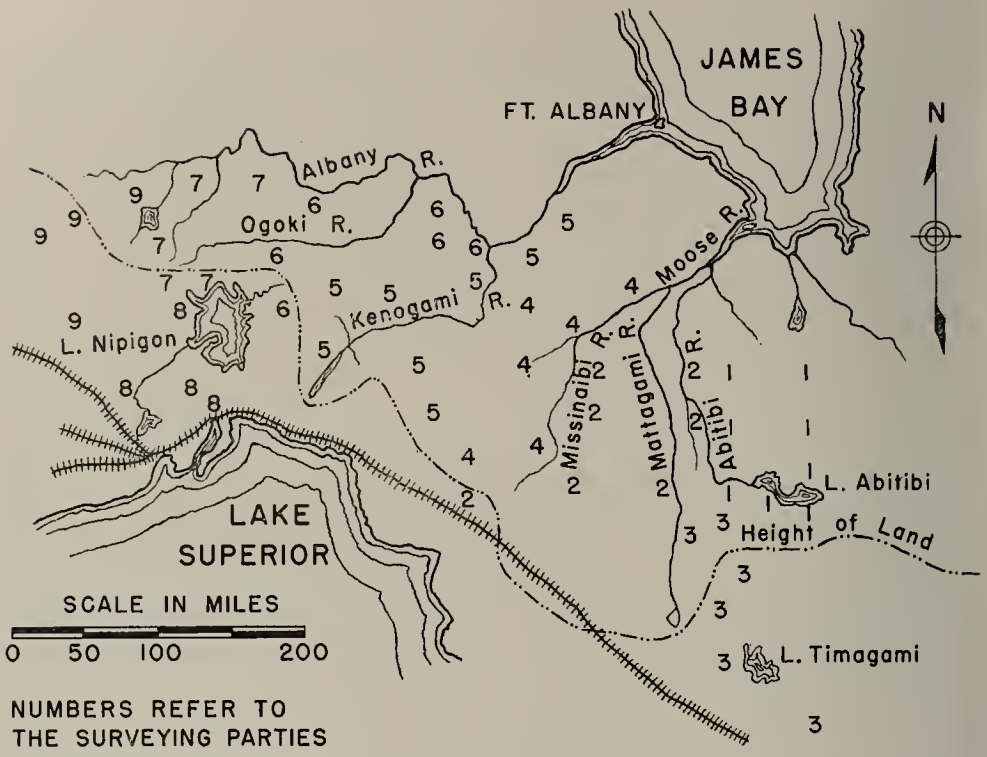

Fig. 10.—Map showing districts explored by surveying parties in northern Ontario in 1900 (from Anonymous 1901). None of the surveying parties reported nesting Canada geese in the districts surveyed.

geese probably do not lie much beyond the coastal strip of country that is underlaid with sedimentary rock, and are not in the adjoining rocky and rugged Canadian shield, is found in the records of 10 surveying parties. In the summer and autumn of 1900, surveys and explorations were made of the natural resources and characteristics of part of northern Ontario by the Ontario Department of Crown Lands (Anonymous 1901). The subject of the survey was a "comparatively unknown part of the District of Nipissing, bounded on the north by the Great Muskeg, adjoining the southern shore of James' Bay." The country, beginning about 80 miles inland from James Bay, was surveyed by districts, an exploring party being assigned to each of 10 districts. The districts that have relation to this study are shown in fig. 10. Each exploring party kept notes on the game conditions in its respective district, and, although a number of kinds of ducks were reported nesting in several of the districts, no nesting Canada geese were noted.

Observations made by Hess (1943) during a plane flight shed additional light on the occurrence of Canada geese southwest from James Bay. His description of the muskeg in that sector could apply to a large portion of the muskeg over the Paleozoic Basin.

By the time we were in McCausland Township, the country had changed from the poplar and jackpine regeneration on the slopes around the Mattagami River to a vast flat area of muskeg, exactly similar to the country around James Bay. (At this point, we were about 100 miles from the Bay.) Throughout this area, except for a belt of fair-sized spruce along the rivers and larger streams and the bigger lakes, there was no tree growth except dwarf widely-spaced tamaracks and the odd bunch of black spruce trees. The remainder of the area was a greyish yellowish green blanket of moss interspersed in large patches by ripple-like depressions filled with water,

giving a striking similarity to waves of moss and water.

Hess observed only four geese in the area described above. After flying a considerable, but unstated, distance farther, he sighted a chain of five lakes, on one of which were two flocks of geese; "young appeared to be present." Hess reported these lakes as being shallow.

The shores to about 100 feet from the water are ringed by black spruce trees about 30 feet high which shade off a short distance from the lake into the muskeg. The immediate shore was covered by alder and willow and in the far distance the larger spruce trees along the Missinaibi River stood out sharply above the scrub larch and muskeg.

Other Populations.—From the 5,747 Canada geese banded at Horseshoe Lake, only 4 bands have been recovered from the country adjacent to Hudson Bay northwest of Fort Severn, fig. 30. Two of these bands were from geese killed in early spring south of York Factory, apparently in the vicinity of their breeding grounds. Of the more than 16,000 Canada geese banded at the Miner Sanctuary in the autumn, none has been re-

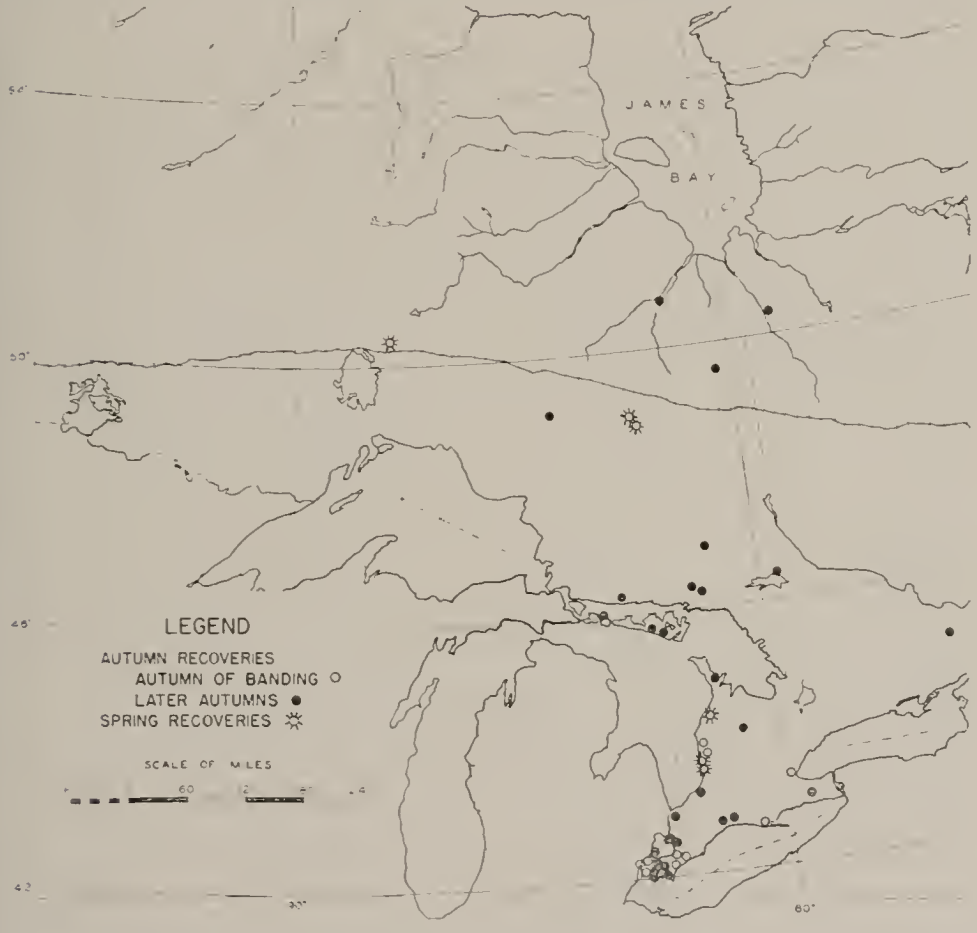

Fig. 11.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary in the autumn, 1915–1944, and reported recovered south of James Bay in Canada. Recoveries reported from fur-trade posts on the coasts of Hudson and James bays are indicated in fig. 7. Banding records indicate that two Canada goose populations, the Mississippi Valley and the Southeast, stop at the Miner Sanctuary in the autumn.

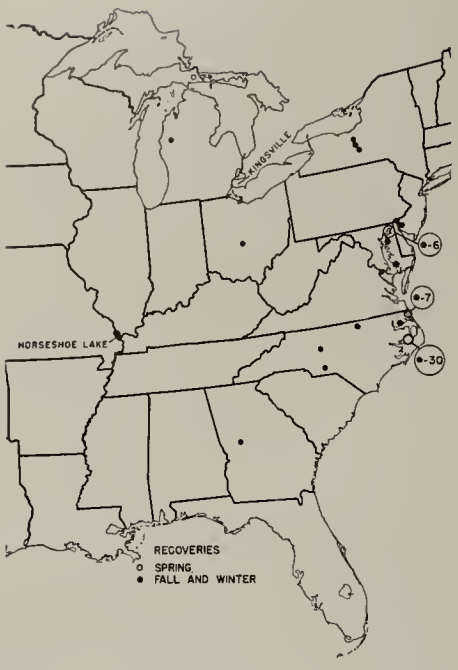

Fig. 12.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary, Kingsville, Ontario, in the spring of years prior to 1934 and reported recovered in the United States in the autumn and winter of 1935–36 and (one from a goose found dead) in the spring of 1936.

ported shot north of Lake River, figs. 2 and 7. Hence, it seems probable that most of the muskeg country between Fort Severn and Churchill is occupied by a population of geese that by-pass both the Miner and Horseshoe Lake refuges on their migration to wintering quarters. Miner bands recovered in Canada south of James Bay are indicated in fig. 11. Since few geese banded either at Horseshoe Lake or the Miner Sanctuary have been reported from western Louisiana and eastern Texas, or from any point at an appreciable distance west of the Mississippi River, figs. 12–21, it appears that the western Louisiana flocks, and perhaps a few concentrations in central Missouri, are derived from the breeding grounds between Fort Severn and Churchill. (Fig. 12 shows recoveries of geese banded in the spring; figs. 13–21 show recoveries of geese banded in the fall and winter.) The geese that breed in this part of Canada should probably be included with the Eastern Prairie population, as recently proposed by Cecil S. Williams of the United States Fish and Wildlife Service.

It is apparent from the distribution of the band recoveries shown in figs. 14–21 that two distinct populations of geese are banded at the Miner Sanctuary in the autumn: one population that migrates southwest to winter in the Mississippi River valley; the other, designated as the Southeast population, fig. 6, that crosses the Appalachian Mountains and winters in the inland areas of the South Atlantic states. From the data at hand we can only speculate on the approximate line of demarcation between these two populations on the breeding grounds. Although band recoveries indicate that the breeding grounds of the Mississippi flyway population extend as far south as the Kinoje River, the mouth of which lies 8 miles south of the mouth of the Albany River, between the Kinoje River and the Moose River country there may be a zone of overlap in which is found a mixed popula-

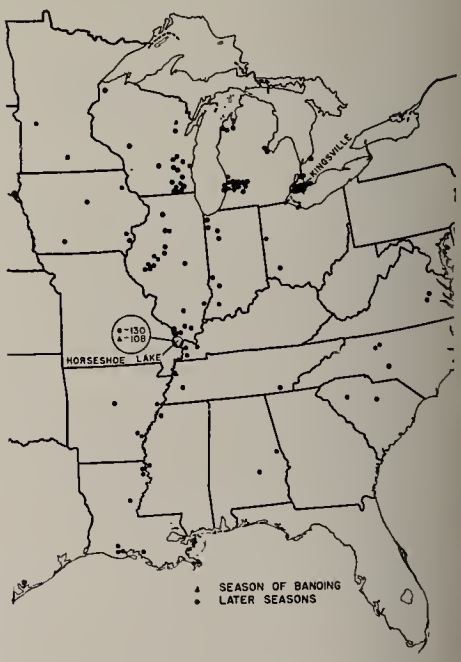

Fig. 13.—Location of band recoveries from Canada geese banded at the Horseshoe Lake Game Refuge and reported recovered in the United States and southern Ontario, 1940–1945. (Missouri recoveries near Horseshoe Lake.)

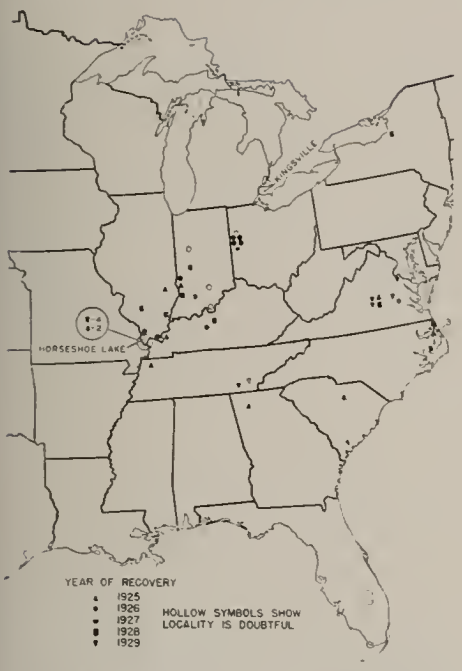

Fig. 14.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1925–1929, and reported recovered in the United States during the season of banding.

tion of geese, some of which winter in the Mississippi River valley and others that winter in the inland portions of the South Atlantic states.

The principal breeding range of the Southeast population lies inland from the south coast of James Bay. The data available at present suggest that it includes areas drained by the Moose River, as well as suitable muskeg lying between the Moose and Nottaway rivers, and perhaps areas lying inland from the east coast for an indeterminate distance north, fig. 6. Banding records from the Miner Sanctuary show that many of the autumn-banded geese are taken in the spring in the country around the south end of James Bay, fig. 7, and many are taken in the autumn in the inland portions of Virginia, North Carolina, South Carolina, Georgia, Alabama, and the Gulf Coast of Florida, figs. 14–21 (also see Appendix A).

Recoveries from geese banded at the Miner Sanctuary in the spring clearly indicate that the breeding grounds of the flocks that winter along the Atlantic Coast from Maryland to North Carolina, fig. 12, include certain islands in James and Hudson bays (see pages 81–82) and areas inland from the east coast of these bays from about Rupert House to southern Baffin Island, fig. 7.

The large number of band recoveries from the Port Harrison region on the east coast of Hudson Bay, despite low nesting densities reported for that area, may be due in part to the influx of geese in late summer into this lake country, which lies north of the tree line. According to the Reverend H. S. Shepherd, large numbers of Canada geese fly in from the north to the barren-ground lakes for the purpose of moulting. Band recoveries suggest that there may also be an influx of geese that have flown in from considerably south of Port Harrison. No confirmation of this influx was received in the questionnaire distributed in the region; however, A. Lunan of the Hudson's

Fig. 15.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1930–1934, and reported recovered in the United States during the season of banding.

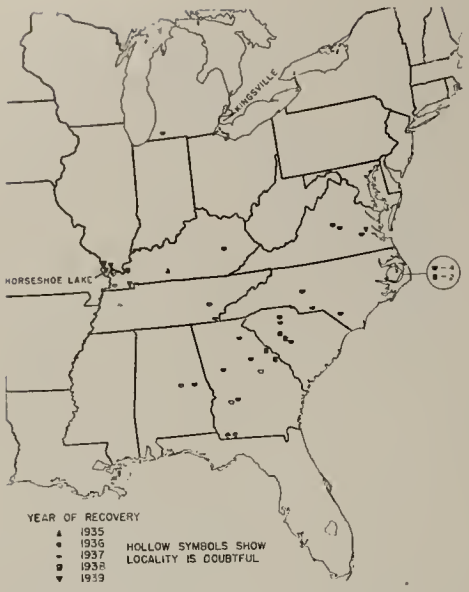

Fig. 16.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1935–1939, and reported recovered in the United States during the season of banding.

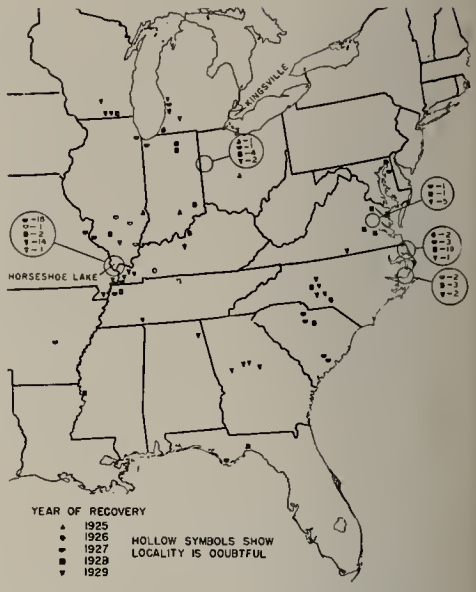

Fig 18.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1924 or before, and reported rccovered in the United States during 1925–1929.

Fig. 17—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1940–1944, and reported recovered in the United States during the season of banding.

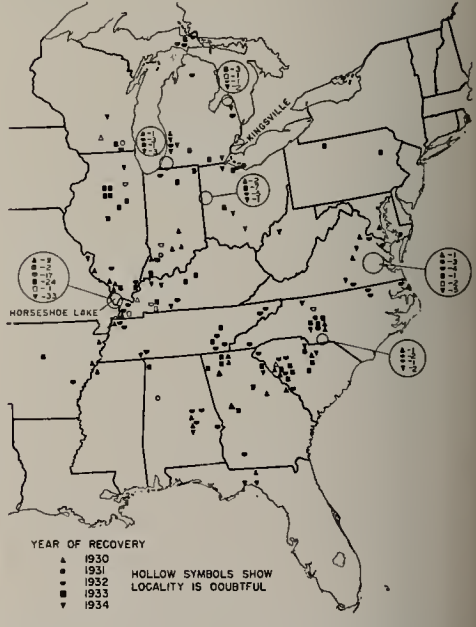

Fig. 19.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1929 or before, and reported recovered in the United States during 1930–1934.

Fig. 20.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1934 or before, and reported recovered in the United States during 1935–1939.

Bay Company, who was stationed a number of years at Port Harrison, recently stated (personal conversation, August, 1949) that about 75 per cent of the geese killed by the Eskimos in that area were moulting geese that came into the area in early June from the south and not birds that nested locally. His observations thus help to substantiate a relationship that could only be surmised from band recoveries. The Eskimos in the vicinity of Port Harrison, finding other kinds of game less easily obtainable in summer, turn to the inland lakes, where apparently they secure a plentiful supply of flightless geese.

Sixteen recoveries of Canada geese banded at Horseshoe Lake, fig. 30, and an important percentage of the total recoveries of geese banded at the Miner Sanctuary in the autumn, fig. 7, have been made in the Port Harrison district. One or more of a number of possibilities may explain these inconsistencies in the recovery pattern: flights by small groups of Mississippi flyway geese across James and Hudson bays in late summer; northward movements by geese of the Southeast population along the east coast of the bays for the purpose of feeding on berries; actual intermingling of birds from the different flyways. Trapping at the Miner Sanctuary has shown that some of the Horseshoe Lake geese stop at the Sanctuary in the spring, along with the flight of South Atlantic geese. Of 33 Canada geese trapped and banded at Horseshoe Lake and retrapped at the Miner Sanctuary, 1943–1945, 11 were retrapped in the spring. The disposition of some Horseshoe Lake geese to follow the South Atlantic geese to the east coast of Hudson Bay would not be surprising. Recovery of F-marked (autumn banded) birds in the Port Harrison district might be partially explained by the banding of South Atlantic geese at the Miner Sanctuary in the autumn. A certain amount of overlap in migration routes, with the resultant intermixing at the Miner Sanctuary of South Atlantic geese with Southeast and Mississippi flyway birds, is no less to be

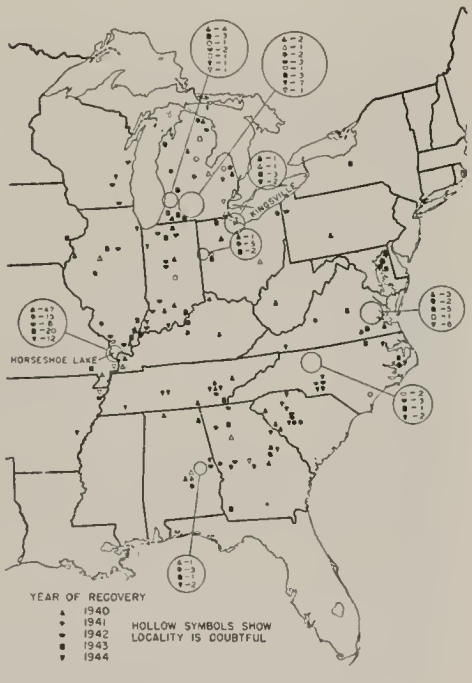

Fig. 21.—Location of band recoveries from Canada geese banded at the Jack Miner Bird Sanctuary during the autumn, 1939 or before, and reported recovered in the United States during 1940–1944.

expected in the autumn than in the spring of the year.

West Coast Muskeg Types

Aerial reconnaissance flights in the region west of James Bay and south of Hudson Bay, fig. 4, revealed that the muskeg in the breeding range of Mississippi Valley Canada geese differs considerably in various sectors in the proportions of timber and water it supports. For the sake of convenience the muskeg can be divided into five main types. It must be remembered, however, that gradations between all types exist.

Type 1. Well-timbered muskeg, with only a few ponds or small, widely scattered lakes, fig. 22.

Type 2. Open muskeg, with treeless or lightly timbered areas of stunted tamarack, alternating with small blocks or extensive stands of black spruce, fig. 23.

Type 3. Lake-land muskeg, relatively well-drained areas, more or less timbered, but notable for the numbers of large, widely scattered lakes without islands, fig. 24.

Type 4. Pothole muskeg, characterized by a myriad of ponds and small lakes, principally from 5 to 30 acres in size and usually possessing one or more islands. These water areas are often so closely grouped that only small patches or narrow strips of land separate one from the other, figs. 25 and 26.

Type 5. "Smallpox" muskeg, that is, muskeg in which sphagnum predominates, the country being more or less a continuous sphagnum bog or series of small bogs in the late stages of filling in so that it can scarcely be classified as land or water, figs. 27 and 28. Fairly extensive areas of this kind occur throughout the Paleozoic Basin and in smaller patches within most areas of the above four types of muskeg.

Aerial observations revealed that the

Fig. 22.—Type 1 or well-timbered muskeg. The muskeg lying adjacent to the southern half of the west coast of James Bay is fairly well wooded with black spruce and tamarack. Alternating with the wooded tracts are extensive areas covered with a heavy growth of willow. Ponds and lakes are relatively few in number in this area.

Fig. 23.—Type 2 or open muskeg. The dark bands across the lower half of this illustration represent stands of black spruce; the lighter colored trees are tamaracks. The spruces are confined mainly to better drained sites and to hummocks of mosses and lichens. The tamarack occurs both as light stands on the better drained sites and as scattered, stunted individuals on open sedge areas. In this type of muskeg, the treeless or lightly timbered areas of stunted tamarack alternate with small blocks or extensive stands of black spruce.

Fig. 24.—Type 3 or lake-land muskeg. Shown here is an area just north of the Albany River (flight 1, fig. 4) about 45 miles inland from the coast of James Bay.

Fig. 25.—Type 4 or pothole muskeg. This photograph was taken a few miles north of the Albany River on flight IV, fig. 4.

Fig. 26.—Type 4 or pothole muskeg about 40 miles north of the Moose River and about 30 miles inland from the shore of James Bay.

muskeg for the first 20 to 25 miles inland from the coast of James Bay in the Albany River country, fig. 4, I and III, exclusive of coastal marshes, is chiefly type 1. The muskeg for the next 35 to 40 miles, or about to the longitude of Fishing Creek Island in the Albany River, is characteristically type 4. Most prevalent in the country between Ogoki and points 50 to 60 miles inland from James Bay, fig. 4, I, are types 2 and 3. From Ogoki, on the Albany River, to a point northwest on the Attawapiskat River, fig. 4, II, muskeg types 2 and 3 characterize the country. From this point on the Attawapiskat River to Fort Albany, fig. 4, III, the kinds and the distribution of the muskeg observed are similar, but in reverse sequence to those seen on flight I, fig. 4.

On flight IV, fig. 4, between the Albany River and Weenusk, the following sequence of muskeg types was found to prevail. Type 4 is dominant between the Albany River and the Atikameg River, which lies 15 to 30 miles north of the Albany; types 2 and 3 most of the way between the Atikameg and Kapiskau rivers, north to the Attawapiskat River, and for an additional 10 to 15 miles beyond. Midway between the Attawapiskat and Ekwan rivers the muskeg varies between types 4 and 5. Near the Ekwan River, the country appears to be better drained and timbered, and the muskeg of type 1. From the Ekwan River northward, muskeg types 2 and 3 again prevail, but near the Sutton River, which enters Hudson Bay from the southwest at a point 64 miles west of Cape Henrietta Maria, the muskeg is poorly drained and well supplied with lakes of all sizes. From the Sutton River country to Weenusk the density of the stands of black spruce decreases and the amount of *Cladonia* lichen as ground cover steadily increases; in other respects the muskeg observed in this part of the flight seems to be either type 3 or type 5.

Fig. 27.—Type 5 or "smallpox" muskeg, about 15 miles north of the Attawapiskat River (flight IV, fig. 4).

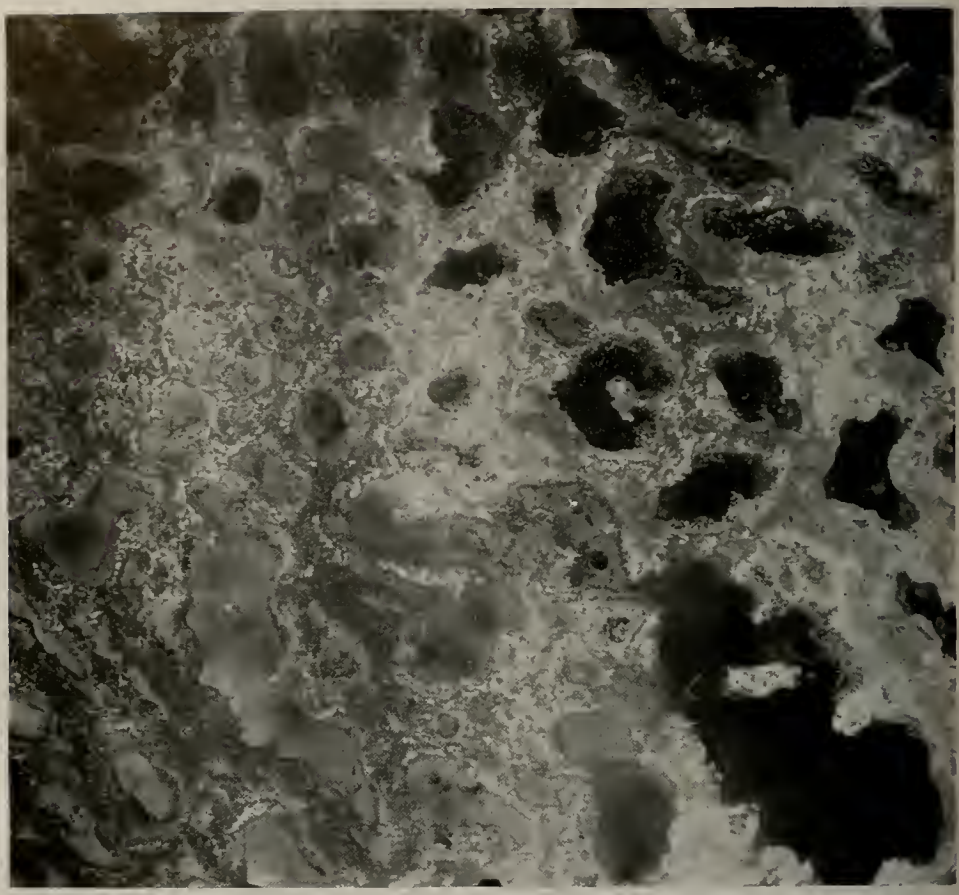

Fig. 28.—Type 5 or "smallpox" muskeg, a vertical aerial view. Small bogs, such as these, in various stages of filling in with sphagnum moss, occupy considerable areas of the muskeg country west of James Bay. They contribute little or nothing to waterfowl production.

Between Weenusk and Fort Severn, fig. 4, VIII, muskeg types 4 and 5 are most common. However, the lakes in this section of the muskeg, some of which are large, do not appear to offer optimum habitat for nesting pairs of geese, as most of them lack islands. The country between Fort Severn and York Factory, fig. 4, VII, appears to be on the whole relatively poor breeding range. In general, the muskeg alternates chiefly between types 3, 4, and 5.

West Coast Production Centers

On the aerial flights outlined in fig. 4, approximately 217 Canada geese, adults and goslings combined, were observed. From these sight observations, from band recovery data given in table 3, the distribution of the various muskeg types, their relation to the configuration of the streams and rivers, and the literature, the existence and location of major production centers, rather than continuous nesting areas, have been deduced. Most of these areas are between two adjacent or converging rivers, similar to the river shown in fig. 29, but in type 4 muskeg.

Most band recoveries and sight observations of geese can be correlated with the distribution of pothole muskeg, type 4. In the majority of areas in which geese were observed, water areas occupied at least 25 per cent of the surface. This muskeg type occupies slight but extensive depressions or troughs in the Paleozoic

Basin, which probably either (1) originated as depressions in the surface of the glacial drift that mantles the region or (2) developed in connection with deposits accumulated during the uplift of the region, probably at an irregular rate, following its submergence during glaciation. These basins now serve as origins of many small streams, while the larger rivers, in seeking the lowest ground when cutting their channels, have tended to converge toward each other in the region of these basins. Consequently, the present-day configuration of the drainage pattern is a clue to the location of pothole muskeg and in turn of production centers for Canada geese.

Available information indicates the following production centers, fig. 30, for the Canada geese that use the Mississippi flyway:

Production Center A. Between the Albany and Attawapiskat rivers in the region of Ogoki and Martin Fall, about 200 miles from the coast of James Bay. Barnston's early report (Richardson 1851) and band recoveries point to the presence of this production center, although it seems to be a relatively unimportant one. The localities mentioned above are just within the western limits of the Paleozoic Basin, figs. 2 and 8. In 1947, the 16 hunters in the Ogoki Indian band were questioned regarding the presence of breeding pairs within their trapping territories. Only a few of the hunters had knowledge of Canada geese nesting in the general region north of Ogoki, and they agreed that breeding pairs were scarce in that sector. A single goose was sighted in this area on flight II, fig. 4.

Production Center B. Between the Atikameg and Albany rivers, from a distance of about 25 miles inland from the coast of James Bay westward to about longitude 82° 50′ or the longitude of Fishing Creek Island in the Albany River. Although the country between the Albany River and the Stooping River, a tributary to the south, was not flown over directly, as much of it as could be seen from the plane appeared to be similiar to the country between the Albany and the Atikameg and equally attractive to nesting geese; probably it should be included as part of the production center. The area

Fig. 29.—The Attawapiskat River, at a point 30 miles inland from the coast of James Bay. Most of the muskeg shown in this photograph is classified as type 2 or open.

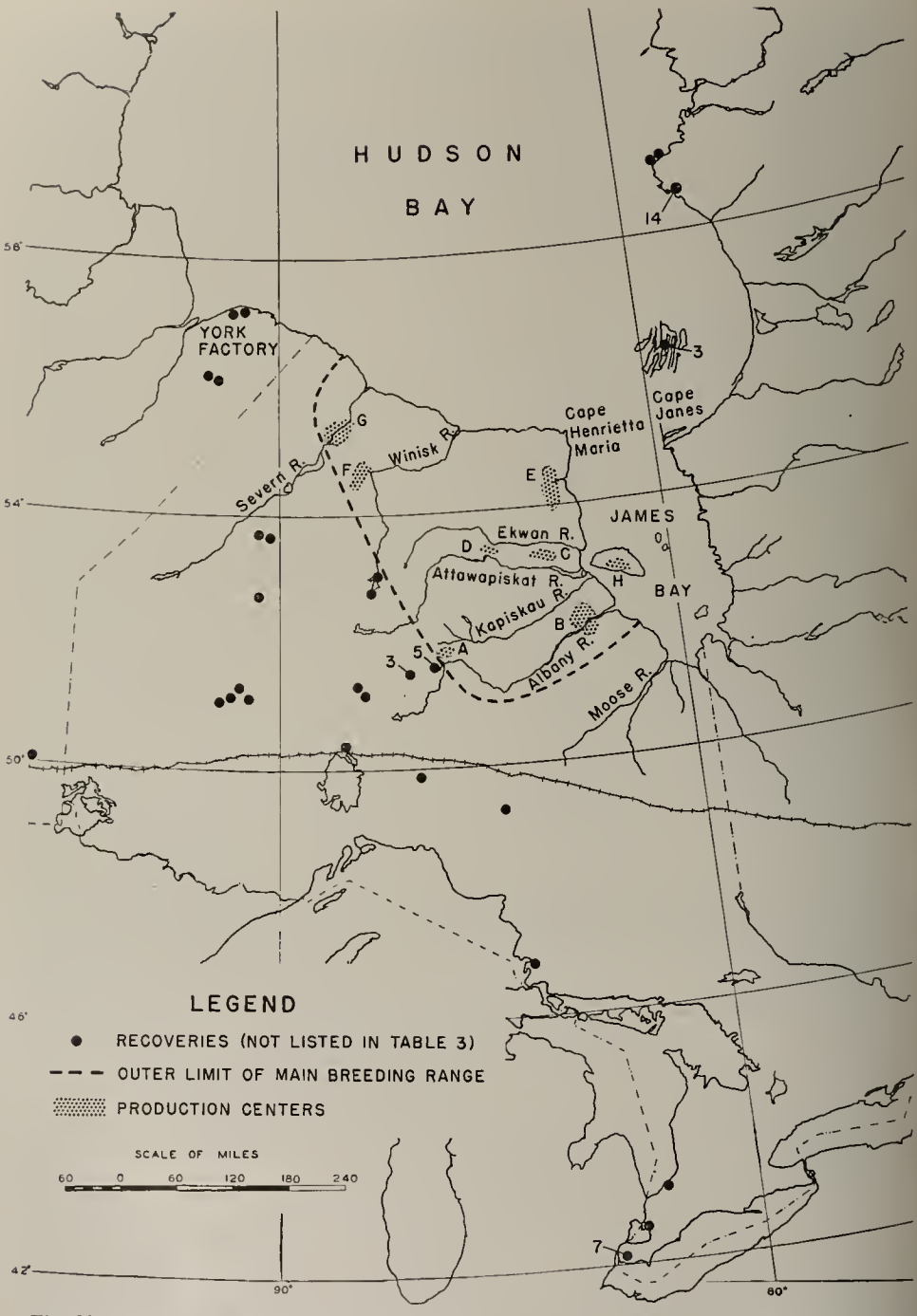

Fig. 30.—Location of production centers, limits of the main range of the Mississippi Valley geese, and located recoveries in Canada, 1941–1947, of Canada geese banded at the Horseshoe Lake Game Refuge. Within the main breeding range 217 band recoveries have been made. (Not shown are one recovery from Warren, Manitoba, and one from McLean, Saskatchewan.)

Fig. 31.—View from the west coast of James Bay about 38 miles south of Lake River. The sinuous tracts of spruce occupy old beach ridges near the coast; the intervening areas are marsh. Many bands were recovered from Canada geese near this part of the coast.

observed, which is characteristically type 4 or pothole muskeg, contained the only geese seen on the east and west flights between Fort Albany and Ogoki. On the return flight, III, fig. 4, 55 adults and 19 goslings were observed. These observations substantiate the location of production center *B* up the Albany River, indicated earlier by band recoveries, table 3.

Field observations and information obtained from Indian hunters indicate that few if any geese nest within 10 miles of the shore of James Bay. The Indians report that very few geese breed in the muskeg close to the bay. Most band recoveries, table 3, from the 9-mile coastal zone probably represent migrating geese shot early in the spring, or wandering, nonbreeding geese.

Despite the fact that some of the Indians from the coastal posts trap and hunt far inland, they have made only a few recoveries of goose bands in the Albany River district more than 60 miles west of James Bay. Substantiating our own finding in the Albany River district, the Indians report that most of the geese breed within 70 miles of the coast, or not much farther west than 30 miles below the juncture of the Albany and Chipie rivers.

Production Center C. Between the Attawapiskat and Ekwan rivers at a distance of between 40 and 50 miles inland from the coast of James Bay. This area was flown over on northward flight IV, fig. 4, from the Albany River to Weenusk. Band recoveries and aerial observations indicate that this area is a relatively unimportant production center. While its extent east and west can only be surmised from band recoveries, aerial observations indicate that its north and south axis is short, approximately 12 miles. Taken as a whole, the potholes and lakes between the Attawapiskat and Ekwan rivers are in a much more ad-

vanced state of filling in than are those between the Atikameg and Stooping rivers and few contain islands. Consequently, they are less attractive to nesting geese. On flight IV, fig. 4, three geese were observed in this production center, and northwest of this center, about 11 miles south of the Sutton River, a single goose was noted.

Production Center D. Between the Attawapiskat and Ekwan rivers, from 90 to 100 miles inland from the coast of James Bay. A production center in this area is suggested by three recoveries, table 3, and some convergence by the two rivers mentioned, as well as by the drainage pattern of the small streams in this area.

Production Center E. South of the barren grounds of Cape Henrietta Maria; from about the latitude of Lake River south to the Swan River and at indeterminate distances inland from the coast of James Bay. The large numbers of recoveries made along the coast in this area, fig. 31, and the multitude of small, short rivers that drain inland areas in this sector suggest that the production center may lie within 15 miles of the James Bay coast. Perhaps indicative of the approximate location of this center is the Kinusheo River, which originates in this region and flows to the northwest to empty into Hudson Bay. When the latest 8-miles to 1-inch maps, based upon high altitude photography carried out in 1947, are completed, the limits of this center will be more easily ascertained.

Production Center F. Between the Winisk River and the Fawn River, at a point about 100 miles inland from the coast of Hudson Bay. In this sector the Winisk River and the Fawn River, the latter a tributary of the Severn River, bow sharply toward each other. Between these rivers a dendritic drainage pattern with a number of poorly defined lakes is shown on an 8-miles to 1-inch Canadian topographic map. At Weenusk, where there are some fairly suitable nesting lakes close to the coast of Hudson Bay, the Indians report that they shoot most of their banded geese, table 3, about 150 miles up the Winisk River in the general region outlined above. The winding of this river accounts for the difference in the two mileage figures given for the location of this production center. Map and band recovery data and the size of the kills made by the Weenusk Indians indicate that this production center is second in importance only to the one between the Atikameg and the Albany or Stooping rivers.

There is probably some scattered nesting over a large area south of Weenusk. On flight IV, fig. 4, two flocks, one of 21 geese and another of 6 with goslings, were sighted about 33 miles south of the Winisk River at a point about 25 miles from the coast of Hudson Bay. On flight VIII, fig. 4, between Fort Severn and Weenusk, 15 Canada geese were observed from the air. However, the lakes flown over on flight VIII did not appear to offer optimum habitat for nesting pairs, as they generally lacked islands. The Weenusk Indians say that they find breeding pairs nesting closer to the coast in early, mild springs than in late, cold springs.

Production Center G. Severn River country. One or perhaps several production centers, poorly defined in either case, may lie in the Severn River country. The configuration of the river and its tributaries and two band recoveries suggest that a production center may be found somewhere between 50 and 90 miles up this river.

William Glennie, a post manager for the Hudson's Bay Company, told the senior author in 1947 that he had seen fresh goose eggs that were taken from nests found in the upper portions of the Severn River watershed, between Windigo and Big Trout Lake, localities that lie just west of the Paleozoic Basin, roughly between latitudes 52° 30′ and 54°, but stated further that the greatest numbers of Canada geese were found along the lower portions of the Severn River.

On flight VII, from York Factory to Fort Severn, a distance of about 145 miles, 28 Canada geese were observed, a number that is indicative of a low population density in this section of the Paleozoic Basin. Observations and aerial photos reveal that the habitat in this area is of relatively poor quality. Many of the water areas are in the late stages of filling in and the great majority of lakes lack islands. Nevertheless, a portion of the muskeg west of Fort Severn probably

Fig. 32.—During the spring and summer the muskeg country is very difficult to traverse on foot. In scene pictured here, small spruce are being put down in order to permit crossing between two mats of floating sedge. The photograph was taken in the Lawapiskau River country on July 3, 1947, at which time ice still could be found in many places 15 inches below the surface of the sedge mat.

should be included in the general breeding range of the Mississippi flyway population because bands have been reported from this country. The breeding density of Canada geese is probably greater than the small number of band recoveries indicate for this section of the muskeg, fig. 30, because of the preference of the Indians at York Factory for hunting other kinds of geese on the coast of Hudson Bay: Richardson's goose *(Branta hutchinsii)* and the lesser snow goose *(Chen h. hyperborea)*, species said to be fat both in the spring and in the autumn, while the Canada goose is reported to be thin and unpalatable when it arrives on the interior breeding grounds.

Production Center H. Akimiski Island. From the accounts of the Indians at Attawapiskat and observations made from the air, nesting on Akimiski Island is found chiefly in the central portion close to the south coast. In this area many suitable lakes were seen and 61 geese were observed on the 1947 flight.

Nest Sites

Although there are a number of fairly well-defined centers of production where most of the geese nest and rear their young, aerial flights in 1947, fig. 4, substantiated the information gathered earlier from the Indians that the breeding pairs are scattered within these centers; there is seldom more than one pair on a given lake. Further evidence pointing to scattered nesting was gained by the senior author in 1947 when traversing the muskeg on foot. A few penetrations of the muskeg were made at points 15 and 25

Fig. 33.—Typical type 4 muskeg lake with small islands. According to native Indians, small islands in lakes of this kind offer preferred nesting sites to Canada geese.

Fig. 34.—Vertical view of type 4 or pothole muskeg. Extending outward from most stands of trees is a floating mat of sedge partially supported by sphagnum moss.

miles up the Lawapiskau River, reportedly goose-nesting country, and at two points 40 miles up the Albany River, which the aerial flights a few days before had revealed as production centers. During these walks, only one pair of geese was observed, but the faint trails of several broods were found, revealing where geese had moved from one small muskeg lake to another.

Unfortunately, because the breeding pairs were scattered and the nesting habitat was highly inaccessible, both from the standpoint of getting a canoe within walking distance of a production center and of actually traversing it on foot, fig. 32, no nests were located in 1947. According to the Indians, small islands in lakes and ponds offer preferred nesting sites, figs. 33 and 34, but, where no islands are present, nearly any location close to the water's edge is suitable. An impression gained from the aerial survey is that small lakes of 5 to 30 acres in size and possessing one or more small islands are the type preferred by nesting pairs.

In the western United States, Canada geese have been found by wildlife workers to concentrate in favored sections of a marsh or breeding range, such as particular islands in lakes and reservoirs. As a result of such colonial-type nesting, young broods of several pairs frequently combine into a large rearing brood, a single pair eventually taking charge of this brood. The fact that only families of normal size have been observed at Horseshoe Lake, or have been reported by Jack Miner at Kingsville (see section on "Productivity"), suggests that scattered nesting is the rule in the muskeg west of James Bay; the assumption is that nesting pairs are so spaced that contacts between broods are infrequent and combination does not take place to an important degree.

Information corroborating this viewpoint was reported by R. M. Duncan and A. H. Michell. Both of these men have spent many years as post managers on the east and west coasts of James Bay. They report that the autumn migration of Canada geese along the west coast is primarily that of small family flocks, observations which are in agreement with those made by the authors. On the east coast, according to Duncan and Michell, flocks of from 20 to 40 or more geese generally comprise the autumn flight. However, the presence of large flocks in the autumn along this coast of James Bay is not surprising since areas of favorable habitat are more limited there and the density of nesting pairs is relatively high, particularly on the Belcher and Twin islands. Donald F. Coates and Donald B. Coombs, as cited earlier (personal communication, 1947), found 6 adults and 21 goslings together on Weston Island. From these reports it would seem that in the Hudson and James bay region, as in western United States, crowding of the nesting pairs is a factor likely to induce the combining of broods.

MIGRATION

The beautiful and often spectacular flights of the Canada goose have probably held a greater fascination for more people than the flights of any of our other native birds. Some persons think of geese in flight as special creations, living enviable and unfettered lives. Other persons thrill to the sight of migrating geese as an object of sport. To the Canadian Indian trapping in the "bush," the first flocks of geese in early spring afford a welcome opportunity for a change of diet from bannock, beans, and dried or salted meats. In years when fur and game animals are at low points of their cycles, and consequently food stocks are close to depletion, the arrival of geese may mean relief from near starvation.

Autumn Migration Routes

Our data on the movements of the Canada goose in the Hudson-James bay area are based on information received from the Indians and white residents and on personal observations. Band recoveries have been the principal source of information relating to autumn migration movements of Canada geese in the United States, figs. 13–21, but these recoveries do not furnish a complete picture of the migration routes. Naturally, most recoveries are from localities where hunters as well as geese congregate, generally in the vicinity of favorite waterfowl rest lakes or feeding areas where the flocks linger before continuing south. Wooded

or hilly country and waterless prairies are usually flown over nonstop by migrating geese. Consequently, very few bands have been recovered from country of this nature, even though large numbers of geese pass overhead each autumn and spring.

Fig. 35.—The tundra of the Cape Henrietta Maria area as seen from the air.

Fig. 36.—The mouth of the Moose River and a portion of Ship Sands Island. The extensive marshes shown in this scene are heavily used by blue and snow geese and to a lesser extent by Canada geese in the autumn.

In Canada.—Before the southward migration from the breeding grounds takes place, a rather complex series of local flights occurs. About August 15, shortly after the young birds are on the wing, a movement begins to the coasts of Hudson and James bays. This is not a mass flight but a movement of family groups and small flocks from some of the production centers near the coast. The geese that have nested adjacent to the southwest coast of Hudson Bay fly north to the coast and then almost due east to Cape Henrietta Maria, figs. 2, 30 and 35; those that nested adjacent to the west coast of James Bay, north of the Ekwan River, fly east to the coast and then north to Cape Henrietta Maria. This cape is an isolated area of tundra attractive to the geese at this season because of the abundance there of blueberries (*Vaccinium* sp.), billberries (*Vaccinium uliginosum*), dwarf raspberries (*Rubus arcticus*), and crowberries (*Empetrum nigrum*). It is of interest to note here that flights to the sea coasts for the purpose of feeding on berries and other foods have been reported for other Canada goose populations in the north country [Newfoundland (Howley 1884); northern Ungava (Bent 1925, quoting Lucien M. Turner); and Labrador (Austin 1932)].

The geese that concentrate on the tundra of Cape Henrietta Maria remain there for varying periods before flying south. The length of time the geese remain in this region depends to a large degree upon the success of the berry crop, but probably all geese leave the cape by the latter part of September. At least half of the "cape geese," as they fly south down the west coast of James Bay, stop at Akimiski Island, where they concentrate on the wide flat marsh on the north side, a favorite feeding area. According to A. H. Michell of the Hudson's Bay Company, this flight usually takes place about September 15.

Most of the geese nesting south of the Ekwan River remain in the interior, although a few of them fly to James Bay, where they congregate in moderate-sized flocks in the coastal marshes about the river mouths, in country similiar to that shown in fig. 36; others continue to the marshes of Akimiski Island.

Apparently, many of the geese that feed on Akimiski Island fly directly to the Jack Miner Sanctuary as soon as they leave the island. The Indians at Fort Albany claim that since Jack Miner started banding geese at his sanctuary they have killed only a few in the autumn.

A number of bands from geese banded at Horseshoe Lake have been recovered in summer from the Belcher Islands and the east coast of Hudson Bay in the region of Port Harrison, fig. 30. Whether these bands have been recovered from South Atlantic geese that strayed from their normal flyway and were banded at Horseshoe Lake, whether they were recovered from Mississippi flyway geese that strayed east of their normal flyway on their spring migration, or whether they were recovered from Mississippi flyway geese that nested west of James Bay and then struck out across the bays can be only conjectured on the basis of available data. In any case, many geese that are on the east coast of Hudson Bay in autumn migrate southward along the coast to the south end of James Bay, where they converge with the groups that have flown south along the west coast of James Bay.

Because band recoveries suggest a northward movement along the east coast of James and Hudson bays in the early autumn by geese that have nested inland from the south coast of James Bay, we believe that the final southward flights along the east coast of both bays may consist of at least some geese from three different populations. Geese of the South Atlantic population that nested along the east coast and on neighboring islands (Belcher and others) make up most of the flight; geese of the Southeast population probably are second in numbers; while individuals of the Mississippi Valley population are least numerous, fig. 7.

At points near the south end of James Bay, the South Atlantic geese split away from the Mississippi Valley and Southeast populations; portions of only the last two populations migrate through the Kingsville region in the autumn. The apparent mechanism of the splitting off of the southward flights along the east coast of James Bay into their various components, fig. 37, has been deduced

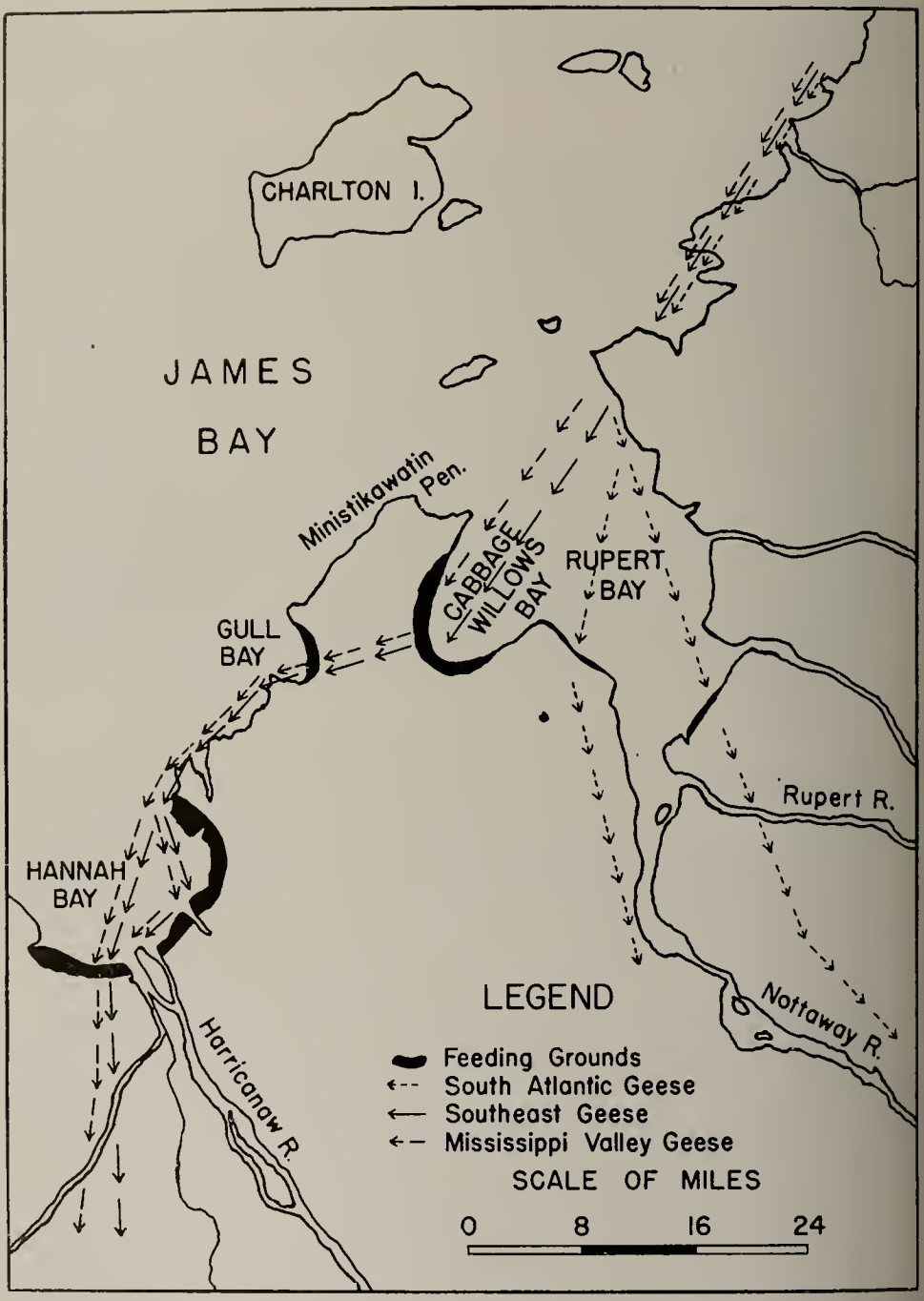

Fig. 37.—Probable migration routes taken by various populations of Canada geese at the southeast end of James Bay. The first splitting away from the combined flocks that migrate southward down the east coast of James Bay occurs somewhere along the northeast shore of Rupert Bay. A second splitting away occurs at or near the feeding grounds bordering Cabbage Willows Bay, the Mississippi Valley geese flying southward, the South Atlantic geese toward the southeast.

from a description of goose flights in the Rupert House area given to us by A. H. Michell, post manager at Rupert House.

The first splitting off of the combined autumn flights evidently occurs somewhere along the northeast shore of Rupert Bay, fig. 37. Some of the birds follow the northeast shore of Rupert Bay to the coastal marshes near the mouth of the Rupert River, where they congregate and feed; then they leave the James Bay region and fly southeast. Other flights cross Rupert Bay and feed in the marshes in the vicinity of Cabbage Willows Bay. At this point a second split occurs; some of the geese fly southeast, while the remainder follow a natural pass along a small stream and a series of muskeg lakes across the neck of the Ministikawatin Peninsula. These birds continue on to Hannah Bay, where they find final feeding grounds before departing from the James Bay region.

The geese that have remained in the muskeg west of James Bay, instead of flying to the coastal marshes, migrate south on a broad front, crossing into upper Michigan, Wisconsin, and eastern Minnesota, fig. 13. Probably they comprise the majority of the birds in the Mississippi Valley population, figs. 13–21.

In the United States.—Band recoveries indicate that the flights of Canada geese that enter the United States by way of upper Michigan, Wisconsin, and eastern Minnesota constitute the bulk of the Mississippi Valley population figs. 13–21. The flocks that migrate through Wisconsin in the autumn adhere principally to the eastern half of the state. Many of the flocks follow the west shore of Lake Michigan. Other flocks favor one of two other routes: (1) the valley of the Wisconsin River; (2) from Green Bay south to Lake Winnebago, the flights probably splitting south of Lake Winnebago, one sector going to the Lake Geneva area and the other following the Rock River.

According to Zimmerman (1943), the greatest concentration of Canada geese in Wisconsin during the autumn migration occurs in Adams, Columbia, Fond-du-Lac, Sauk, Walworth, and Waushara counties; the Arlington prairie in Columbia County and the Rock and Big Foot prairies in Walworth County attract the greatest numbers. At the peak of the flight in 1941, about November 15, it was estimated that 15,000 to 20,000 geese were using Lake Wisconsin (Zimmerman 1942). Five thousand of these birds fed in the cornfields in the vicinity of Sumpter, Sauk County (Zimmerman 1942).

Appreciable numbers of Canada geese follow the west shore of Lake Michigan south, according to A. B. McDonald of Wadsworth, Illinois, who reported to Frank C. Bellrose of the Illinois Natural History Survey that each year flocks of Canada geese follow the shore line as far south as Zion, Illinois, at which point they leave the lake and fly southwestward. The exact route taken each year is said to remain identical.

The Canada geese entering the United States from the Miner Sanctuary by way of southeastern Michigan or northwestern Ohio constitute a part of the Mississippi Valley population. Recoveries of geese banded in the autumn at the Miner Sanctuary show that this segment of the Mississippi flyway population migrates almost straight southwest to the Ohio or lower Wabash rivers, stopping en route in considerable numbers at Lake St. Mary or Grand Reservoir, a 17,500-acre impoundment lying in Mercer and Auglaize counties, western Ohio. On leaving Lake St. Mary this group seemingly flies directly to the Ohio River valley, which it follows to Horseshoe Lake.

Another group of geese appears to migrate across lower Michigan from Saginaw Bay to the counties in the southwestern portion of the state. Some of these geese winter in the vicinity of the W. K. Kellogg Bird Sanctuary near Gull Lake, Kalamazoo County, and along the lower Kalamazoo River. The majority eventually continue southward, crossing north-central Indiana to the Wabash River bottoms; some of them join geese that have migrated south along the east shore of Lake Michigan and then fly either straight south to the Wabash and Ohio river bottoms or in smaller numbers fly southwestward directly to Horseshoe Lake.

Much of the Canada goose flight entering Illinois from Wisconsin in all likelihood traverses the length of Illinois on a fairly broad front, but band recoveries

Table 4.—Canada geese banded at the Horseshoe Lake Game Refuge and recovered in the United States away from Horseshoe Lake, seasons of 1940–41 through 1945–46.

Season of Banding	Total Geese Banded	Early Banding[1]	Hunting Season			Hunting Season of Recovery and Direction of Recovery from Horseshoe Lake																
						Season of Banding			First Season After Banding			Second Season After Banding			Third Season After Banding			Fourth Season After Banding			Fifth Season After Banding		
			Northern Zone	Central Zone	Southern Zone	South[2]	East[3]	North[4]	South[2]	East[3]	North[4]	South[2]	East[3]	North[4]	South[2]	East[3]	North[4]	South[2]	East[3]	North[4]	South[2]	East[3]	North[4]
1940–41	315	0	10/1–11/29	10/16–12/14	11/2–12/31	0	0	0	3	0	7	1	2	1	0	0	5	0	1	2	0	0	2
1941–42	402	0	10/1–11/29	10/16–12/14	11/2–1/10	0	0	0	3	1	2	0	0	6	1	0	1	0	0	0			
1942–43	1,036	443	9/26–12/4	10/15–12/13	11/2–1/10	0	0	0	5	1	4	2	2	4	0	1	5						
1943–44	2,329	2,095	9/25–12/3	10/15–12/13	11/2–1/10	1	0	0	4	4	7	2	0	20									
1944–45	853	651	9/20–12/8	10/14–12/12	11/2–1/20	0	0	0	0	0	10												
1945–46	310	302	9/20–12/8	10/14–1/1	11/2–1/20	0	0	0															
Total	*5,247*	*3,491*				*1*	*0*	*0*	*15*	*6*	*30*	*5*	*4*	*31*	*1*	*1*	*11*	*0*	*1*	*2*	*0*	*0*	*2*

[1] Number of geese banded in fall up to 2 days before close of hunting in Southern Zone.
[2] Lower Mississippi River valley and coastal marshes of Louisiana.
[3] Southeast states, Virginia to Alabama.
[4] Sections of the Mississippi flyway north of the normal winter range of the Horseshoe Lake flock.

suggest that important numbers of birds follow the Illinois River to its juncture with the Mississippi River. At that point the Illinois River flight may be augmented by flocks (relatively few in number) that follow the Mississippi River southward toward Horseshoe Lake.

Because there has not been sufficient banding of Canada geese in southern parts of the Mississippi flyway, the flight lanes of Canada geese wintering on the lower Mississippi River, from Tennessee to Louisiana, are less apparent than the routes taken by flocks wintering farther north. Recoveries of geese banded at Kingsville, Ontario, in the autumn, figs. 14–21, suggest that many of the flocks migrate down the lower Ohio River valley to the Tennessee River, which they follow south instead of continuing on to Horseshoe Lake. Presumably, at a number of points these flocks later leave the Tennessee River and cross over to the lower Mississippi River.

Additional data indicating that considerable numbers of geese by-pass Horseshoe Lake to the east via the Tennessee River are found from band recoveries of geese raised at Seney National Wildlife Refuge in the northern peninsula of Michigan, fig. 39*K*. Of the total number of band recoveries made, the number reported from Arkansas was second only to the number reported from Michigan (Johnson 1947). These recoveries were made during the same period that heavy kills were occurring at Horseshoe Lake. It is, of course, assumed that the migrant birds from the Seney Refuge joined other wild flocks from the north or at least used the traditional paths of migration.

Recently Earl L. Atwood, manager of the Kentucky Woodlands National Wildlife Refuge, informed the senior author (personal communication, December, 1947) that the Tennessee River valley is a traditional flyway for Canada geese.

There is no evidence, either from observation or from band recoveries, to indicate that there is an important turnover in the flock using the Horseshoe Lake area in the autumn. According to our records, only one goose banded at the refuge has been taken an appreciable distance south of it the same season as banded, fig. 13 and table 4. If a turnover in the flock occurs, it must be early in the autumn before many geese have been banded.

There is reason to believe that the Horseshoe Lake Refuge has acted as a "bottleneck" in that each year it has attracted increasing numbers of geese that previously have wintered along the lower Mississippi River. Few of these geese, having entered the refuge, would be expected to continue migration later in the season, except under pressure of extreme weather. Hence, they would augment the concentration surviving from previous years as well as contribute to the kill. The theory that the refuge acts as a "bottleneck" assumes that ingress of new birds from other areas exceeds the egress of old flock members. The decoying effect of a large concentration, abundant food, and a roost lake would seem the basis for a differential in favor of ingress.

We do not yet have satisfactory data on the migration routes of Canada geese wintering in western Louisiana. Recovery records of geese banded at the Miner Sanctuary and at Horseshoe Lake indicate that the migration routes of the Mississippi Valley population do not lie far west of the Mississippi River. Hence, the flocks that migrate through central or western Minnesota, Iowa, Missouri, and Arkansas, and those (possibly the same) that winter in western Louisiana, constitute part of a distinct population, the Eastern Prairie, but scattered band recoveries of geese banded at Horseshoe Lake and taken in Manitoba, South Dakota, western Minnesota, Louisiana, and eastern Texas are evidence that there is some exchange of birds between the Mississippi Valley population and the Eastern Prairie population.

Spring Migration Routes

There are too few spring band recoveries in the United States to depict accurately the northward migration routes of Mississippi flyway geese. Judged by trap records from the Miner Sanctuary, the spring movement is more directly northward and somewhat west of the autumn migration routes. Each spring in early March, a marked increase is noted in the numbers of Canada geese at Horseshoe Lake and at Hovey Lake, Posey County, Indiana. The latter area

harbors few geese in the autumn, but is host to large concentrations after the middle of February. It is conceivable that the late winter concentration may consist of geese of the Southeast population, which may take a more westerly route in their northward than in their southward migrations. Other important late winter or spring concentration points are the drainage districts near Putnam, Illinois (spring 1946 and 1947), the Horicon National Wildlife Refuge (Hopkins 1947), bottomlands of the Bark River in Wisconsin, farm lands at the south end of Lake Oshkosh in eastern Wisconsin, and Gull Lake in southwestern Michigan.

As most spring band recoveries are from the remains of geese shot the previous autumn, no differentiation is made between autumn and spring recoveries in figs. 13–21.

Apparently, after feeding in the rich farm lands along the migration routes in the United States and southern Canada, the flocks fly almost directly to the breeding grounds.

Time and Rate of Migrations

The autumn migration of geese wintering at Horseshoe Lake is spread out over at least a 3-month period, the earliest migrants leaving James Bay in the forepart of September and the last reaching Horseshoe Lake in December, the exact dates depending on the severity of the weather.

Migration records from federal refuges and Horseshoe Lake, table 5, suggest that the outward movement of geese from the breeding grounds may be compared with a segment of the concentric waves produced by an object striking the surface of a body of water; the earliest flocks or migratory waves travel the greatest distances in the shortest periods of time and reach their wintering grounds in the far south before many other flocks have left the north country. First arrivals are noted at Horseshoe Lake and at federal refuges farther south as early as or earlier than they are recorded at refuges farther north. A similar picture has been found to be true for areas lying only short distances apart. Leopold & Jones (1947) reported that in 5 out of 6 years flocks of Canada geese were recorded near Madison, in Dane County, Wisconsin, 2 to 27 days before they were observed about 40 miles to the northwest, near the Wisconsin River, in Sauk County.

Table 5.—Dates of first recorded autumn arrivals of Canada geese at federal refuges and at Horseshoe Lake, Illinois, 1938–1944.

Refuge	Degrees North Latitude	Dates of First Arrival							Average Arrival Date
		1938	1939	1940	1941	1942	1943	1944	
Rice Lake, Minnesota	47	—	10/12	10/26	10/15	—	10/6	10/1	10/10
Necedah, Wisconsin	44	—	10/20	10/12	10/8	10/8	—	—	10/12
Union Slough, Iowa	43	—	—	—	—	—	10/15	10/20	10/17
Upper Mississippi	See footnotes	10/22[1]	—	10/13[2]	10/8[3]	10/9[4]	—	9/23[1]	10/9
Squaw Creek, Missouri	40	—	9/24	10/15	—	10/4	—	10/10	10/6
Swan Lake, Missouri	40	10/14	10/4	10/4	10/10	10/11	9/17	—	10/5
Horseshoe Lake, Illinois	37	—	—	—	9/10	9/21	10/1	9/24	9/22
Kentucky Woodlands (Gilbertsville Reservoir)	37	—	—	—	10/28	12/31	10/26	11/5	11/14
Reelfoot Lake, Tennessee	36	—	—	—	—	9/27	9/12	9/8	9/16
Wheeler, Alabama	35	—	11/4	10/8	10/18	12/8	11/2	11/4	11/2
White River, Arkansas	34	10/19	10/17	—	10/1	9/27	9/25	10/1	10/5
Lacassine, Louisiana	30	—	9/28	10/12	12/21	—	10/1	9/2	10/1
Sabine, Louisiana	30	10/20	10/14	9/27	9/25	9/12	10/30	10/5	10/6
Delta, Louisiana	29	—	10/27	10/6	—	10/18	10/26	10/25	10/20

[1] Section of refuge unknown.
[2] Savanna, Illinois, District, 42° N. Latitude.
[3] Guttenberg, Iowa, District, 43° N. Latitude.
[4] Bellevue, Iowa, District, 42° N. Latitude.

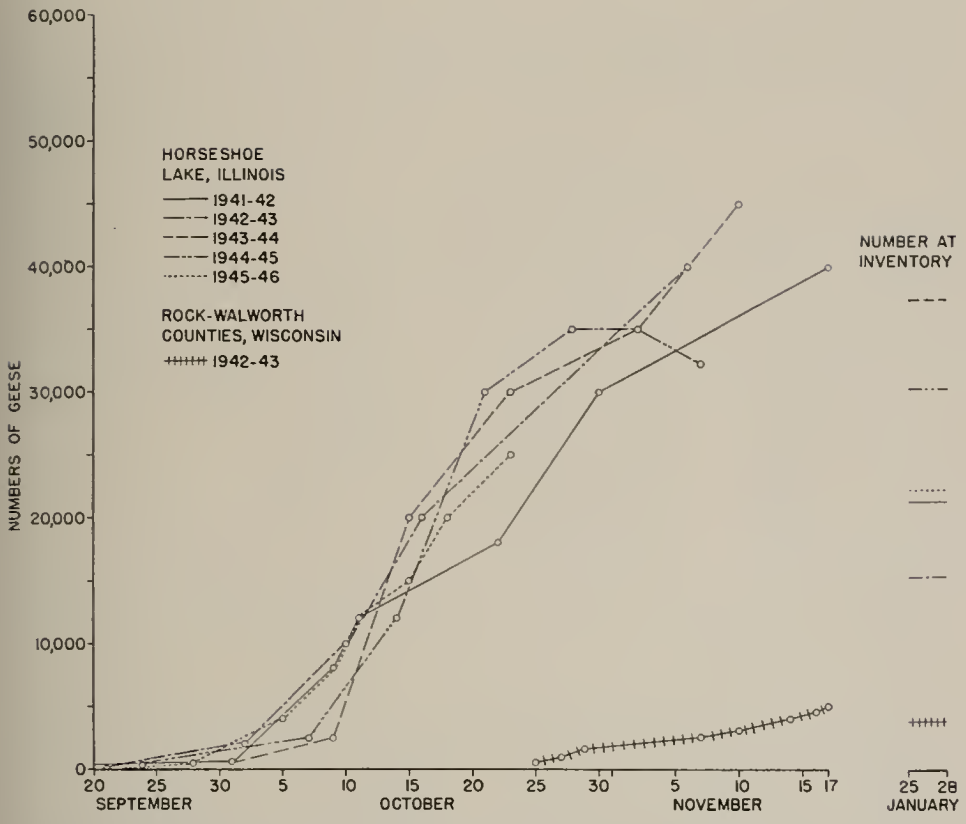

Fig. 38.—Build-up of the Canada goose flock at Horseshoe Lake during the autumn and winter of the years 1941–1946. Also shown is the build-up of the Canada goose flock in Rock and Walworth counties in the autumn and winter of 1942–43 (from Zimmerman 1943).

The build-up of autumn concentrations at Horseshoe Lake is shown in fig. 38. As the majority of the geese wintering at this refuge arrive before the bulk of the kill has been made farther north, probably the flocks that leave the breeding grounds later, and winter farther north, contribute most to the kill in areas north of the refuge.

Spring migration movements appear to be more leisurely than the flight south, but this impression may be created by flocks of nonbreeding adult or yearling geese that are under no stimulus to reach the breeding grounds at an early date. We have seen several hundred geese in the vicinity of Lake Wisconsin throughout the first week in May, and Hopkins (1947) states that the last flock in the Horicon Marsh area in 1947 remained until May 8. On the other hand, the arrival of the first flocks in the James Bay region is quite punctual, generally between April 15 and 25, which is the time of the goosemoon, "nisku pesim," of the Cree Indians. In most years, the earliest flocks arrive on the breeding grounds 2 to 3 weeks before the breakup of the major rivers, table 6.

George MacCloud, a lifelong resident of the James Bay area, reported to the senior author that a second flight of Canada geese generally takes place about June 10. These late geese are said to be in large flocks, whereas most of those that arrive earlier are paired. He thought that the late arrivals were largely young of the previous year. Although we have been in the bay area during June, we are unable to confirm, by personal observation, the "flight of stragglers."

However long the northbound Canada

Table 6.—First arrival or first kill of Canada geese at Fort Albany, Ontario, and date of breakup of the Albany River.*

YEAR	ARRIVAL OF CANADA GEESE		DATE OF BREAKUP OF THE ALBANY RIVER	NUMBER OF DAYS BETWEEN FIRST ARRIVAL OF GEESE AND RIVER BREAKUP
	Date	Comment		
1884	May 1	First goose observed	May 17	16
1885	April 26	First goose observed	May 15	19
1888	April 21	First goose observed	May 12	21
1889	April 12	First goose observed	May 6	24
1891	April 15	First geese observed	May 14	29
1896	April 15	First geese observed	May 10	25
1897	April 12	First geese observed	May 7	25
1898	April 14	First geese observed	April 27	13
1900	April 6	First goose observed	May 2	26
1901	April 18	First goose killed	May 1	13
1902	April 14	First goose killed	May 15	31
1903	April 23	First geese observed	May 20	27
1904	April 23	First geese observed	May 8	15
1913	April 17	First geese observed	April 28	11
1914	April 21	First goose killed	May 6	15
1918	April 19	First goose killed	—	—
1919	April 19	First goose killed	—	—
1920	April 25	First geese observed	—	—
Average				*20.6*

* Data on the arrival of Canada geese before 1901 and most data on breakups from Lower (1915); arrival data on Canada geese 1901–1920 from Fort Albany diary of Bishop Robert John Renison and other local sources.

goose flocks may linger in the United States, the final lap over the forested areas of Canada is apparently often made in a single day. Miner (1929) stated that frequently, when flights of geese have left his refuge at a half hour before sundown, he has wired the news ahead to towns lying north between Kingsville and James Bay. The following morning, generally between 6 and 8 o'clock, large flights have been seen over Cochrane, Ontario, a town about 490 miles north of Kingsville. If their course was fairly direct, and if it is assumed that the geese that left the Miner Sanctuary were the ones sighted over Cochrane, a not unwarranted assumption, their average speed was 35 to 40 miles per hour.

A few flocks stop to feed each spring on the farm lands of the clay belt in central Ontario; the New Liskeard area was host to migrating flocks in 1947. In early May of that same year, flocks held up by severe winter conditions remained in the Kapuskasing area sufficiently long to warrant artificial feeding; little natural food was available, as the country was still under several feet of snow, and all rivers and lakes were frozen. Despite this fact, a large flight of Canada geese was reported over Frazerdale the night of May 4, and the following day the first big flight was observed in the Moose River country, nearly 2 weeks before the breakup of the Moose River, which occurred on May 17.

No attempt has been made in the present study to compile additional data on the correlation of Canada goose movements with the advance of the isotherm of 35 degrees F., a correlation reported to hold only for the vanguard of migrants (Lincoln 1939).

WINTER CONCENTRATIONS

The Canada geese of the Mississippi River valley winter from the latitude of southern Wisconsin to the Gulf Coast of Louisiana, using definite concentration areas during the winter season, as well as during the migration periods. They are hardy birds, able to withstand winters of the severity of those occurring in southern Wisconsin and southern Ontario without ill effect, as long as they are provided with abundant food and a water supply. When rest lakes in northern areas become frozen over, the flocks resort to open streams for drinking water, but the lake ice pro-

vides acceptable roosting sites. When the local food supply is exhausted or covered with snow, or when feeding is curtailed, as at the Miner Sanctuary in early December, the geese in the northern sectors of the flyway migrate farther south.

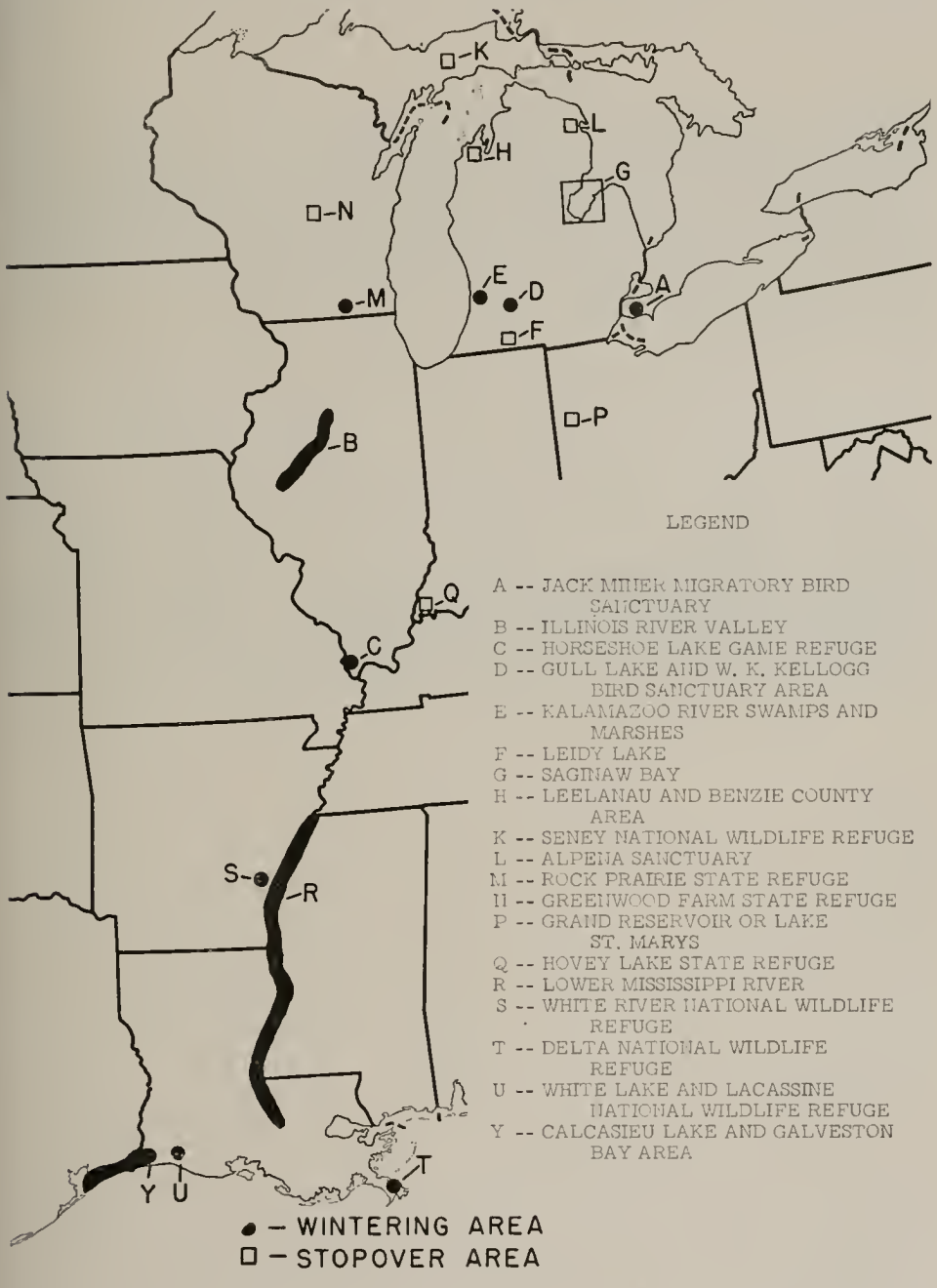

Fig. 39.—Location of important concentration areas for Canada geese of the Mississippi Valley population.

Each January an inventory of the waterfowl populations wintering in the United States is made by the United States Fish and Wildlife Service and cooperating agencies, assisted by selected private individuals. The January inventories have produced useful information, particularly in regard to population trends but, because these inventories are taken over a limited period of time (4 days), in some areas they have been subject to considerable error in past years. For example, the immense coastal marshes of Louisiana, which are notoriously difficult to traverse on the ground, cannot be covered adequately except by plane. Because thorough aerial censuses of the Canada goose population in Louisiana were not made before the winter of 1943–44, and because adequate data are lacking for many other parts of the flyway prior to that winter, we do not consider the population data previous to that date to be of sufficient reliability to meet present-day management needs. Even some of the data in table 7, particularly the 1944–45 figures for the populations in Arkansas and on a considerable portion of the lower Mississippi River, may not be of sufficient reliability because complete coverage by aircraft was not possible.

For reasons explained in the section "Autumn Migration Routes," we believe that the flocks of western Louisiana probably are not an integral part of the Mississippi Valley population. Nevertheless, they should be considered along with the Mississippi Valley population in order to detect whether major population shifts occur between the flyways in some years and to determine the effect that kills in the upper Mississippi River valley may have on the western Louisiana populations. A brief survey of the various concentration areas and the populations using them follows.

Jack Miner Bird Sanctuary

The Jack Miner Bird Sanctuary, located in the rich farm lands of Essex County, Ontario, figs. 39*A* and 40, 4 miles from Lake Erie, was one of the first waterfowl refuges established in North America. The history of this refuge and of Jack Miner's work with Canada geese has a bearing on discussions

Table 7.—Population of Canada geese in the Mississippi River valley, 1943–44 through 1946–47. Data are from the annual January inventories, except as noted.

State or Other Area	Season			
	1943–44	1944–45	1945–46	1946–47
Michigan	4,220	2,200	2,343	3,512
Wisconsin	6,350	4,100	4,310	5,000
Minnesota	—	5	100	—
Ohio	248	—	—	105
Indiana	343	750	985	1,369
Illinois (Mason County)	925[1]	800[1]	360[1]	31,649[2]
Horseshoe Lake	37,000[3]	30,000[4]	22,000[3]	
Iowa	125	6	—	—
Kentucky	3,720	2,280	1,200	1,230
Mississippi River (Tenn.-Miss. line to White Castle, La.)	3,300[5]	10,000[6]	1,650	7,540
Arkansas	5,000[5]	10,500	5,400	800
Missouri	3,300	5,440	665	2,370
Louisiana Delta	1,000[5]	1,000[5]	10,000[7]	8,065[7]
Western Louisiana	11,000[5]	12,000[5]		
Total	*76,731*	*79,181*	*49,013*	*61,640*
Total, exclusive of western Louisiana	65,731	67,181	—	—

[1] Census by Frank C. Bellrose, Illinois Natural History Survey.
[2] Of the number of Canada geese in Illinois, about 30,000 were at Horseshoe Lake and 800 at the Union County refuge.
[3] Census by Paul S. Smith, United States Fish and Wildlife Service, and Harold C. Hanson at January inventory.
[4] Average of estimates by Robert H. Smith, Paul S. Smith, and Frank C. Bellrose after hunting season.
[5] Census by Robert H. Smith.
[6] Total for Tennessee and Mississippi combined in January inventory.
[7] Inventory figure for all of Louisiana. According to Richard H. Griffith, United States Fish and Wildlife Service, 1,500 Canada geese were at the Delta National Refuge and 5,440 at the Lacassine and Sabine National Wildlife refuges in the winter of 1946–47.

in this paper and is also of general interest.

Jack Miner (1923) built his first pond and set out decoys to attract geese in 1904, but did not lure in a family of geese until 1908. The numbers of geese using the refuge built up slowly in the early years, and until 1915 the refuge attracted Canada geese only in the spring. In later years the autumn flight equaled the spring flight in size.

Fig. 40.—View of the main pond and feeding grounds at the Jack Miner Bird Sanctuary, Kingsville, Ontario. Contact of the geese with human beings is avoided whenever possible. Corn is distributed at night, and visitors remain concealed while observing the geese.

Efforts at trapping and banding Canada geese did not succeed until 1915, and large-scale bandings were not accomplished until nearly 10 years later. Table 2 presents the best available data on the numbers of Canada geese banded at the Jack Miner Bird Sanctuary in the autumn.

The Miner homestead, ponds, and feeding grounds consist of 17 acres. All feeding is done around the ponds, but a few rye and timothy fields are planted as retreats and sources of food to be used when the geese on the ponds are disturbed. Additional farm land, owned by the Jack Miner Migratory Bird Foundation, Inc., amounting to 400 acres, surrounds the 17-acre homestead area. About 100 acres are planted to rye and timothy, the remainder to corn, which constitutes the only grain fed to the geese. Fields of timothy, which have been cut for seed, are said to make ideal pastures for Canada geese and are heavily grazed. Approximately 20,000 bushels of ear corn are fed during the autumn and spring seasons; when there is an appreciable local kill the corn is fed more heavily than at other times.

By Proclamation and Order in Council of the Provincial Government, no shooting is permitted on an additional 1,600 acres of land neighboring the 400 acres owned by the Miners. Thus, the geese are protected in all directions from the central feeding grounds by a buffer strip about 1 mile deep.

A few geese arrive at the refuge by late September. Noticeable increases in numbers usually occur between October 10 and 15, and peak numbers are reached by about November 10. There is a constant renewal of the population as some individuals continue their migration south and others arrive from the north. The bulk

of the autumn flock leaves by late November or early December. In some years prior to World War II, as many as 5,000 geese were reported to have remained all winter. Some of these wintering geese from the autumn flight have received "S" marked bands in the spring along with birds that have wintered at Currituck Sound and Lake Mattamuskeet, thereby explaining why some spring bands are subsequently recovered in the Mississippi River valley, fig 12.

Illinois

Of the areas in Illinois important to migrating and wintering flocks of Canada geese, the two most important are the Illinois River valley and the Horseshoe Lake Game Refuge in Alexander County at the southern end of the state.

Illinois River Valley.—Canada geese have been reported from 23 bottomland lakes in the Illinois River valley, fig. 39*B*, but regularly from only seven lakes, table 8. These lakes act chiefly as roost areas; feeding is done in the cultivated uplands and in some drainage districts. Geese of five of the Illinois concentrations disperse to feed as follows: Beebe Lake geese depend largely on the winter wheat and the corn of Duck Island; Lake Chautauqua and Clear Lake geese feed mainly in the cultivated fields of Mason County; Crane Lake and Jack Lake birds seek most of their food in or near a 1,000-acre private club 2 miles southeast of Bath. Flocks frequenting Goose Pond and Lake Senachwine (the part formerly known as Swan Lake) have not been observed feeding in any particular sector. In general, feeding areas are within 7 miles of a roost lake. Population data for the above areas are summarized in table 8.

Horseshoe Lake Game Refuge.—The most important Canada goose wintering ground in the Mississippi River valley in recent years, the Horseshoe Lake Game Refuge, with its surrounding area, figs. 1 and 39*C*, during the period of this study harbored approximately 50 per cent of the goose population of the flyway for varying autumn and winter periods. Because of inadequate food supplies on the refuge, as well as intense hunting pressure in surrounding privately owned fields, the flock fed in most winters over a 15-mile radius. The majority of the geese roosted within the refuge each night, although some flocks resorted to islands and bars in the Mississippi River.

The lake, fig. 41, 1,200 acres in size, of an oxbow type common to the bottomlands in the flood plain of the Mississippi River, in many places is 200 or more yards in width and 4 to 6 feet in depth. A dam maintains fairly stable water levels, but most of the land enclosed by the lake is subject to flooding when the Mississippi or Ohio River reaches high flood stage. Open water surrounds the island except for a

Table 8.—Canada goose populations in three regions of the Illinois River valley, autumns of 1938–1946.

Year	Bath Region (Jack, Crane Lakes)		Chautauqua Region (Chautauqua, Clear, Beebe Lakes)		Putnam Region (Goose Pond, Lake Senachwine*)		Approximate Average Number in Valley
	Peak	Average	Peak	Average	Peak	Average	
1938	1,420	800	75	22	?	60	882
1939	2,100	520	500	34	?	100	654
1940	800	509	250	110	?	83	702
1941	1,500	391	337	84	37	?	475
1942	1,340	1,150	325	400	80	60	1,610
1943	1,900	500	300	425	400	?	925
1944	1,600	400	150	400	14	?	800
1945	1,400	0	330	360	46	?	360
1946	500	285	430	281	190	86	652
Total	*12,560*	*4,555*	*2,697*	*2,116*	*767?*	*389?*	*7,050*
Average	1,398	506	300	235	—	—	784

* Part of Lake Senachwine formerly known as Swan Lake.

Fig. 41.—View of the east arm of Horseshoe Lake. The large open expanses of the lake are favored by the geese for roosting purposes.

Fig. 42.—The greater portion of Horseshoe Lake is open water, but the north and south portions have heavy stands of live and dead cypress and tupelo gum trees. A dam maintains fairly stable water levels except when the Mississippi or the Ohio River reaches high flood stage.

Fig. 43.—Aerial view of Canada geese on Horseshoe Lake in November, 1945. The population of the entire flock could be counted with a considerable degree of accuracy if suitable aerial photographs were available.

small portion at the north end, where the lake is swamplike and has an irregular stand of tupelo gum and cypress trees, fig. 42. Gums and cypresses border the remainder of the lake, and in some places the cypresses extend entirely across the lake.

During late years of this study the refuge contained about 3,660 acres. The

Table 9.—Number of Canada geese using the Horseshoe Lake Game Refuge, 1928–29 through 1946–47.

SEASON[1]	PEAK NUMBER	NUMBER AT JANUARY INVENTORY	TOTAL LOSS (INCLUDING CRIPPLING LOSS, FROM TABLE 15)	APPROXIMATE NUMBER OF GEESE TO ARRIVE AT REFUGE DURING FALL AND WINTER
1928–29	1,000–1,900[2]	—	—	—
1929–30	7,000–8,000[2]	—	—	—
1932–33	30,000[2]	—	—	—
1940–41	45,000	17,000	—	—
1942–43	55,000	15,000	—	—
1943–44	50,000	37,000	15,980	53,000
1944–45	35,000	30,000	10,549	40,500
1945–46	26,000	22,000	7,117	29,100
1946–47	—	31,641	—	—

[1] The term *season* refers to the period of time in autumn and winter that the geese are at the refuge.
[2] From Uhler (1933). Other censuses except last two by Illinois Natural History Survey staff and Paul S. Smith; 1945–46 and 1946–47 census by Survey staff and Robert H. Smith.

island has an area of 1,360 acres, of which 1,200 have been farmed in recent years to produce food for the geese. The remaining acreage supports some of the finest virgin bottomland timber in the state. Of the cultivated portion of the island usually 300 to 400 acres are planted to corn and 700 acres sown to wheat, but these acreages have varied considerably from year to year. In the last several years all crop land on the island has been planted in corn. Wheat or corn is sown on the 100 acres of the refuge adjoining the east shore across from the island.

Many of the published statements in recent years regarding the size of the Canada goose flock at Horseshoe Lake have not been in agreement. The result has been confusion in the minds of the public. While a few "census figures" have been based on pure guesswork and are therefore unreliable, many of the differences in published data may be related to the times of the year the censuses were taken, and whether they included only the number of birds alive on certain dates or the total number arriving at the refuge in any given year. The population data given in table 9 summarize the census figures for several years.

Population estimates of the Horseshoe Lake flock since 1939 have been made by staff members of the United States Fish and Wildlife Service and the Illinois Natural History Survey, table 9. These estimates have been made by visually dividing the flocks into blocks, counting the number of geese in the sample blocks when the great bulk of the geese are feeding in the wheat fields on and near the refuge, and then using the sample counts to calculate the total population. The practice in some years has been to make periodic estimates from the time the first geese arrived in late September until peak populations have been reached in late autumn. Since 1944, aerial censuses just before and after the hunting seasons have

Fig. 44.—Aerial view of Burnham Island and adjacent bars in the Mississippi River, 4 miles west of Horseshoe Lake. Prior to the establishment of the refuge, Canada geese wintered in large numbers on similar bars and islands of the Mississippi River, from Chester to Cairo, Illinois. Geese have made some use of these islands even since the refuge was established.

been made at Horseshoe Lake and nearby areas, figs. 43 and 44. Population figures for 1941–42 through 1945–46 are shown graphically in fig. 38.

Michigan

In Michigan there are three major concentration areas and two of minor importance.

Kalamazoo River Bottoms and Nearby Lakes.—The Kalamazoo River bottoms and a number of lakes in the southwestern section of the state constitute the most important region in Michigan for concentrations of migrant and wintering Canada geese, fig 39. This general area includes three specific concentration sites.

1. Gull Lake and the W. K. Kellogg Bird Sanctuary and Farms are located in Prairieville and Barry townships in Barry County and in Richland and Ross townships in Kalamazoo County, fig. 39*D*. Gull Lake, with an area of 3,000 acres, is designated as a rest lake. Hunting is prohibited on the quarter-mile strip surrounding this lake and on the Kellogg tract of 600 acres.

The above district lies on an extensive outwash plain and is characterized by small lakes and kettle holes. Some nearby sections are too hilly to be farmed, but hay, corn, and wheat are raised extensively on the less hilly sections. The geese feed in the cultivated upland fields and also they are hunted there.

In 1945, the maximum autumn population in the area was 5,000 birds, and about the same number were present during the peak of the 1946 spring migration. The wintering population usually varies from 1,000 to 2,000, but may be considerably less for several weeks in midwinter. In 1944–45, 500 geese wintered at Gull Lake (Dr. Miles D. Pirnie, then in charge of the sanctuary, personal communication). Normally a majority of the birds leave by mid-January and return again by mid-February. Weather determines their movements; usually a portion of Gull Lake remains open throughout the winter, and waste grain is generally available in the uplands for geese that winter in the area.

2. The Kalamazoo River swamps and marshes, fig. 39*E*, principally the Pottawattomie and Ottawa marsh areas, the latter a part of the Swan Creek Wildlife Experiment Station located in Heath, Manlius, and Valley townships, and the Todd Farm Sanctuary in Ganges and Clyde townships near the Kalamazoo River, all in Allegan County, are some of the most important concentration grounds for Canada geese in Michigan. Each site differs somewhat from the others and there is a free interchange of birds from one area to the other.

The Pottawattomie and Ottawa areas consist of 2,800 acres, principally marshy bottomlands with adjacent timbered areas. These areas serve as both private and public hunting grounds.

The Swan Creek Wildlife Experiment Station has a 550-acre sanctuary of partially flooded land, once farm land, and timbered bottomland.

The Todd Farm Sanctuary comprises 1,500 acres of drained lake-bottom farm land. This sanctuary furnishes both feeding and resting sites. Hutchins Lake, north of the farms, is used by geese as a rest lake in the autumn. A spring-fed creek crossing the farm remains open through the winter, and food is available to the geese in the cultivated fields.

The greatest concentration of geese recorded in the above sections was 6,000, in the autumn of 1945. The wintering flock was estimated at 2,000. Both figures are said to represent spectacular increases in comparison with those of previous years. In 1944 the wintering flock was estimated to be only 400.

3. A 250-acre sanctuary at Leidy Lake in Leonidas Township, St. Joseph County, fig. 39*F*, serves as an important spring concentration point; over 2,000 geese were estimated to be on the area in 1946. It is used less in the autumn, 300 to 400 being average numbers of geese present at that time.

Saginaw Bay.—Saginaw Bay is a major concentration area for both autumn and spring flights of Canada geese, fig. 39*G*. The spring flights may consist largely of South Atlantic geese en route north from the Miner Sanctuary. The geese do not linger long at Saginaw Bay in the autumn because of the absence there of sanctuaries. They have been forced by hunting pressure to reverse their normal

daily routine, feeding after dusk in the grain fields and roosting in daylight hours on the open waters of the bay. They do not winter in this sector, as there is no open water.

The best estimates available place the maximum numbers frequenting the bay during the autumn or spring migrations at about 15,000 birds.

Leelanau and Benzie Counties.—Leelanau and Benzie counties in Michigan, fig. 39*H*, constitute a less important concentration area than the Kalamazoo River or Saginaw Bay areas. A number of scattered sites are favored: Glen Lake and about four sections of hilly grassland in Empire Township, Leelanau County, and Lake Ann, Upper Platte River, and Platte Lake in Benzie County. A 1,200-acre refuge recently established in Empire Township provides feeding and resting areas.

Canada geese have used this area as a regular stopping place for only about 10 years. In recent years as many as 2,000 geese have frequented it regularly, but few winter in the area; there were about 50 in 1945. Some Canada geese may nest in this region.

Other Michigan Areas.—There are two other concentration areas in Michigan of less importance than the above. The Seney National Migratory Waterfowl Refuge, fig. 39*K*, consists of 30,000 acres surrounded by a vast area of wild land. The autumn concentration in 1945 was estimated at 3,000 geese. The spring maximum was 2 500.

The Alpena Sanctuary, fig. 39*L*, comprises 500 acres of land on the Thunder Bay River in Alpena Township, Alpena County. Geese stocked at this refuge have attracted as many as 400 migrants in the autumn.

Wisconsin

In Wisconsin there are two refuges or concentration areas of importance.

Rock Prairie Refuge.—The Rock Prairie Refuge, fig. 39*M*, consisted of 640 acres when established in 1936. Before the refuge was relocated, it lay partly in Richmond Township, Walworth County, and partly in Johnstown Township, Rock County. In 1945 the refuge was shifted 3½ miles to the west so that it lay entirely within Rock County.

The entire refuge is in cultivated prairie uplands and is used for feeding only. Since feeding was initiated in 1940, between 25 and 45 tons of corn have been fed each season. The geese that frequent this refuge in the autumn and winter usually fly to Lake Geneva and Lake Koshkinong for roosting.

Canada geese do not remain in southern Wisconsin during severe winters. In 1945–46, local estimates placed the wintering flock at 3,000. In 1942, 4,500 geese wintered in these two counties (Zimmerman 1942). Peak autumn populations in Rock and Walworth counties have generally varied from 4,000 to 6,000 birds. The build-up in numbers of geese in the autumn of 1942 is shown graphically in fig. 38.

Greenwood Farm Refuge.—The Greenwood Farm Refuge, established in 1940, contains 1,751 acres. It is situated in Hancock and Deerfield townships, western Waushara County, fig. 39*N*. Although it is intended primarily as a rest area, in some parts of this refuge farmers are paid to leave corn standing in the fields for the geese. The flocks roost on the sand bars of the Wisconsin River, about 20 miles to the west. The refuge was first used by a few geese in 1942; as many as 3,000 birds had been reported on the area by 1946.

Ohio

Lake St. Marys, or Grand Reservoir, fig. 39*P*, a 17,500-acre impoundment in Mercer and Auglaize counties, is heavily used by Canada geese in migration, but few geese winter there or in other parts of Ohio. January inventory figures, 1941–1946, show an average of only 400 Canada geese in the entire state; inventory figures for the state, 1936–1941, averaged 1,600 per year.

Indiana

Hovey Lake, fig. 39*Q*, the most important wintering area for Canada geese in Indiana, is located in Posey County in the extreme southwestern tip of the state, 4 miles from the confluence of the Wabash and Ohio rivers. The lake and adjoining marsh and swamp land, totaling 900 acres, were purchased in 1938 with funds made available through the Federal Aid

in Wildlife Restoration Act. The lake, nearly a half mile wide and three-quarters of a mile long, has an area of about 400 acres. Bald cypress is found around certain parts of the lake, but willow, elm, and soft maple, with an understory of buttonbush, occupy most of the shore line.

Approximately half of the lake is open to waterfowl hunting; the remainder is a refuge. No supplemental feeding is carried out on the refuge sector, a factor that may partially explain why the geese that use the area have retained their wildness. Nearby wheat fields are cropped by the geese to a considerable extent, but no serious damage has been reported. During the winter period the geese do much of their feeding in overflow, bottomland cornfields that have been harvested with mechanical pickers.

There are seldom more than 300 geese in the vicinity of Hovey Lake during the hunting season. Maximum numbers during three recent winters are as follows: 1,000 on January 8, 1944; 1,500 on January 20, 1945; and 2,000 on January 27, 1946.

Arkansas

The geese wintering in the lower White River and Arkansas prairie area, fig. 39*S*, use several distinct types of habitat: the flood-plain swamp lakes of the White River National Wildlife Refuge, the neighboring prairie area of Arkansas County, and the sand bars of the lower Arkansas River and adjacent parts of the Mississippi River.

The flood-plain lakes are shallow, cypress-rimmed oxbows, devoid of submerged vegetation and used by the geese only for roosting. The geese make daily flights from these lakes to the prairie for feeding. The prairie is intensively cultivated; rice, winter oats, soybeans, and lespedeza are the principal crops. The practice of leaving the rice fields fallow periodically and using them for pasture makes attractive foraging areas for geese, as the ground between the old rice levees is frequently flooded or at least wet during the winter.

Because of the difficulty of censusing the extensive areas of bottomland swamps, we believe that in most years our data on populations in Arkansas are not reliable. In the winter of 1943–44, the population was successfully censused and estimated to be 5,000, but we are unable to state with any certainty what the population was in prior or subsequent years, as the birds wintering in this region occasionally use the Mississippi River bars and may have been included in the estimate for the Mississippi River area. Duplications in the inventory figures for Arkansas and the lower Mississippi River in 1944–45 may account for the indicated increases for this region in that winter and partially explain the apparent sudden great drop in the total population of Mississippi flyway geese in the following year, table 7.

Lower Mississippi River

Islands and bars in the Mississippi River attractive to wintering Canada

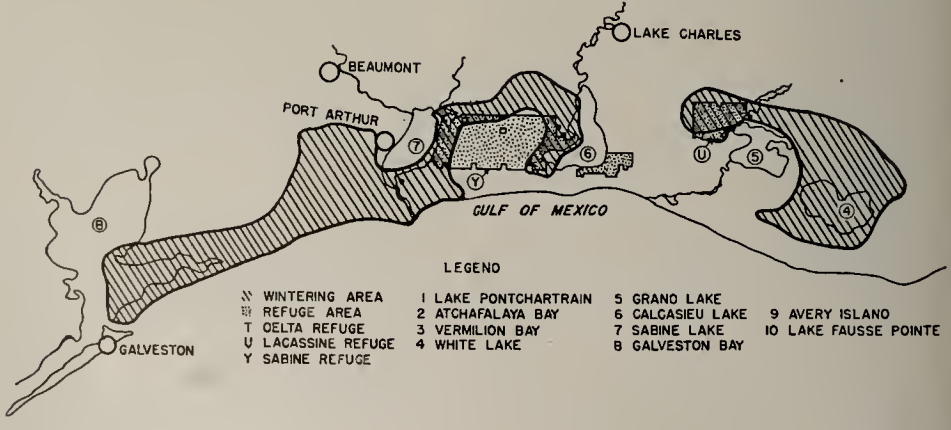

Fig. 45.—Location of wintering grounds of Canada geese on the coast of the Gulf of Mexico.

geese extend north to Chester, Illinois, and south to White Castle, Louisiana. However, except for scattered flocks, few Canada geese have wintered on the Mississippi River between Cairo, Illinois, and the Tennessee-Mississippi state line in recent years.

The portion of the Mississippi River used by Canada geese throughout the winter, fig. 39*R*, has an area, from levee to levee, of well over 1,500 square miles. In this huge expanse of territory the channel has constantly shifted by cutting and tearing on one side and depositing on the other; the result is a labyrinth of chutes and oxbows that have formed numerous islands and bars. Each island usually has one or more sand bars, and most of the bends in the channel have bars on the inside, fig. 44. Portions of the higher islands and bars, covered with small switch willows, grasses, and sedges, are used as feeding areas by the geese. At times, the bark of the small switch willow appears to be staple food of geese throughout the area.

The geese using this section of the river are widely scattered; usually they are in small or medium-sized flocks, but occasionally in large flocks. They show a preference for certain bars, which they use year after year. Varying water stages affect the accessibility of the bars to the geese and may cause the flocks to shift about when water levels change rapidly.

In primitive times the geese depended on forage produced on sand bars and in shallow flood-plain lakes, since there were then no cultivated crops in the bottomland country. Early agricultural developments tended to keep them on the bars in the southern sections of the flood-plain and upper delta country because cotton and sugar cane were the only crops extensively raised. Each year increasingly large acreages are planted to winter grains and legumes in the north and central portions of the bottomlands, thereby increasing the food resources for the geese in that section.

The habitat at Grand Lake and Lake Fausse Pointe, fig. 45, while near the coast, is of the sand-bar type rather than marsh. The geese are found on the upper ends of the lakes where the distributaries of the Atchafalaya River have formed a subdelta, creating conditions very similar to those found on the river sand bars. The geese sometimes work back and forth across the Atchafalaya swamp between Grand Lake and the Mississippi River, as less than 25 miles separate the lake from White Castle, Louisiana, the nearest point on the river.

Our data on goose populations in this sector of the valley are meager. Estimates made by the United States Fish and Wildlife Service have varied from 1,600 to 10,000 geese between 1944 and 1946. Accurate census figures are especially

needed from the lower Mississippi River each year, because data from this area are apt to indicate to what extent kills made in the Horseshoe Lake region are at the expense of populations wintering below Cairo, Illinois.

Coastal Marshes

The coastal marshes of Louisiana and east Texas extend from the mouth of the Mississippi River west to Galveston Bay. In this vast expanse of marsh, totaling over 5,000,000 acres, less than 700,000 acres are inhabited by Canada geese. Western sections of this range are used also by white-fronted geese, and between the Delta and Rockefeller refuges the winter range of the Canada goose is overlapped by that of the blue and snow geese.

In the coastal marshes are three principal concentration areas for Canada geese, figs. 39 and 45, and, as these vary somewhat as to type of habitat involved, each is discussed separately.

Delta of the Mississippi River.—At the mouth of the Mississippi River, Canada geese are concentrated on the Delta National Wildlife Refuge and the adjacent area in the vicinity of Main Pass, *T* in figs. 39 and 45. Here they use a variety of marsh types, from the relatively hard deltaic flats bordering the Gulf Coast to the deep marsh—the "floating prairie" of the interior. This is the most isolated wintering area on the Louisiana section of the Gulf Coast. The marshes to the west between the Delta Refuge and White Lake, an air-line distance of 180 miles, are devoid of Canada geese, except for a small flock inhabiting Avery Island.

White Lake and Lacassine Refuge.—In the White Lake and Lacassine area, Canada geese occupy an extensive range (*U* in figs. 39 and 45): east to Cow Island, north to the edge of the prairie below Gueydan, west to Sweet Lake, and south to the Rockefeller Refuge, which lies below Pecan Island; the range does not include Grand Lake and Lake Misere. Within this area Canada geese are most abundant south of Gueydan, where prairie and marsh merge, and on the Lacassine Refuge. In the zone of contact between the prairie and the marsh, there are marginal rice fields and wet pastures, interspersed with patches of maidencane, *Panicum hemitomon,* and southern wildrice, *Zizaniopis miliacea.* A vast expanse of maidencane and Jamaica saw grass, *Mariscus jaimaicensis,* with occasional low grassy ridges, is found throughout the marsh between White Lake and the edge of the prairie. At the west end of Pecan Island there are old stranded beach ridges roughly paralleling the coast line. The ridges, pastures, and rice fields are used extensively by geese for feeding areas. The deep marsh is used primarily for roosting.

Calcasieu Lake to Galveston Bay.—The Canada geese occupying the range from Calcasieu Lake to Galveston Bay are found on Calcasieu and Sabine lake ridges, the edge of the prairie, and the relatively high sea-rim marshes from Johnson Bayou to Port Bolivar, Texas, (*Y* in figs. 39 and 45). The Louisiana section of this range is limited, consisting only of a narrow fringe around an extensive area of deep marsh. In Texas, however, the reverse is true: a wide area of sea-rim and prairie marshes around a relatively small area of deep marsh. Consequently, almost the entire Texas area is good Canada goose range. The marshes in this area, along with the high marshes of southwestern Louisiana, are heavily grazed by cattle, which keep the forage in an ideal condition for feeding geese. The geese frequently roost on the inshore waters of Calcasieu and Sabine lakes and Galveston Bay, as well as on such smaller water areas as Black and Brown lakes.

Inventory of goose habitat on the Gulf Coast in 1943–44 and 1944–45 revealed populations of 12,000 and 13,000 birds, respectively. Partial coverage of the Gulf Coast in 1945–46 indicated no significant change in numbers over the previous 2 years. The above figures represent great divergence from what was commonly believed to be the Canada goose population on the Gulf range. Vast areas of excellent marsh are unused by Canada geese. Alfred M. Bailey stated (personal communication) that, even in the late twenties, Canada geese could be found in only a few places on the Gulf Coast. The geese frequent these same places today.

"It has become scarcer of late years," Bailey & Wright (1931) wrote several

years ago regarding the Canada goose population on the Gulf Coast. While there may have been much greater numbers of Canada geese wintering in the marshes of Louisiana 25 or more years ago, the decrease to present-day populations has not occurred altogether in recent years. It is more likely that the decrease was a gradual one, probably much of it caused by heavy shooting in northern parts of the range and in Louisiana. It seems altogether probable that at least some of the geese that normally would have wintered in Louisiana have been decoyed into Horseshoe Lake for entire seasons and have contributed to the annual kills there, but data are not available to show the extent to which hunting at Horseshoe Lake has affected Gulf Coast populations. For reasons discussed under "Autumn Migration Routes," it is difficult to believe that the kill made at Horseshoe Lake in any recent year would materially affect Louisiana populations the same year, for there are no data to show that an appreciable turnover in the population occurs at Horseshoe Lake within a single season.

In 1943—44, aerial coverage showed the following distribution of the Gulf Coast Canada goose populations: Delta Refuge 1,000, White Lake and Lacassine Refuge 7,000, Sabine Refuge (Gum Cove and Hackberry Island) 4,000.

GOOSE BEHAVIOR AND HUNTING LOSSES

The tremendous number of Canada geese bagged in the vicinity of Horseshoe Lake in recent years has made this area one of the most widely publicized shooting spots on the continent. The fearless and unwary behavior of the geese that winter at the Horseshoe Lake Game Refuge is responsible in large measure for the heavy kill, fig. 46. The response of this flock to hunting is contrary to the traditional reputed behavior of Canada geese. For centuries, the Canada goose has been extolled as one of the wisest and wariest of all birds and has been regarded as one of the most difficult to hunt successfully, but hunters and personnel engaged in wildlife management who have observed the habits of the Horseshoe Lake flock in Alexander County agree that these habits do not conform to the traditional pattern of Canada goose behavior.

How can the behavior of the Canada goose in Alexander County be reconciled with its traditional reputation? If the species is so wary or intelligent, why is it so unsuspicious and easily killed in Alexan-

Fig. 46.—A portion of the Horseshoe Lake Canada goose flock near the refuge headquarters. In many years, when food was scarce this flock lost much of its normal wariness.

der County? That the traits of the Horseshoe Lake flock are apparently singular cannot be denied, but there are many clues in the literature that help to explain its seemingly perplexing behavior. For example, many authors, after discussing the sagacity of the Canada goose, cite examples of the behavior of this goose that conflict with their previous remarks.

Grinnell (1901) has aptly expressed the enigmatic behavior of Canada geese: "The wild goose has long been proverbial for his shyness and wariness, and he well deserves the reputation that he has gained, and yet sometimes he is found to be 'as silly as a goose.' So that the gunner who follows the geese enough to see much of them will find that at one time great acuteness and at another a singular lack of suspicion are present in the ordinary wild goose. Few birds are more difficult to approach than these, and yet few come more readily to decoys or are more easily lured from their course by an imitation of their cry." A veteran goose hunter describes the Canada goose as "a bird of many moods. At times, very wise, but at other times very foolish" (Darby 1916).

Barnston (1862), referring to the Canada goose in the Hudson Bay region, writes: "Its disposition has less of wildness in it than that of the snow goose."

These citations and others given below show that many of the traits which make Canada geese vulnerable to hunting have been recognized elsewhere in the country, indicating that the behavior of the Horseshoe Lake flock is not as unique as one might be led to suspect. The unusual aspect of the reactions of the Horseshoe Lake geese seems to be that all or most of their behavior traits that tend to make them vulnerable to hunting are exhibited in the vicinity of Horseshoe Lake.

Wariness, Innate and Acquired

Many observers point out that geese are not so wary as various species of ducks, especially the mallard and black duck. Brandt (1943) noted a difference in wariness even in the newly hatched: "Young ducks of most kinds, just hatched, are very wild little creatures, which scatter at once and hide by all sorts of ruses. Newly hatched geese are most trusting little fellows."

The origins of the behavior differences between ducks and geese are deeply rooted. Lorenz (1937), Lack (1941), and Tinbergen (1942, 1948) have contributed to an understanding of these origins, which seem to relate in an important degree to the "innate perceptory patterns." There appears to be an inverse relationship between the specificity and specialization of these patterns and the degree to which the behavior patterns are (1) directed by "imprinting" (Lorenz 1937) during a brief period after hatching and are (2) developed, subsequent to the imprinting stage, by associative learning.

The acute wariness that adult geese normally possess seems to be mostly an acquired trait. Experience and association of the young geese with older birds appear to play an important role in the development of the traditional behavior pattern. If newly hatched goslings are taken before they have left the nest and are hand reared, their subsequent behavior shows considerable divergence from that of the wild birds. The readiness with which the Canada goose will become semidomesticated when given protection may possibly be related to the slow development of wariness in young birds.

A factor contributing to the fearless behavior of the Horseshoe Lake geese is the dual role played by man on and in the vicinity of the refuge. As the geese are accustomed to the sight of refuge workers, visitors, and the activities of a relatively dense rural population outside the refuge from the time they arrive in the autumn until the opening of the hunting season, they are apparently unable to comprehend the unfriendly role of the hunter. The same reaction to man has been found to be true in other places. Todd (1940) writes, "Under the protection now afforded at Erie Bay, the geese are less wary; on March 25, 1932, a party of which I was a member saw about twenty-five resting on the shore of a sheltered cove, and without apparent concern they permitted us to drive up in an automobile within one hundred feet."

Stone (1937) relates how Canada geese have responded to food and protection on the Atlantic Coast: "In season the farmers of this region [Cecilton, Maryland] go goose shooting on the

wheatfields and have decoy Canada geese to attract the wild birds. Of late years the ground has been baited and the geese return year after year to the places where they have been fed, which accounts for their abundance and tameness." (Notes from a field trip taken in February, 1927, when decoys and baiting were permitted.)

Even when Canada geese are wintering along the vast coastal marshes of the Gulf of Mexico, where, with an abundance of natural food, they might be expected to retain their independence, free-flying wild individuals will momentarily accept man at close range. At the Florence Club, near Gueydan, Louisiana, geese formerly used for decoys and tame cripples are brought into the club grounds for feeding each evening by calling and beating on a tin pan. On these occasions, numbers of wild geese accompany the tame birds into the club grounds and feed from the caretaker's hands. At all other times these same individuals seem to be unapproachable.

The importance of the role of man in conditioning the behavior of an entire flock was brought forcibly to our attention at the Miner Sanctuary. Until about 1925, wild Canada geese using the sanctuary were fed at a pond, 150 feet in diameter, which is located a few yards from the secondary road that passes in front of the Miner home. During the migration periods, when the geese were fed at this small pond, they were usually under the observation of large numbers of visitors, who, unconcealed, viewed them at close range. As a result of this encouraged familiarity, the vigilance of the geese toward man relaxed to such an extent that the local kills increased. Because the situation needed to be remedied, the geese were fed at a larger pond, fig. 40, away from the road, where they were hidden from public view by a dense grove of pine trees and a tight, 7-foot, wooden fence. Visitors who wanted to view the main concentration were required to use blinds or an observation tower overlooking the ponds. The resultant change in the behavior of the geese was profound, and local kills were soon reduced. After these new management measures were instituted, the sight of man was usually sufficient to flush the geese; previously, they had to be practically driven out of the front pond before they would take flight.

Although the Canada goose possesses mental powers that at times seem to be superior to those of most birds, and that are undoubtedly of great survival value under primitive conditions, individuals appear unable to solve problems of self-preservation that arise in a highly modified environment such as that in the Horseshoe Lake region. During the hunting season the geese wintering in that region exhibit almost a complete disregard for gunfire, flying back day after day to fields that often are the most heavily shot. This situation has perhaps been aggravated in recent years by the fact that the geese can feed in these same fields with impunity after the close of the day's shooting but are shot at on returning to feed the next day. The flock as a whole appears to be baffled by the presence of food and protection on the refuge at all times, and by the presence of food (standing corn, winter wheat) at all times but protection only a part of the time away from the refuge.

Family Grouping

Jenkins (1944), in a report on the social organization of a family of geese, states that "This well-integrated [Canada goose] family might be called a family supra-organism, since it performs the activities of a larger, more complex individual, through coördination of its components. This results in the dominance of the family, which is of survival value to its members in that they can feed first and rest in the center of the aggregation and are not pecked or chased."

Strong family ties in geese are undoubtedly of survival value against natural enemies, each family being a protective unit. Against man, during the hunting season, family grouping proves to be a liability, as the death or injury of one member frequently lures the rest of the family within gun range. Many a veteran goose hunter can cite examples of surviving members of a family flock, confused by the loss of one of its members, returning to a shooting pit to be shot at again. Bent (1925), in describing the duck-stand method of shooting geese on the inland ponds and lakes of Massa-

chusetts, writes, "When the geese are near enough and properly bunched a raking volley from a battery of guns is poured into them and other shots are fired as the survivors rise, with the result that very few are left to fly away. Even some of these may return and be shot at again if the leaders or parents of the young birds have been killed." This behavior trait has also been reported by Phillips (1916): "Now if a successful shot [probably meaning a series of shots fired at one time] is finally made into such a flock, and perhaps one half or three fourths of their number have been killed, the remainder, after a few turns in the air, or a short flight of five or ten minutes, will almost always return to the pond, where, if not actually disturbed, they will remain from several hours to a day or so. Sometimes they will decoy a second time."

The closely allied little cackling goose, *Branta minima,* sometimes exhibits the same type of behavior. "Even upon first arrival [in Alaska] many of the birds appear to be mated, as I have frequently shot one from a flock and seen a single bird leave its companions at once and come circling about, uttering loud call-notes. If the fallen bird is only wounded its mate will almost invariably join it, and frequently allow itself to be approached and shot without attempting to escape. In some instances I have known a bird thus bereaved of its partner to remain in the vicinity for two to three days, calling and circling about" (Nelson 1887).

Because of the concentration of birds at Horseshoe Lake, individuals from a broken family that return to the shooting fields in search of missing members can seldom be identified. However, one such instance was observed by a hunting club owner in 1944. Four geese from the refuge swung over a pit and two were dropped; the two remaining flew back toward the refuge, and when over the lake they made a wide swing and came directly back over the same pit, where they also were shot.

In 1945, another incident was noted that demonstrated the high vulnerability of the surviving members of a broken family. A flock of five geese entered a shooting field and, as the birds approached the second pit, two of the flock were killed and one crippled. The two uninjured geese immediately alighted and remained with the cripple for about 10 minutes before taking flight toward the refuge lake. On their way to the lake, they were crippled, one being hit so severely it barely gained the refuge.

It is apparent from these examples of Canada goose behavior that the permanency of family ties offers one explanation why geese, unlike ducks, cannot easily be shot out of a field. Surviving members of broken families searching for mates, parents, or young that have been shot probably contribute appreciably to the total bag; thus, a high kill at a shooting club early in a hunting season may insure continuance of a high kill through the remainder of the season. The presence of the survivors over the shooting fields would tend to decoy unbroken families into gun range. As a result, the performance of the geese at some clubs toward the close of the hunting season might be aptly described as a perpetual-motion shooting gallery, the birds moving across the hunters' horizon in a never-ending procession against the heaviest kind of gunfire.

Sociability

The Canada goose is a social bird and, except during the breeding season, it tends to congregate in fairly large numbers. This tendency, which was common to some of our now extinct species of birds and mammals, often has two important undesirable results: first, under some conditions it causes the species to lose some of its normal wariness; and, second, when the remnants of a population band together they give an unwarranted impression of general abundance.

Audubon (1843) made the observation that the behavior of geese using small water areas may differ from that of flocks that resort to large bodies of water; that is, the behavior may vary according to relative densities on an area. "The Canada goose is less shy when met with far inland, than when on the sea-coast, and the smaller the ponds or lakes to which they resort, the more easy it is to approach them."

Apparently wariness is related both to the total size of an aggregation and its size in proportion to the area it uses. The first relationship may be of a psychological nature; many species of mammals and birds show a reduction in wariness when they are in large herds or flocks. It is fairly common knowledge that many species, for example the ruffed grouse, are very wild when at the bottom of their cycles but are quite readily killed when abundant. At Horseshoe Lake the wariness of the geese in the autumn decreases as the flock increases and spreads out over the refuge, thereby reducing the area of unoccupied ground to which disturbed flocks can retire.

While the loss of natural wariness in aggregations of wild game is serious from a long-term standpoint, the impression of abundance that local concentrations create in the minds of observers may serve as a fairly immediate threat to the future of a species since it becomes a premise for unlimited gun pressure. To substantiate this point we need only cite recent history of the flock at Horseshoe Lake. From 1942–43 to 1945–46 this flock had grown smaller each year, while most of the local residents and visiting hunters at Horseshoe Lake believed that each year there were "more than ever." To many hunters, a closed season on this flock in 1946 seemed to be a needless infringement of their privileges.

Hewitt (1921) has stated, "It should also be pointed out that when a formerly abundant animal becomes reduced in numbers the remnant may tend to herd together and thus give an impression locally of great abundance. . . . . *Local* abundance, therefore, should never be taken as an indication of *general* abundance, and as a reason for permitting killing in large numbers."

Jackson (1943) has stressed the dangers of overshooting local remnants: "Extinction in every case was probably brought about at first by gradual depletion of the population and through local extirpation. When the population becomes reduced to a danger point, extinction may come with unexpected rapidity. Dislike the assertion as we may, in recent times the human species has been the prime factor in the extermination of other species."

HISTORY OF GOOSE HUNTING IN ILLINOIS

The hunting of Canada geese was once common in widely scattered areas over the state of Illinois. In most of the areas that formerly offered considerable shooting, the hunting of Canada geese as a sport of any consequence has ceased to exist. In a few, goose hunting has continued on a smaller scale; only in the Horseshoe Lake area has the kill in most years been high. Because the history of the sport in Illinois parallels the history of many other goose-shooting areas in the flyway, and because it relates to present goose-management problems, it is briefly reviewed here.

Two factors have been chiefly responsible for changes in the methods of goose hunting, and for the decrease or increase of goose hunting in different sectors: (1) the development of state, federal, and private refuges, frequently attended by artificial feeding, and (2) the outlawing of both baiting and use of live decoys. Formerly, fair bags of Canada geese were made on the Big Foot Prairie in the northeastern portion of Illinois near the Wisconsin state line, but, with the establishment of a refuge and feeding station in southern Wisconsin, fewer birds have been available to northern Illinois hunters. The Putnam area, west of Lake Senachwine, in the Illinois River valley, yielded fair bags of geese until 1935, when both baiting and use of live decoys were prohibited. When feeding was curtailed, the area no longer proved attractive enough to hold flocks for sufficient time to provide hunting.

In about 1925, Mason County, bordering the Illinois River, was the most important goose-shooting area in Illinois. The use of live decoys in the fields of winter wheat situated near large bottomland lakes was responsible for the popularity of this area. Field-pen hunting of Canada geese at private shooting clubs and at commercial day-shooting "clubs" in this county was centered largely east of Clear and Chautauqua lakes, northeast of Havana, and between Bath and Snicarte.

The average kill of honkers in the Clear Lake area in the twenties is reported to

Fig. 47.—Before paved roads and the Horseshoe Lake Game Refuge brought the hunter and the Canada goose into close proximity, goose hunting in southern Illinois was a fairly arduous undertaking. Here is a party of well-equipped hunters on their way to a Mississippi River bar. This photograph was taken in Alexander County in the early twenties. (Photograph by Bob Becker.)

Fig. 48.—Canada goose hunting as it was carried out on the Mississippi River sand bars in southern Illinois before the creation of a refuge at Horseshoe Lake. (Photograph by Bob Becker.)

have been about 100 per year or roughly 7 to 10 per cent of the number reported to have lingered in that area in those years. The top kill in the Bath-Snicarte area by the Brownstone Club in 1928 was 514 geese, more than the combined kill of all the other clubs in that region. In the late twenties and early thirties the average kill at Brownstone was about 400 per year. After the prohibition of baiting and use of live decoys, commercial day-

change in the type of wintering habitat, from one that was relatively primitive to one approaching parklike conditions, goose-hunting methods underwent an equally drastic change.

The following description is quoted from an unpublished report in 1941 by Arthur S. Hawkins, then of the Illinois Natural History Survey, and Paul S. Smith, then, as now, of the United States Fish and Wildlife Service.

Fig. 49.—Scene at goose-hunting club near Horseshoe Lake. The Horseshoe Lake region has been one of the most intensively hunted areas in the United States. The refuge totals only about 3,700 acres, but between 1941 and 1945 the area around it devoted to hunting averaged 11,000 acres controlled by an annual average of about 50 clubs. The number of pits and blinds in this acreage in the same period averaged approximately 400 and the total hunter capacity of the area 1,000.

shooting in the Illinois River valley was at an end, and only one private club primarily for goose shooting still exists. The continuance of Canada goose hunting in Mason County is due largely to the operation of two refuge areas, one private and one federal, that holds the birds in the area. In recent years, kills in the entire Illinois River valley have been about 400 birds per hunting season.

The river bars and islands of the Mississippi River between Chester and Cairo, Illinois, have been a wintering ground for Canada geese for many years, and since pioneer days this area has been noted for the goose shooting it afforded. The recent concentration of geese at Horseshoe Lake is in marked contrast to the wide dispersal of the birds in earlier times. With the

At the beginning of the present century there were comparatively few goose hunters, because goose hunting was no sport for the novice. Most of the hunters were skilled river men; those who traveled to the hunting grounds by land did so by horse- or mule-drawn vehicles over many tiresome miles of nearly impassable roads, fig. 47. Once at the shooting grounds there remained the task of digging a pit and placing the decoys, fig. 48. After a hard day's hunt, the hunter either camped out on a bare sand bar or faced a long return trip. Although there were more geese and fewer hunters in those early days, real skill was required to bag geese consistently because the goose range was extensive and the sand bars numerous.

Then, as now, silhouettes or "shadows," as they are called locally, were used to decoy the geese. Live decoys were seldom

Fig. 50.—Modern-day goose hunters in a typical pit at a day-shooting club adjacent to the Horseshoe Lake Game Refuge.

Fig. 51.—Typical goose blind in a soybean field near the Horseshoe Lake Game Refuge.

used until after 1906, when it became the custom to use three live decoys in combination with the silhouettes. The silhouettes were arranged in V-formation, with the apex of the V downwind from the pit. A live "caller" was placed at the vertex and at each end of the V. In between were the "shadows." Bait was not used, but, in order to induce the geese to work into the proper bar, hunters sometimes placed "scarecrows" on adjacent bars.

Improved roads and faster transportation brought goose hunting within the reach of the masses, fig. 49. Heavy competition for the better hunting places ensued. The demand for more hunting grounds resulted in the development of field shooting.

Long before baiting came into prominence, goose hunters recognized that no other type of feed was more attractive to geese than a large field of fall-planted wheat or rye. As soon as the weather turned cold, however, shelled and ear corn, wheat kernels, cowpeas, and similar feeds, when properly scattered, proved very attractive to the geese, although their desire for greens continued.

When decoys were used, the usual procedure was to construct a pen using a roll or two of 3-foot wire. In this pen were placed as high as 100 geese. Usually one or more geese were separated from their mates so that they would "talk" back and forth to each other. Another trick was to place a trained goose, which was wing-clipped, in the blind; the goose was then thrown from the blind and permitted to walk to the pen, "talking" to its mate in the pen as it went. If the first decoy failed to entice a wild flock within the range of the gunner, others were released from the pit until the wild geese decoyed as desired, or the supply of decoys was exhausted. Only a small percentage of captive geese behaved in such a manner as to make good decoys. These geese became as valuable an aid in goose hunting as well-trained bird dogs are in quail hunting, and commanded equally high prices on the market. The function of live decoys was to attract the geese, while that of feed was to hold them and to encourage the birds to return again.

One answer to increased hunting pressure was the formation of goose hunting

Table 10.—Goose hunting regulations as they applied to Alexander County, Illinois, 1927–1945.

YEAR	OPEN DATES (INCLUSIVE)	NUMBER OF DAYS	TIME[1]	BAG LIMIT	POSSESSION LIMIT	LIVE DECOYS	BAIT	MISCELLANEOUS
1927	10 1–1 15	106	*a*	8	None	Yes	Yes	
1928	9 16–12 31	106	*a*	8	None	Yes	Yes	
1929	9 24–1 7	106	*a*	8	None	Yes	Yes	
1930	9 24–1 7	106	*a*	4	8	Yes	Yes	
1931	11 1–11 30	30	*a*	4	8	Yes	Yes	
1932	10 16–12 15	60½	*a*	4	8	Yes	Yes	
1933	10 16–12 15	60½	*a*	4	8	25	Yes by permit	
1934	10 6–1 13[2]	30	*b*	4	8	25	No	Duck stamp
1935	10 21–11 19	30	*c*	4	4	No	No	Duck stamp, 3-shell law
1936	11 1–11 30	30	*c*	4	4	No	No	Duck stamp, 3-shell law
1937	11 1–11/30	30	*c*	5	5	No	No	Duck stamp, 3-shell law
1938	10 15–11/28	45	*c*	5	10	No	No	Duck stamp, 3-shell law
1939	10 22–12/5	45	*c*	4	8	No	No	Duck stamp, 3-shell law
1940	10 16–12 14	60	*d*	3	6	No	No	Duck stamp, 3-shell law
1941	10 16–12 14	60	*c*	3	3[3]	No	No	Duck stamp, 3-shell law
1942	10 15–12 13	60	*e*	2	4	No	No	Duck stamp, 3-shell law
1943	10 15–12 13	60	*e*	2	4	No	No	Duck stamp, 3-shell law
1944	10 14–12 12[4]	60[4]	*f*	2	4	No	No	Duck stamp, 3-shell law
1945	11 24–12/31[5]	38[5]	*g*	2	4	No	No	Duck stamp, 3-shell law

[1] Shooting permitted: *a*—one-half hour before sunrise to sunset; *b*—sunrise to sunset, except that in 1934 on baited grounds closing time was 3 P.M.; *c*—7 A.M. to 4 P.M.; *d*—sunrise to 4 P.M.; *e*—sunrise to 12 noon; *f*—one-half hour before sunrise to 12 noon; *g*—12 noon to 4:30 P.M.

[2] Two days a week.

[3] Three in any 7 consecutive days.

[4] Or season limit of 6,000 geese (actually 21 days); by agreement of clubs, season began October 28 and was closed November 17. Information from V. C. Conover, Game Management Agent, United States Fish and Wildlife Service.

[5] Or season limit of 5,000 geese (actually 5 days).

clubs, but since the time of the Egyptian Hunting and Fishing Club, organized in 1904, goose clubs have changed considerably in Alexander County. Present-day clubs, with a few exceptions, are strictly commercial. In contrast, this first club (which had annual dues of only $5) was a nonprofit organization. At one time, it boasted a membership of 50, all local hunters. In 1941, there were at least two dozen clubs in Alexander County, each of which, according to a direct comparison of kill records, killed more geese annually than did the Egyptian Club.

Goose hunting first took on a commercial aspect when in 1913 a Chicago business man began to lease the sand bars most frequently used by the geese. By 1916, most of these bars were no longer open to public hunting. Up to that time field shooting had been scorned by most real goose hunters. Now that the river shooting was largely under the control of a few men it was field shooting or nothing for the old timers.

The purchase of Horseshoe Lake for a refuge in 1927 created a boom in commercialization of goose shooting. Mediocre farm lands located near the refuge suddenly commanded fancy prices. Now almost every field located around the refuge contains pits and blinds during the hunting season, figs. 50 and 51.

Data obtained from veteran hunters on the number of geese killed along the Mississippi River in the eighties and later have been too contradictory to permit any definite conclusions. None of the information obtained, however, indicates that the kills made in those early years exceeded recent kills at Horseshoe Lake. A summary of hunting regulations as they applied to geese in Alexander County is given in table 10. The relationship between number of hours of open season, number of geese bagged, and hourly kill per season is shown in figs. 52 and 53.

Neither the hourly bag nor the seasonal bag shows significant correlation with the number of hours open to hunting.

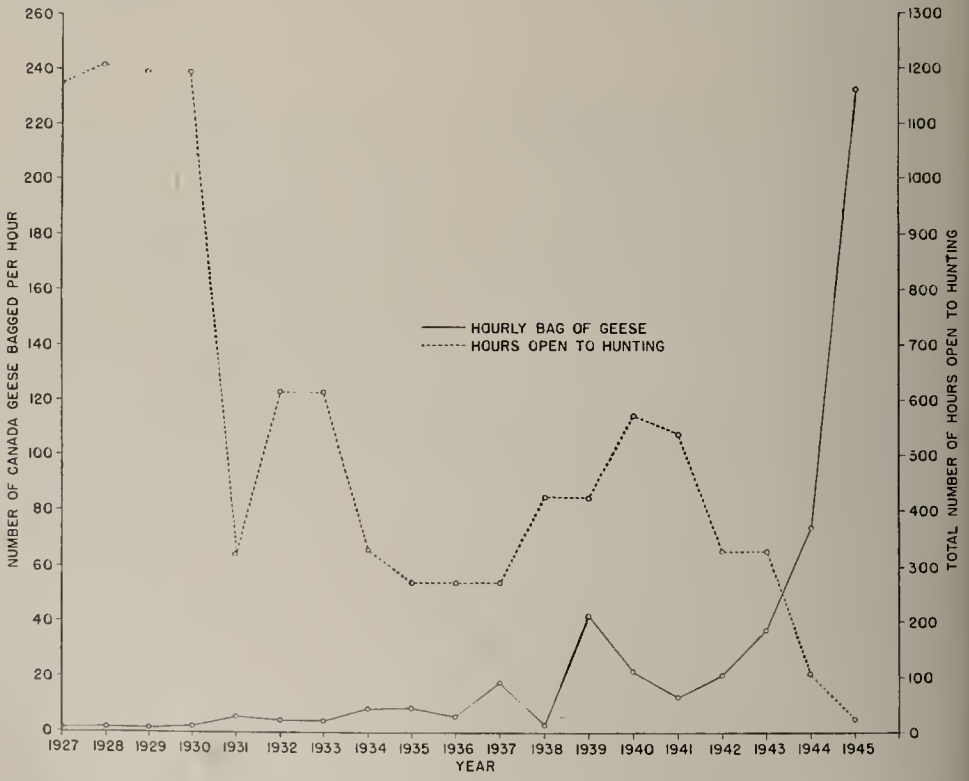

Fig. 52.—Hourly bag of Canada geese and number of hours open to hunting in Alexander County, Illinois, 1927–1945.

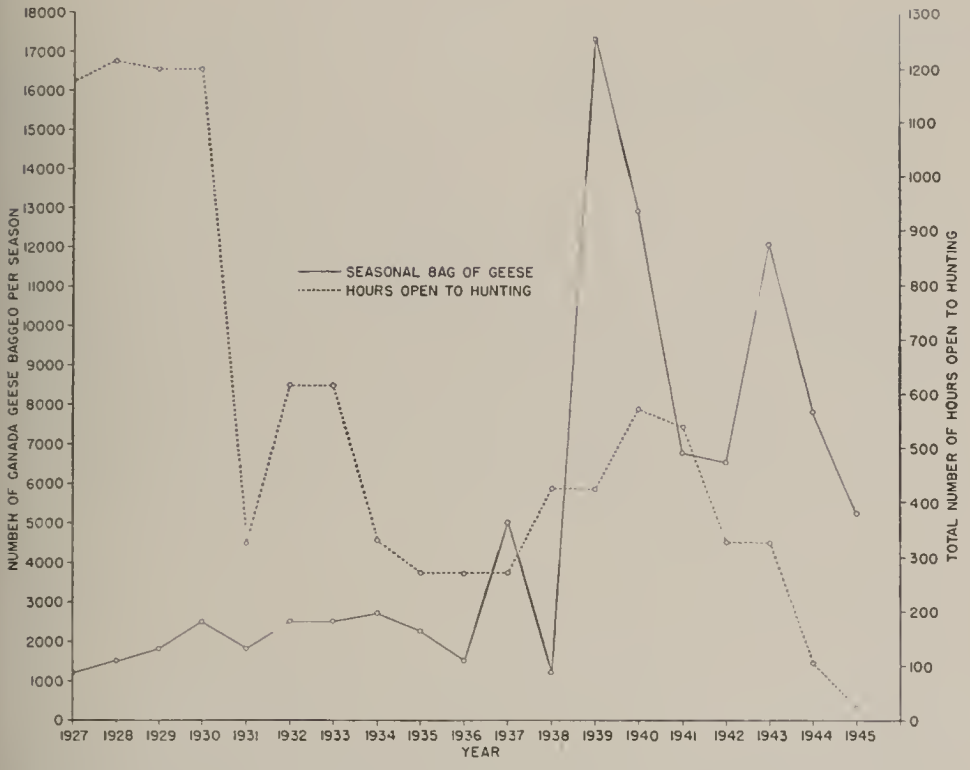

Fig. 53.—Seasonal bag of Canada geese and number of hours open to hunting in Alexander County, Illinois, 1927–1945.

ANNUAL BAG

In recent years the annual kill by hunters of Mississippi flyway Canada geese has probably exceeded losses resulting from any other single cause. The hunter kill includes the geese bagged and those so severely crippled by gunfire that they soon die.

Hochbaum (1944) has pointed out that the ratio of the number of hunters to ducks is such that it is mathematically possible for the licensed hunters legally to exterminate the continental duck population in one season. In the case of the Horseshoe Lake flock of Canada geese, the threat of extirpation has been real. If hunting in Alexander County, Illinois, had been permitted for the duration of the full 80-day waterfowl season either in 1944 or 1945, that population might have been reduced to a remnant, fig. 54.

Of all mortality factors, the bag by hunters is the one that can be most easily controlled to insure preservation of the Canada goose population. Insofar as management of Mississippi flyway Canada geese is concerned, the annual bag has two subdivisions: the bag made by Indians on the breeding grounds in Canada, and the bag made by hunters in southern Canada and the United States while the geese are in migration or in the vicinity of the wintering areas.

On Breeding Grounds

Man is believed to be the predator taking the heaviest toll of Canada geese on the breeding grounds. Responsible for the bulk of the take in the James Bay area are the Cree Indians, natives of the region; the handful of white residents also kill a few geese. Food is the primary consideration for killing geese in the North; any sport involved only adds flavor to the undertaking.

In the James Bay and Hudson Bay area the native populations are dependent on

waterfowl as one of the few reliable sources of meat; big game animals are usually scarce and small game is subject to violent cyclic fluctuations in numbers. The importance of waterfowl, particularly geese, to the Cree Indians in former

Fig. 54.—The registered kill of Canada geese (1,400) on opening day at hunting clubs near Horseshoe Lake in 1945 was approximately equivalent to the number of geese shown in this illustration. (Photograph taken at the Horseshoe Lake Game Refuge by George W. Sommers.)

years can be readily realized from Barnston's report (1862). He estimated the annual kills of all species of geese on the west coast of James Bay and the south coast of Hudson Bay as follows: Moose Factory district, 10,000 annually; York Factory and Churchill district and region to the north, 10,000; Fort Albany district, 17,000 to 20,000 in the autumn and 10,000 in the spring; Fort Severn district, 10,000.

The species of geese that made up the bag at these posts must have varied considerably then as they do today. We have no data regarding Churchill, but we conclude from Barnston's report that the white-fronted goose was shot in fair numbers by the Churchill Indians. It seems certain that snow geese and lesser Canada geese also contributed to the total kill in that area. In recent years at Moose Factory, Fort Albany, Attawapiskat, figs. 55 and 56, and Weenusk, the annual kill of geese has consisted chiefly of blue geese and snow geese, with Canadas running a poor third. At Fort York, the annual kill of Richardson's geese, *Branta hutchinsii,* equals the combined kill of snow, blue, and Canada geese; the Canadas are outnumbered in the native hunter's bag at this post by the "wavies."

Big game represents an unpredictable source of food for the present-day Indian. In the early part of this century, caribou,

Fig. 55.—Attawapiskat, Ontario, summer, 1947. The Cree Indians of the James Bay region gather at such coastal posts as this soon after the breakup of the rivers in spring. In late summer or autumn they return to their inland trapping grounds. Those who trap far inland leave before the autumn hunt for blue geese and snow geese begins along the coastal marshes.

Fig. 56.—Summer scene at Attawapiskat. After a long winter of arduous trapping and hunting, often entailing considerable hardship, the native Indians are usually content to summer quietly at or near the coastal trading posts.

perhaps the barren-grounds type, migrated along the west coast of Hudson and James bays as far south as Fort Albany. They are now gone except for a small band at Cape Henrietta Maria, which may represent remnants of this migratory group. Woodland caribou are found scattered over the muskeg country in small bands, but their total numbers are not great.

When the long and dreary winter has fully expended itself, and the willow grouse *(Tetrao Saliceti)* have taken their departure for more northern regions, there is frequently a period of dread starvation to many of the natives, who are generally at that time moving from their wintering grounds to the trading posts. The first note, therefore, of the large gray or Canada goose *(Anser canadensis)* is listened to with

Fig. 57.—Through the establishment of a system of preserves and regulated trapping, beaver populations in the Hudson-James bay region are gradually being restored to former levels. Besides furnishing many pounds of highly nutritious meat and thereby reducing the hunting pressure by Indians on waterfowl, beavers also improve the character of small streams as brooding areas for Canada geese. This illustration shows a beaver dam on Little Partridge Creek, which empties into the southwest corner of James Bay. The tall trees that border the stream are black spruce; the principal shrubs are willow, alder, and sweet gale.

Moose, always quite abundant in the country just south of James Bay, were scarce in the muskeg belt lying west of the bay until 1946 and 1947, when there was an unprecedented influx of these animals, presumably from the south and west. On the whole, however, except for the waterfowl he kills in spring and autumn, the James Bay Indian must rely on small game, such as snowshoe hares, muskrats, grouse, and ptarmigan for his meat supply. When these cyclic species fail he is usually in dire straits. Barnston (1862) wrote:

a rapture known only to those who have endured great privations and gnawing hunger. The melancholy visages brighten, and the tents are filled with hope, to which joy soon succeeds, as the happy father, or the hopeful son and brother, returning successful from the hunt, throws down with satisfaction and pride the grateful load.

Although the economic plight of the Indian has been gradually improved from those early times, particularly in recent years, through Dominion government family allowance, government relief, and liberal credit at the fur posts, the first

arrival of geese in the spring is always an event of great importance. Bishop Robert J. Renison of the Diocese of Moosonee relates one of the highlights of his early years as Anglican minister at Fort Albany. A funeral service had just been held at the small church and the mourners, cold, sick, discouraged, and hungry after a long winter, were moving on snowshoes toward the cemetery (Renison 1944).

The Missionary walked in front, treading warily among the tents where husky dogs prowled, on his way to the little grave yard where two men with pickaxes had been for hours chipping the frozen earth deep enough to make a shallow trench. Although in the morning the whole scene looked and felt like the ragged end of winter, now the South wind grows warmer every moment and already the haze is seen in quivering waves over the melting ice and snow.

As the cortege was lost in the maze of wigwams, suddenly the cry of wild geese was heard. The funeral procession stood still and from all over the settlement came the answering call from every living soul. A great flock of Canada grey geese swept like a gigantic airplane over the trees rejoicing at what seemed a welcoming call. The phalanx turned to leeward and sailed slowly down over the spot from which the sounds came. It was too much even for sorrow and decorum. The Chief Mourner dived into his tent and appeared in a moment with his loaded gun. With incredible ease and grace he brought down a goose with each barrel. Cheers and laughter rang out. The oldest instinct of man triumphed in every simple heart and as the pallbearers patted the bereaved husband on the back, he modestly replied like a true sportsman, "She did it. I always had luck when she was with me." Then the spell was broken; the procession resumed its direction.

The recent increase of beaver through restocking and the establishment of beaver preserves on the west side of James Bay will, now that trapping is open, add thousands of pounds of highly nutritious meat to the Indian food resources, fig. 57. Since beaver and most of the Canada geese are secured in early spring, beaver restoration will materially reduce the annual toll of geese. This shift in hunting pressure is reported to have taken place in the Rupert House country where beaver trapping has recently been on a sustained-yield basis.

The spring kill of the Canada goose west of James Bay takes place inland when the Indians are still on their trapping grounds and the rivers are frozen over. Hunting is done from blinds or stands built of brush and set out on the river ice. Decoys made of willow twigs or small stumps or blocks of wood of proper size are set up in such a way as to bear a crude resemblance to a flock of sitting geese, fig. 58. Often using inferior arms with hand-loaded shells, the native hunters easily overcome the handicaps of poor equipment by their expert ability to call geese, an art practiced from

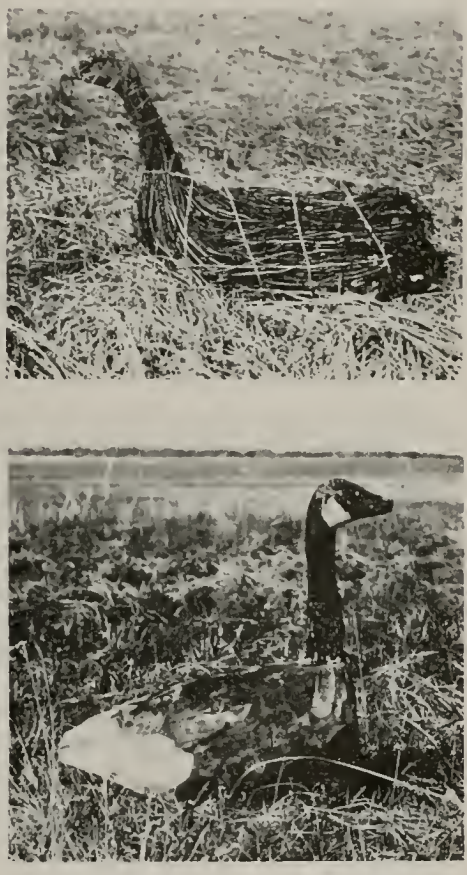

Fig. 58.—Decoys made by Cree Indians hunting in Hannah Bay at the south end of James Bay. The decoy in the top picture was made of willow twigs; the lifelike decoy in the lower picture was made from a log and a charred stick.

childhood. In late summer, some of the Indians supplement their meager diet by hunting ducks along the coast, fig. 59, while in autumn most of the hunters are in the coastal marshes for blue geese and native hunters with the aid of an interpreter, fig. 60. In some cases it appeared that the hunter questioned could remember his exact bag of the current year and of the previous year. In many other cases,

Fig. 59.—Indian encampment on Cape Henrietta Maria. The Indians of this group trade at the Lake River outpost, but visit Attawapiskat briefly in the summer. Before autumn, they return to the cape to hunt waterfowl.

snow geese, hoping to accumulate a supply of meat for at least a part of the winter. Any Canada geese killed at these times are incidental to the hunt for "wavies," as then the latter outnumber the Canadas along the coast by the ratio of many hundred to one.

Our bag data were secured from post managers and other informed residents and through direct questioning of the it was equally obvious that the hunter could remember only the approximate number of geese killed and bagged, as he gave figures in multiples of 5 or 10. The inherent tendency to exaggerate in giving "rounded off" figures introduces considerable error. Therefore, we believe that the data in table 11 may exceed the actual bag by perhaps 10 to 15 per cent.

A few Indians, fortunate enough to

Fig. 60.—The number of Canada geese killed by Indians was calculated from information secured through personal interviews with native hunters. The hunter being questioned here, with the aid of an interpreter, is a member of the Ogoki band. Sixteen hunters of this band were interviewed in 1946 and the same number the following year. The total number of Cree hunters interviewed was 94 in 1946 and 171 in 1947.

Table 11.—Number of Cree Indian hunters, average bag per hunter, and total calculated bag of Canada geese by native hunters residing in the breeding range of the Mississippi Valley goose population, 1946 and 1947.

Fur Trade Post and Indian Trapping Territory	Total Number of Hunters	Number of Hunters Interviewed		Average Bag per Hunter Interviewed		Calculated Bag per Trapping Territory	
		1946	1947	1946	1947	1946	1947
Ogoki	16	16	16	3.0	3.6	48	56
Fort Albany (including Kapiskau and Ghost River outposts)	100	24	67	9.5	11.1	950	1,110
Attawapiskat[1] (including Lake River outpost and Akimiski Island)	134	28	31	13.3	15.6	1,782	2,090
Weenusk	33	—	31	15.0[2]	19.0	495	627
Fort Severn	47	26	26	14.0	17.0	658	799
Total	*330*	*94*	*171*	*65.0*	*66.3*	*3,933*	*4,682*
Average				13.0	13.1	—	—

[1] The bag at Attawapiskat in 1948 was 1,720 according to Dr. John Honigman, resident anthropologist at the post that year (personal communication).
[2] An estimate, based on data for later year.

have their trapping grounds located in good Canada goose hunting territories, bag as many as 45 geese per hunter, while other Indians, located in poor goose habitat, take only a few geese or none. In 1944, when the inventory showed that there were approximately 66,000 geese in the Mississippi flyway, the estimated bag on the breeding grounds was 5,500, or about 8 per cent of the number of birds believed to have been available to the Indians in the spring of that year. In 1946 and 1947, the calculated bag, table 11, represented about 10 and 9 per cent, respectively, of the total population available in the springs of those years, table 7. Band recoveries, on the other hand, indicate that the annual bag of the natives is about 5 to 6 per cent of the available population. Taking into consideration the kind of error inherent in these data, it would seem that the Indians do not kill more than 10 per cent of the Canada goose population that reaches the breeding grounds in the spring.

The time of kill of Canada geese by Indians on the breeding grounds is indicated in fig. 61.

Southern Canada and United States

Available data on the goose bag in the United States and in southern Canada are very unsatisfactory. Goose bag records from Illinois are more nearly complete

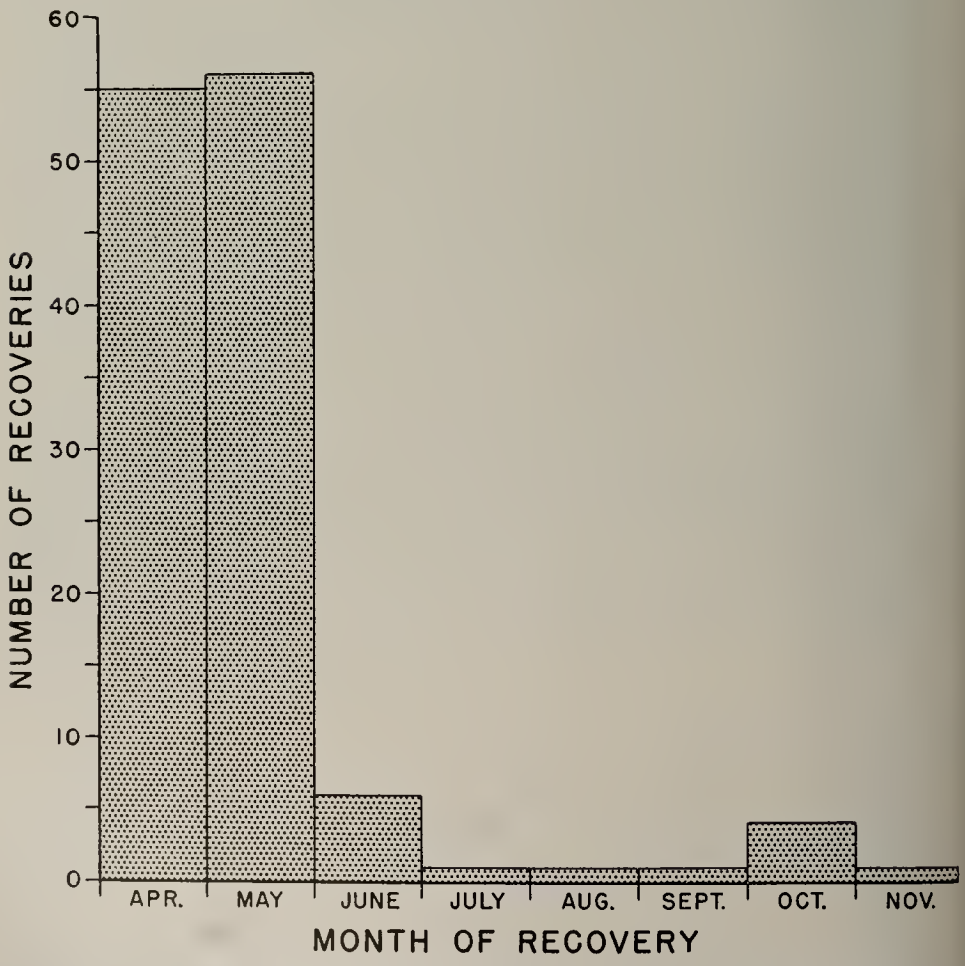

Fig. 61.—Time of kill of Canada geese by Indians on the breeding grounds, as shown by recovery records, 1941–1947, of geese banded at the Horseshoe Lake Game Refuge.

Table 12.—Estimated bag of Canada geese in regions frequented by the Mississippi Valley population, 1941–1945.

PROVINCE, STATE, OR OTHER AREA	LOW ANNUAL BAG	HIGH ANNUAL BAG	ESTIMATED MEAN BAG
West coast of James Bay	3,950	5,500	4,700
Ontario, exclusive of James Bay region	100	700	400
Minnesota	100	300	200
Wisconsin	450	850	620
Michigan	1,000	5,000	2,000
Indiana	1,000	2,000	1,500
Illinois	5,250	18,400	8,400
Ohio	?	?	200
Iowa	50	100	75
Missouri	150	400	260
Arkansas	200	400	300
Kentucky	25	100	50
Tennessee	50	150	100
Mississippi	50?	800	400
Louisiana (eastern part only)	?	?	150
Total	*12,375*	*37,700*	*19,355*

than those from any other state, in part because of a law that requires all licensed clubs to keep daily records of their take and in part because only a small number of areas in the state afford goose hunting. Most states in the flyway, however, attempt to calculate the take, either from report cards attached to the hunting licenses (the cards are designed to be mailed to a state official at the end of the season) or from data obtained from questionnaires sent to a sample of the licensed hunters. A few states make no attempt to secure bag data.

Bag data based on the hunter-report-card system are apt to be exaggerated. Studies made by Bellrose (1947) have shown that the state-wide bag of ducks in Illinois calculated from report cards is several times the actual bag. In Wisconsin, the calculated bag of Canada geese for two counties has been from 3.5 to 4.6 times the actual bag (see section on Wisconsin, below). Furthermore, as many states do not record the goose bag by species, the actual portion of the calculated bag that consists of Canada geese can only be estimated.

Table 12 summarizes our information on the Canada goose bag in recent years in those regions that lie in the Mississippi flyway. A more detailed analysis of the bag follows.

Southern Ontario.—In spite of the fact that the Miner Sanctuary, at Kingsville, in Essex County, has been a heavy concentration point for Canada geese for over 20 years, no commercial shooting clubs have operated in the fields surrounding the sanctuary. All of the hunting in the Kingsville area is reported to be flight shooting from public roads as the geese go to and from the sanctuary and their roosting grounds on Lake Erie.

The number of banded geese reported taken in this area does not indicate the true size of the bag since some of the local shooters do not appreciate the importance of the banding program at the Miner Sanctuary and do not report the bands they recover.

When live decoys and baited fields were permitted, the autumn bag in Essex County was about 1,000 birds, but, since these practices were outlawed, the bag has probably not exceeded 500 and frequently is as low as 200 or 300 birds. We are informed that the 1945 kill was unusually low, not over 50 geese.

We are told that near the Miner Sanctuary it is possible to bag geese easily only on days when there is a heavy overcast and a strong wind is blowing, thus causing the geese to fly low. On most days the geese are reported to be well out of gun range when they pass over the hunters who shoot on the perimeter of the protected area, the radius of which extends 1 mile beyond the sanctuary property.

Table 13.—Recoveries in the Mississippi flyway,* 1925–1944, of Canada geese banded each autumn and winter at Kingsville, Ontario.

State	Recoveries by 5-Year Periods								Total	
	1925–1929		1930–1934		1935–1939		1940–1944			
	Number of Recoveries	Per Cent of Total Recoveries	Number of Recoveries	Per Cent of Total Recoveries	Number of Recoveries	Per Cent of Total Recoveries	Number of Recoveries	Per Cent of Total Recoveries	Number of Recoveries	Per Cent of Total Recoveries
Michigan	8	8.4	36	13.0	30	18.6	57	19.5	131	15.9
Wisconsin	4	4.2	3	1.1	2	1.2	3	1.0	12	1.4
Minnesota	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Ohio	14	14.6	28	10.1	8	5.0	26	8.9	76	9.2
Indiana	13	13.5	15	5.4	9	5.6	28	9.6	65	7.9
Illinois	34	35.4	143	51.8	61	37.9	131	44.7	369	44.7
Iowa	0	0.0	0	0.0	1	0.6	1	0.3	2	0.2
Kentucky	8	8.3	23	8.3	15	9.3	11	3.8	57	6.9
Tennessee	7	7.3	12	4.4	13	8.1	13	4.4	45	5.4
Missouri	5	5.2	9	3.3	17	10.6	15	5.1	46	5.6
Mississippi	1	1.0	1	0.4	1	0.6	1	0.3	4	0.5
Arkansas	2	2.1	6	2.2	0	0.0	5	1.7	13	1.6
Louisiana	0	0.0	0	0.0	4	2.5	2	0.7	6	0.7
Total	*96*	*100.0*	*276*	*100.0*	*161*	*100.0*	*293*	*100.0*	*826*	*100.0*

* Recoveries made in central and eastern Ohio, Kentucky, and Tennessee would be at the expense of the Southeast population.

We have no data on bags elsewhere in Ontario, but recoveries indicate that relatively few geese are shot between James Bay and the Miner Sanctuary. According to Dr. C. H. D. Clarke of the Ontario Department of Mines and Resources, very little goose hunting is now carried out along the east shore of Lake Huron. Formerly the use of live decoys in this area provided fair shooting. The average annual bag of Mississippi flyway geese in southern and western Ontario is estimated to be about 400.

Illinois.—More Canada geese of the Mississippi flyway are bagged in Illinois than in any other state in the wintering grounds. Recoveries of Miner autumn-banded geese show 45 per cent from Illinois; recoveries of Horseshoe Lake bandings show 60 per cent from Illinois, tables 13 and 14.

Most of the geese bagged in Illinois are shot in the Illinois River valley and Alexander County; only a few geese are shot in other sections of the state. From a knowledge of kills at the principal goose-shooting clubs and from information gained through talks with sportsmen, Frank C. Bellrose of the Illinois Natural History Survey placed the average annual bag in the period covered by this report at 1,100 birds for the Illinois River region and the rest of the

Table 14.—Recoveries within the wintering range of the Mississippi Valley population of Canada geese banded at Horseshoe Lake, 1940–41 through 1944–45.

State	Number of Recoveries*	Per Cent of Total
Michigan	20	8.9
Wisconsin	23	10.2
Minnesota	2	0.9
Ohio	2	0.9
Indiana	7	3.1
Illinois	135	60.0
Iowa	5	2.2
Kentucky	3	1.3
Tennessee	2	0.9
Missouri	14	6.2
Mississippi	2	0.9
Arkansas	1	0.5
Louisiana	9	4.0
Total	*225*	*100.0*

* Exclusive of recoveries the season of banding. Table also includes several recoveries for which exact locality data were unknown. Bands recovered in Missouri were in counties close to Horseshoe Lake and were probably from geese belonging to the Horseshoe Lake flock.

Table 15.—Annual shooting losses of Canada geese in the region of Horseshoe Lake, 1941–1945.

Hunting Season	Reported Bag by Licensed Clubs in Alexander County	Estimated Bag on Non-Club Grounds in Alexander County	Bag in Cape Girardeau, Scott, and Mississippi Counties, Mo.	Total Number of Geese Bagged*	Crippling Loss at 30 Per Cent of Total Bag	Estimated Illegal Bag	Approximate Total Loss
1927				1,200			
1928				1,500			
1929				1,800			
1930				2,500			
1931				1,800			
1932				2,500			
1933				2,500			
1934				2,700			
1935				2,250			
1936				1,500			
1937				5,000			
1938				1,200			
1939	17,300	?	?	17,300			
1940	12,900	?	?	12,900			
1941	6,524	100	150	6,774	2,032	150	8,956
1942	6,279	100	150	6,529	1,958	150	8,637
1943	11,162	600	300	12,062	3,618	300	15,980
1944	7,157	250	400	7,807	2,342	400	10,549
1945	4,444	500	300	5,244	1,573	300	7,117
Total				*95,066*			
Total last 5 years	35,566	1,550	1,300	38,416	11,523	1,300	51,239

* Bags for 1927–1938 estimated by Paul S. Smith from information gathered from club owners and others familiar with the area. Bags for 1939–1945 from club records.

state exclusive of the Horseshoe Lake area. The bag figures for the Horseshoe Lake area, which are much larger, are given in table 15. On days when the geese traded back and forth between the refuge and outside areas, particularly when the food supplies at the refuge were exhausted, most hunters having blinds or pits near the refuge secured their limits.

Michigan.—Michigan is probably second only to Illinois in its take of Canada geese of the Mississippi flyway. More bands from autumn-banded Miner geese were recovered in Michigan, 1925–1944, than in any other state except Illinois, table 13. Also, band recoveries indicate that, during the past 20 years, Michigan has harvested increasingly larger percentages of that portion of the Mississippi flyway population that migrates between the Kingsville, Ontario, region and Lake Michigan.

Although hunters in Michigan are required to report their annual bags of geese, they are not asked to denote the species bagged. Consequently, the state-wide bags computed from hunter reports, table 16, include blue geese and snow geese, as well as Canada geese. Except for years when blues and snows linger on their flight south, Canada geese represent about two-thirds of the yearly kills, ac-

Table 16.—State-wide bag of all species of geese in Michigan, as calculated from hunter reports, 1938–1945. Data furnished by the Michigan Department of Conservation.

Year	Calculated Bag
1938	3,902
1939	6,635
1940	5,296
1941	5,921
1942	2,899
1943	6,567
1944	7,220
1945	23,129

cording to H. J. Miller of the Michigan Department of Conservation.

The figures given in table 16 are not comparable from year to year, because between 1938 and 1944 the number of licensed hunters sending in bag reports to the Department of Conservation dropped from 65 to 20 per cent. Because successful hunters are more apt to turn in their report cards than unsuccessful hunters, the accuracy of the computed kill varies from year to year. Excluding from table 16 the probable bag of blue geese and snow geese and taking into consideration exaggeration inherent in calculating statewide bags from hunter report cards, we estimate that the annual kill of Canada geese in Michigan from 1938 through 1944 was between 1,000 and 3,000 birds. In 1945, the total calculated bag of all species of geese was more than 23,000. Of this number, well over half consisted of blue geese and snow geese (Dr. Miles D. Pirnie of Michigan State College, personal communication) that failed to make their usual rapid southward migration and that were observed and shot in unusual numbers. The large number of banded geese reported shot in Michigan in the autumn of 1945 does, however, furnish undeniable evidence that there was a large increase in the total bag of Canada geese in that year over the number bagged between 1938 and 1944. Of 20 Canada geese banded at Horseshoe Lake between 1940–41 and 1944–45 and bagged in Michigan, table 14, 13 were bagged in the autumn of 1945.

The following Michigan counties, which are in the vicinity of important autumn concentration points and wintering areas, yielded the largest bags of geese of all species: Chippewa County in the northern peninsula; Leelanau County in the northwest sector of the lower peninsula; Huron, Tuscola, and Bay counties bordering Saginaw Bay; and Allegan, Kalamazoo, Barry, Berrien, and Calhoun counties in the southwestern lake section. According to Dr. Miles D. Pirnie of Michigan State College (personal communication in 1945) between 500 and 1,000 Canada geese were bagged within a 20-mile radius of the W. K. Kellogg Refuge, Barry and Kalamazoo counties, in 1944.

Various counties represented by 159 banded Canada geese shot in Michigan, 1925–1944, are shown in table 17.

Table 17.—Recoveries of Canada geese in Michigan, 1925–1944, banded at Horseshoe Lake, Illinois, and at the Jack Miner Bird Sanctuary, Kingsville, Ontario.

County	Number of Recoveries	County	Number of Recoveries
Allegan	31	Presque Isle	2
Berrien	16	Alpena	2
Barry	13	Benzie	2
Huron	12	Lenawee	1
Kalamazoo	12	Livingston	1
Calhoun	11	Otsego	1
Sanilac	10	Gratiot	1
Monroe	5	Gladwin	1
St. Joseph	5	Grand Traverse	1
Van Buren	4	Saginaw	1
Chippewa	4	Roscommon	1
St. Clair	4	Luce	1
Mackinac	3	Kent	1
Cass	3	Oscoda	1
Washtenaw	2	Lapeer	1
Wayne	2	Eaton	1
Newaygo	2	Lake	1
Total recoveries			*159*

Whatever the actual bag of Canada geese is in a given year in Michigan, it probably is not all at the expense of the Mississippi flyway population, as some geese belonging to the Southeast population undoubtedly are bagged as they migrate down the eastern edge of the state.

Wisconsin.—Band recoveries, table 14, indicate that Wisconsin is second only to Illinois in the toll its hunters take of the Horseshoe Lake flock. The largest kills of Canada geese in Wisconsin are made in Rock and Walworth counties, in the vicinity of the Rock County Refuge.

Geese in the Rock-Walworth county area show little of the tameness exhibited by the Horseshoe Lake flock. On leaving the refuge on the upland prairie for their roost lakes, they are said generally to spiral high up out of gun range before crossing over its boundaries, thus accounting in part for the relatively small kill, which is equivalent to about 8 per cent of the geese that are present in these two counties in late autumn and winter.

Careful estimates of annual bags in the Rock County Refuge area by personnel of the Wisconsin Conservation Department and the United States Fish and Wildlife Service, 1940–1945, did not exceed 400 birds; the average annual bag was considerably less. Wisconsin Conservation Department estimates for the probable and maximum Canada goose bags in these counties are as follows:

1940—200
1941—75, not exceeding 150
1942—317, not exceeding 400
1943—150, not exceeding 200
1944—40, not exceeding 50
1945—350, not exceeding 400

When the above estimates are compared with the bags calculated from hunters' report cards (1940, 732; 1941, 581; 1942, 1,445; 1943, 629), it appears that the annual calculated bags are exaggerated 3.5 to 4.6 times. These calculated bags are derived from a sample of the kill cards sent in by about 35 per cent of the licensed hunters. If the calculated state-wide bags reported by the Wisconsin Conservation Department are exaggerated to the same degree as are bags for Rock and Walworth counties (3.5 times), the corrected state-wide annual bag of Canada geese in Wisconsin between 1932 and 1944 has averaged about 500 birds and varied from about 170 (1935) to 860 (1942). If our method of estimating the state-wide bag is sound, it appears that the annual kill of Canada geese in Wisconsin has seldom approached the thousand mark.

Important kills have also been reported for Waushara County. The bag in this county in 1942 was estimated by Zimmerman (1942) to be 400. The total number of migrant geese that offered shooting to hunters in this area is unknown.

Minnesota.—Most of the Canada goose hunting in Minnesota is said to occur in the western third of the state, especially during the wet years. Kills in the eastern sections rarely occur, so that the total bag of the Mississippi flyway geese in Minnesota is probably small. The lack of band recoveries from eastern Minnesota substantiates this belief. From 1935 through 1944, the computed state-wide bags of all species of geese, based on reports received from 10 per cent of the hunters, ranged from 1,869 to 5,050 birds. As in Michigan, the 1945 calculated bag for all geese was the largest on record, 10,908.

Ohio.—We have few kill data for Ohio other than band recoveries. The principal kills of importance to Mississippi flyway geese would be those made in the region of Lake St. Marys. Kills made in central and eastern Ohio would be primarily at the expense of the Southeast flyway geese. We have arbitrarily placed the bag of Mississippi flyway Canada geese in Ohio at 200 per annum.

Indiana.—According to William B. Barnes of the Indiana Department of Conservation, goose hunting in Indiana is heaviest in the Kankakee region of northwestern Indiana and in the lake district to the east. As the flights move through northern Indiana to the southwest, additional shooting is provided in the Wabash River valley. Hunting pressure in this state appears to be, on the whole, relatively moderate. Of the total number of recoveries of geese banded at the Miner Sanctuary during the autumn in the past 20 years, approximately 8 per cent have been from Indiana, table 13.

At Hovey Lake Refuge about 300 Canada geese are generally present during the open hunting period, and the largest bag in any one season in a 5-year period, 1940–1944, was only five birds, 1.6 per cent of the flock. Partly responsible for this small bag was the wildness exhibited by the geese in the refuge vicinity.

Judging from questionnaire answers received from hunters by the Indiana Department of Conservation, it is doubtful if the kill of Canada geese in Indiana in recent years has ever greatly exceeded 2,000 birds and probably in most years the kill is considerably less than this figure.

Iowa.—According to Bruce F. Stiles of the Iowa State Conservation Commission, the yearly kill of Canada geese in Iowa is about 1,200 birds. He states that the heaviest migration is down the Missouri River valley. As band recoveries indicate that central and western Iowa is well west of the migration routes of the Mississippi flyway population, only a small portion of the above kill would be at the expense of this population. The paucity of band recoveries from eastern Iowa,

tables 13 and 14 and figs. 13–21, signifies that few Mississippi flyway geese migrating through this sector of the state stop en route long enough to afford much shooting.

Missouri.—The Missouri Conservation Commission estimates that, prior to the establishment of the Horseshoe Lake Game Refuge, approximately 75,000 Canada geese wintered on the sand bars and islands of the Mississippi River between Ste. Genevieve and Caruthersville, Missouri. Band recoveries, table 13, with the exception of returns from 1935 through 1939, indicate no pronounced change in the Missouri kills in relation to the Illinois kills since 1925. Before 1941, when the geese using the Horseshoe Lake Game Refuge were reported to have made daily flights to the river bars, considerably larger kills are said to have been made in Cape Girardeau, Scott, and Mississippi counties than in more recent years. Band-recovery data indicate that this period of higher kills was between 1935 and 1939. The yearly bags, estimated for the above counties by Paul S. Smith, are given in table 15. According to information received from M. O. Steen of the Missouri Conservation Commission, the annual bags in Missouri in the region of Cape Girardeau, Scott, and Mississippi counties averaged approximately 175 geese in recent hunting years.

State-wide annual bags, 1943–1945, are estimated to have been less than 400 birds. Besides the bag in southeastern Missouri, about 125 geese were killed on the Missouri River between Booneville and Jefferson City in central Missouri, and approximately 100 were killed in the vicinity of Swan Lake National Refuge in the north central part of the state. However, on the basis of present evidence, it would appear that the geese killed in central Missouri belong to the Eastern Prairie population and are not Mississippi flyway birds. Considerable numbers of Canada geese are reported to migrate through central and southwestern Missouri in the autumn, and it seems reasonable to conclude that they winter in western Louisiana and eastern Texas.

Kentucky.—Little information is available in regard to the state-wide kill in Kentucky, though band recoveries indicate that only the kills made in the western portion of the state would be from the Mississippi Valley population. Band recoveries show that since 1940 the annual bag of Mississippi Valley geese in this state has been greatly reduced, table 13. In 1939 and 1940, Paul S. Smith estimated that about 100 geese from the Horseshoe Lake flock were bagged in Kentucky; in more recent years, band recoveries and the findings of reliable observers indicate that very few geese from the Horseshoe Lake flock have been shot in Kentucky.

Tennessee and Mississippi.—The section of the Mississippi River bordering Tennessee, Arkansas, and Mississippi may be considered as a single unit insofar as the kill of Canada geese using the river bars is concerned. In 1943, it was estimated that not over 50 geese were killed on and in the vicinity of the Tennessee section. It is the belief of W. F. Dearman, formerly director of the Mississippi Department of Fish and Game, that the 1943 bag for his state along the Mississippi River was approximately 800.

Arkansas.—Kills of Canada geese in eastern Arkansas, exclusive of the Mississippi River, are made over such an extensive area and in such relatively small numbers in any given locality that it is difficult to make an accurate appraisal of the over-all loss. In 1943, the bag was about 400, and in 1945 it was probably even lower. After talking with hunters, employees of hunting clubs, and employees of local cold-storage plants, we concluded that the bag of Canada geese in the Stuttgart region in 1945 did not exceed 200.

Louisiana.—In 1943, losses of Canada geese through hunting in the delta and coastal marshes were estimated to be approximately 1,000. Of this number about 150 were estimated to be Mississippi flyway geese; the greater portion of the Canada goose population in Louisiana is in the western portion of the state and probably belongs to the Eastern Prairie population.

Total Annual Bag

Before sound management measures can be instituted for the Mississippi Valley Canada geese, the over-all kill in the population must be known within

fairly close limits. We do not have complete data on the kill, but a reasonably accurate appraisal can be made from available information.

Table 12, summarizing bag data contained in previous discussions, is fairly accurate in some instances and in others represents very rough estimation. It should be remembered that the lowest and highest bags for the various areas represented did not occur in the same calendar year; hence, totals for those respective columns do not represent annual extremes. It would appear from table 12 that the average annual bag in the flyway, 1941–1945, was somewhere in the neighborhood of 19,000 birds.

The annual loss of geese through hunting, expressed as a percentage of the population that left the breeding grounds in the autumn, may be roughly estimated* for the Horseshoe Lake flock and the flyway population as a whole.

The number of geese calculated to escape death from natural causes after leaving the breeding grounds and to be subjected to hunters' guns may be arrived at by adding known hunting losses to inventory figures after the hunting season. For example, the Horseshoe Lake flock numbered about 37,000 geese at the time of the 1943–44 inventory, table 9. Local losses in the Horseshoe Lake area, including crippling, were approximately 16,000 geese, table 9. Assuming that losses between the Canadian border and Horseshoe Lake were average that year, an additional 3,250 geese (2,600, a figure based on band recoveries, plus an assumed 25 per cent crippling rate) were lost.

The autumn kill by the Indians on the breeding grounds is small, fig. 61, as is also the kill by white hunters in southern Canada. Including crippling losses of 25 per cent, the combined kill may be in the neighborhood of 800 birds, about half of which would be contributed by potential Horseshoe Lake geese. Of the 37,000 geese leaving Horseshoe Lake in the spring, approximately 8 per cent are bagged by the natives plus an estimated additional 2 per cent lost through crippling, or a total of 3,700 geese lost. The estimated combined total of all hunting losses for 1943–44 was 23,350.

Inventory figures plus hunting losses for 1943–44 (omitting the spring Indian kill which occurs after the inventory) indicate that the Horseshoe Lake population that left the breeding grounds in the autumn of 1943, and subsequently eluded death from other causes during the following 6 to 8 months' period, was roughly 56,650. Thus, total losses through hunting (including spring losses in Canada) are computed to have been about 41 per cent of the geese that survived death from natural causes. When crippling losses are deducted, it appears that hunters bagged about 30 per cent of the geese that survived death from natural causes.

Over-all loss rates due to hunting for 1944–45 and 1945–46, calculated in a similar manner, were approximately 39 and 40 per cent, respectively, of the population that survived other types of mortality.

Hunting losses for the flyway population as a whole, as might be expected, were at a considerably lower rate than for the Horseshoe Lake flock. In some recent years, the bag of geese in the flyway has been about 19,000, table 12. In some of the same years, inventory figures, table 7, indicate an average population of approximately 60,000. If the bag prior to inventory (roughly 14,600) and the over-all crippling, arbitrarily placed at 25 per cent (total 18,250), are added to the approximately 60,000 surviving at inventory, an original population of 78,250 is indicated. Thus, of all flyway geese that survived natural mortality during recent hunting periods, at least 23 per cent are estimated to have succumbed to hunters.

Canada vs. United States Kill

Are the people of Canada, especially the Indians and Eskimos, getting an unjustifiably large share of the Mississippi flyway Canada goose population? Many hunters in the United States would like to believe that such is the case. However, investigators (Soper 1930, Sutton 1932, Brandt 1943, Gillham 1948) of bird life in the far north believe that in most instances the future of waterfowl populations in arctic and subarctic regions is not threatened by the kills made by the native

* Accuracy of the following estimations is in large measure dependent on the accuracy of inventory figures used in the computations.

peoples. It is their belief that the fate of waterfowl populations breeding in the north will be decided by the treatment accorded them on their wintering grounds. We likewise believe that the future of the Mississippi Valley population is dependent on the protection and care it is given south of the breeding range.

On the breeding grounds of the Mississippi Valley Canada geese, there has been a decrease, in recent years, in the number of Indians dependent upon the game resources of the country. After World War I, many of the Fort Albany Indians moved to new trapping grounds far into the interior. According to Dr. T. J. Orford, formerly Indian agent at Moose Factory, in 1945 there were 124 Indians from the Fort Albany band at Lac Seul, a locality to which they had moved in the 1920's. There was another exodus of Fort Albany Indians from the James Bay area in 1942 when 150 transferred to the Constance Lake band on the Canadian National Railway line. Additional Indian families moved down to Moosonee from Fort Albany and Attawapiskat during the years of World War II. As a result of these movements, Indian hunting pressure on wildlife in the James Bay area has decreased. In contrast, the number of hunters shooting Canada geese in the United States, notably in Illinois, has increased tremendously since World War I.

Data in table 12 show that the take in Canada, 1941–1945, was roughly 25 per cent of the total bag of Mississippi Valley geese. When it is remembered that the Indians are partly dependent on geese for survival, that their kill is not a new drain on the goose population, and that in recent years the kill has been found to be proportional to the goose population, this kill cannot be considered excessive.

The relative kill by the Indians and by hunters outside the breeding grounds in Canada and in the United States can be found by comparing the number of geese killed by each group to the total number of birds available to each. It was shown earlier that the Indians kill about 10 per cent or less of the goose population available to them. As the kill in Canada away from the breeding grounds is estimated as not exceeding 1 or 2 per cent of the population, the total Canadian kill is concluded to be 10 to 12 per cent of the population available in any year.

A rough measure of the bag contributed by the flock between the Canadian border and the Horseshoe Lake Game Refuge can be derived from an analysis of band recoveries. Between 1941 and 1944, the number of band recoveries from north of the refuge was equivalent to 33 per cent of the number of recoveries in the region of Horseshoe Lake 1 or more years after banding. The number of geese to terminate their migrations at Horseshoe Lake, 1941–1944, averaged about 45,000. The known bag by licensed clubs in Alexander County in those years averaged 7,780, table 15. Figures based on estimates from band recoveries in 1941–1944 indicate that the flock contributed an average yearly bag of about 2,600 birds before reaching the refuge, or a loss of about 5 to 6 per cent of the numbers that crossed the Canadian border. As the Horseshoe Lake flock in recent years has comprised about 50 per cent of the Mississippi flyway population, the bag of Horseshoe Lake geese (2,600) computed from band recoveries for areas between the Canadian border and the refuge should, if doubled (5,200),* approximately equal the bag of all Mississippi flyway geese in the same area. Calculations from data in table 12 indicate that the estimated mean annual bag for states in the flyway north of Horseshoe Lake (Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois,† and Iowa) for 1941–1945 is 5,695, a figure close to the bag figure approximated from band recoveries and from inventory figures and bag data from the Horseshoe Lake area. A check of band-recovery records for the period 1925–1944 shows that most geese bagged in this area were killed in November, fig. 62.

In the fall of 1943, when hunters between the Horseshoe Lake region and the Canadian border bagged between 5 and 6 per cent of the Mississippi flyway geese

* This figure, based on a comparison of band-recovery rates, may be low for two reasons: (1) the percentage of hunters reporting bands they recover is probably lower over most of the flyway than it is at Horseshoe Lake, where the importance of reporting bands has been well publicized, and (2) the geese that spend the greater part of the hunting season north of the refuge are subject to heavier shooting pressure in that region than are the Horseshoe Lake geese in the short time they are there.

† The figure for Illinois (about 1,100) does not include the bag for the Horseshoe Lake area.

available to them, hunters in the region of Horseshoe Lake bagged 23 per cent of the total number of geese attaining the refuge in the fall and winter of 1943–44. Figures for the Horseshoe Lake region, as calculated from data in tables 9 and 15, are 23 per cent for 1943–44, 19 per cent for 1944–45, and 18 per cent for 1945–46.

It is desirable at this point to discuss a type of rumor at times common among waterfowl hunters. During the 1944 hunting season, several hunters at Horseshoe Lake expressed the opinion that, if the ducks and geese needed further protection, the Indians in Canada should be prohibited from gathering and selling duck and goose eggs to a company manufacturing pancake flour. That this kind of complaint is an old story and has no basis in fact was shown by Grinnell (1901).

> Various explanations of the change [waterfowl decrease] are given. The blame is laid on the market shooter, on the supposed destruction of birds and eggs on the northern breeding grounds, and on supposed changes in the lines of flight by migrating birds, but most gunners are unwilling to accept the logic of events and to acknowledge that the principal cause of the lessened number of the fowl lies with the gunners themselves, and is an inevitable accompaniment of civilization, not to be changed except by radical measures. . . . .
>
> One of the most grotesquely fantastic explanations of the scarcity of wildfowl was put forth several years ago in the newspapers: . . . This story told of an enormous destruction of wildfowl eggs in the Northwest for commercial purposes; millions of shiploads and trainloads of such eggs, it was gravely related, being annually gathered in Alaska and British America, and shipped

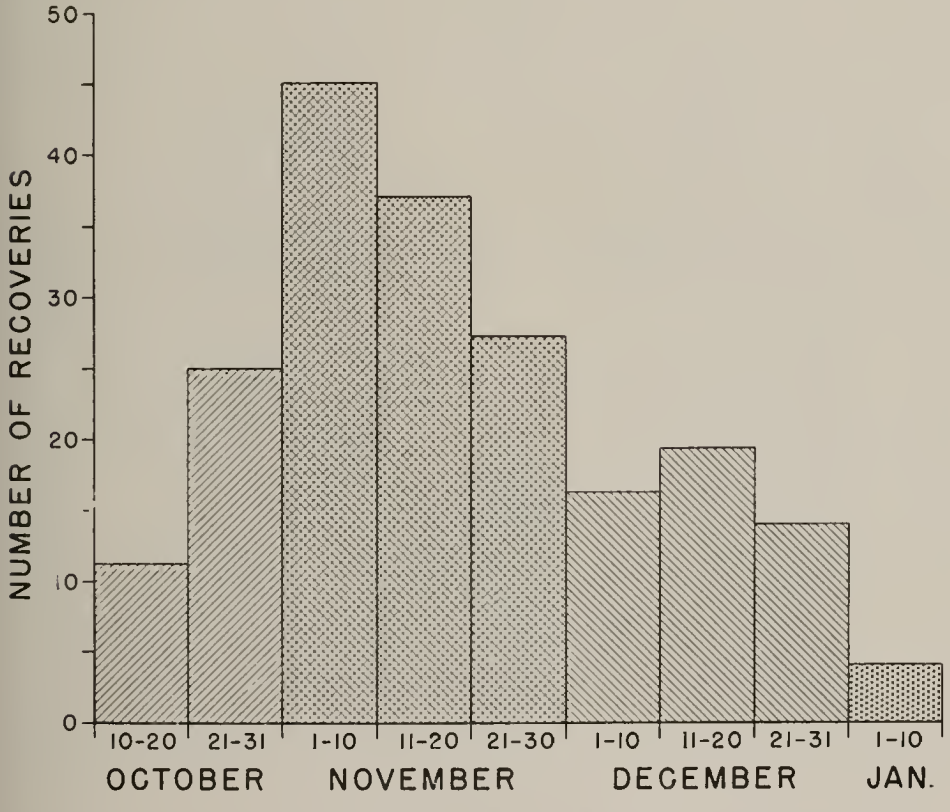

Fig. 62.—Time of kill of Canada geese in Wisconsin, Michigan, and Indiana, as shown by recovery records of Canada geese banded at the Horseshoe Lake Game Refuge and the Jack Miner Bird Sanctuary and recovered in the period 1925–1944. Migration dates and the time of most hunting seasons combined to make November the month of heaviest kill.

thence to points in the East, where they were manufactured into egg albumen cake. . . .

This, then, was the conclusion of the whole matter: Those who professed to have information on the subject were unable to substantiate the stories which they told; the transportation companies have carried no such eggs; none have ever been received at the ports of entry; the albumen trade knows nothing whatever about them, and in view of the total lack of evidence to support the story, there is no doubt that it is a pure invention.

DIFFERENTIAL HUNTING LOSSES

To manage a wildlife species that is subjected each year to heavy gun pressure, it is important to know not only how many individuals of a population are shot annually, but also if the kill in each of the various age and sex groups is proportional to its size in the group, and if the kill places an undue burden on any particular component. One of the causes of concern relative to Canada goose shooting at Horseshoe Lake in recent years has been the disproportionately large kill of juvenile birds, table 23.

What are the underlying factors responsible for a differentially heavier kill of the younger geese? One factor has already been mentioned, namely, the strong bonds existing between members of family units. Related factors are the fearlessness of young geese and their dependence on adults for guidance during their first year of life.

The relationship of juvenile age to unwary behavior in Canada geese was in-

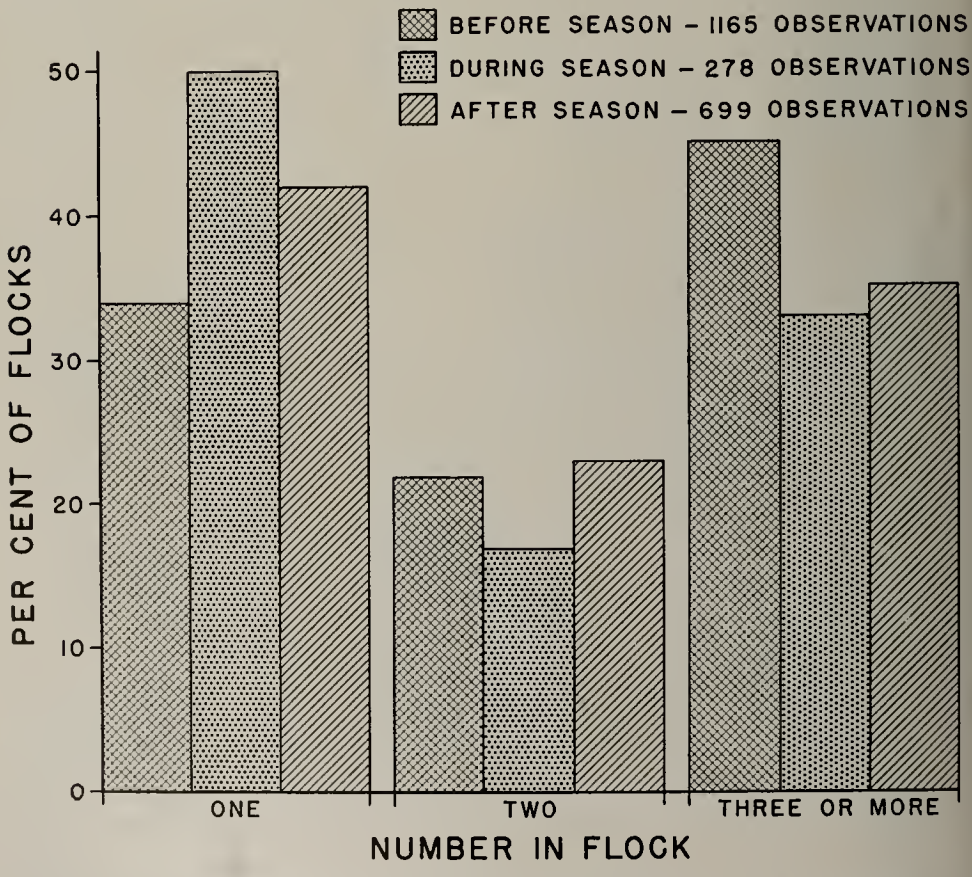

Fig. 63.—Percentages of each of three size-groups (single bird, pair, group of three or more geese) in the total number of flock formations of Canada geese observed before the season, during the season, and after the season at Horseshoe Lake, 1945.

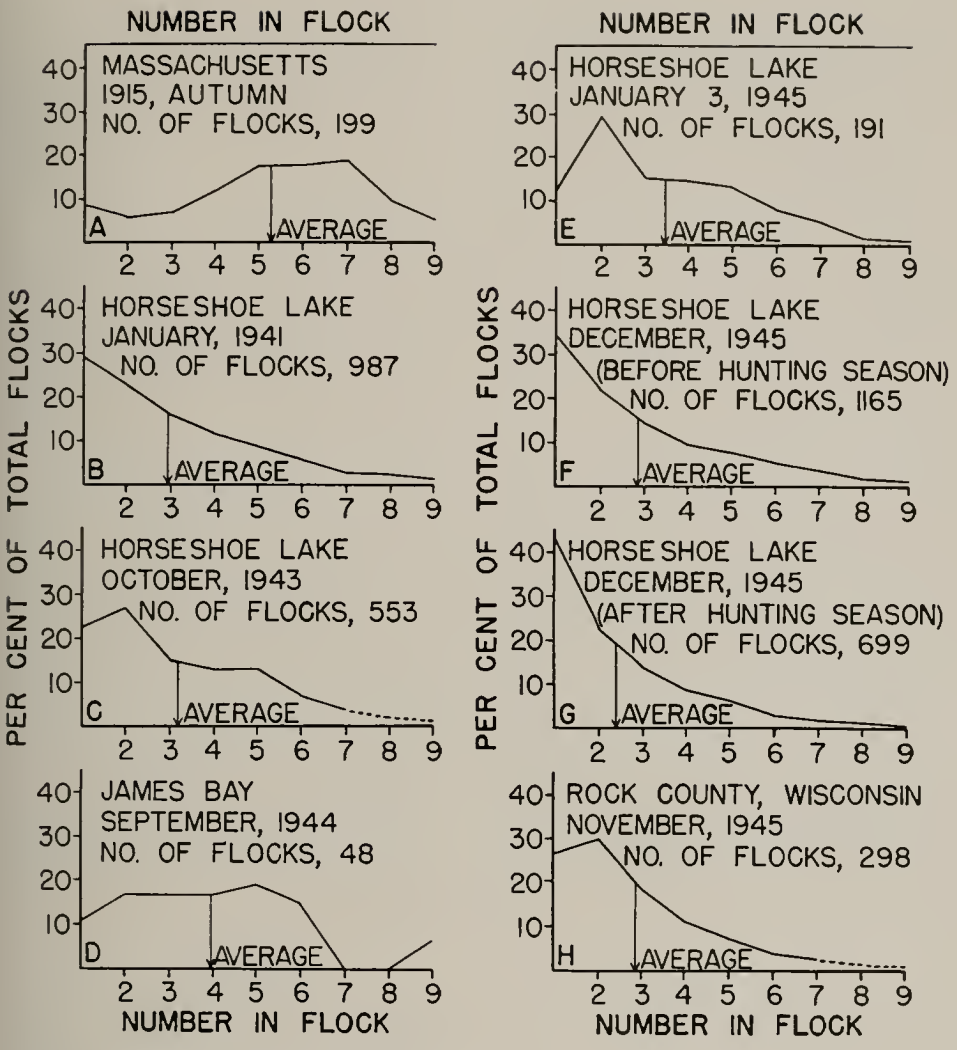

Fig. 64.—Frequency counts of flocks numbering nine or fewer geese and the average size of Canada goose flocks at four different locations.

timated by Phillips (1921). "It was remarked by Massachusetts gunners that there seemed to be a large proportion of young geese, and the same was true of Currituck Sound, N. C., where geese also appeared in unusual numbers and were very tame. The tameness of the geese in Massachusetts this past season caused comment everywhere, and I saw instances of it myself."

At Horseshoe Lake it was found that, as the shooting season progressed, the relative number of single birds increased because of the breaking up of family units, figs. 63 and 64*F*, *G*. Single juvenile birds separated from their families were frequently observed to associate and feed with other family units, as well as with unattached adults, but they were often at the bottom of the peck order, and, as they never appeared to be accepted into the ranks of other families, they often flew alone.

Every veteran goose hunter knows that single birds are "suckers," more readily decoyed than pairs or flocks. During the 1945 season, Arthur S. Hawkins, then with the Natural History Survey, and the

Table 18.—Number of Canada geese shot and size of flock from which they came. Observations at Horseshoe Lake in 1945.

Number in Flock Contributing to Kill	Number Shot From Flocks		Total Individuals Shot	Per Cent of Total Individuals
	One	Two or More		
One.....	139	—	139	50 0
Two.....	33	15	48	17.3
Three or more...	75	16	91	32.7
Total..	*247*	*31*	*278*	*100 0*

authors kept a tally of the geese observed killed at several Alexander County shooting clubs and recorded whether they were shot as singles, from pairs or out of flocks. The data gathered, table 18, show that geese shot as singles comprised 50 per cent of the total observed kill. Because single birds were outnumbered by individuals making up pairs and flocks, it is evident that they suffered a disproportionately large share of the kill.

In 1945, when examining bagged geese for sex and age, we asked each hunter whether the bird being checked was shot as a single, from a pair, or from a flock. Because of the two-bird limit, many hunters could easily remember the circumstances under which each of their birds was killed. In some instances we were able to examine geese that we had personally observed shot. The analysis of this portion of the total bag reveals that juvenile geese probably comprised 81 per cent of the number of geese shot as singles,

Table 19.—Age class of Canada geese and size of flocks from which they were shot. Data obtained from hunters at time of bag inspections in Alexander County, 1945.

Number in Flock	Age Class of Geese			Total Individuals
	Juvenile	Yearling	Adult	
One.....	78	6	12	96
Two	11	1	4	16
Three or more.	42	6	17	65
Total...	*131*	*13*	*33*	*177*

and that approximately 60 per cent of all juveniles bagged were flying alone when shot, table 19.

In most other years for which we have data, the juveniles contributed a disproportionately large share of the total kill, table 23. The extent to which juveniles were more vulnerable to shooting than older geese has been calculated from band-recovery ratios from these two age groups (see page 169). Sufficient data to indicate the approximate difference in vulnerabilities are available for only 1 year. In 1943, the vulnerability ratio in the Horseshoe Lake area was calculated to be 1.0 adult to 8.3 juveniles. Bag inspection data indicate that the ratio continued high in 1944 and 1945, table 23.

Further analysis of our band-recovery data reveals that young geese in their second spring of life, that is, on their return to the breeding grounds as yearlings, continued to be more vulnerable to hunters than the older birds, although the differential was not so great as at Horseshoe Lake. The vulnerability of yearlings compared with that of older geese is based on bandings and recoveries between 1941 and 1944.

The following formula was used to determine the relative vulnerability of yearlings and of older geese on the breeding grounds for the springs of 1942, 1943, and 1944.

$$\text{Vulnerability quotient } V = \frac{\dfrac{\text{Number of recoveries of yearlings from breeding grounds}}{\text{Number of handed yearlings (minus losses at Horseshoe Lake)}}}{\dfrac{\text{Number of recoveries of adults* from breeding grounds}}{\text{Number of banded adults* (minus losses at Horseshoe Lake)}}}$$

By substituting in the formula the appropriate data from our banding files for the years 1942, 1943, and 1944, we have the following equation:

$$V = \frac{\dfrac{75}{2415}}{\dfrac{20}{1804}} = 2.8$$

* Older than yearlings.

Our calculations indicate that the average yearling was about 2.8 times as vulnerable to hunting by the Indians on the breeding grounds as was the average adult (older than 1 year) in the springs of 1942, 1943, and 1944.

Since the bulk of the Indian kill is made from April 15 to June 1, fig. 61, 5 months after the close of hunting in southern Illinois, it would seem that experience gained by the young geese in that interval does not greatly reduce their vulnerability on the breeding grounds. A crucial period that immediately follows their abandonment by the adults results in continued vulnerability of the yearlings to gun pressure.

There is ample evidence that this abandonment occurs just prior to nesting. Unless broken up by shooting, family groups at Horseshoe Lake are often maintained throughout the autumn and winter period. From observations made at his sanctuary, Jack Miner (1923) believed that goose families do not break up until they reach the breeding grounds. This belief is substantiated by the Indians, who have observed that the young of the previous year are separated from the adults shortly before the breeding season. The breeding adults in the captive goose flock at the Bright Land Farm near Barrington, Illinois, according to Charles Kossack of Barrington, are similarly known to drive off their yearling young at nesting time. "Cast off" young geese are on their own, without the guidance of adults, and probably are associated at first in small groups.

One of the reasons for the differential vulnerability of the yearlings on the breeding grounds was suggested in 1946 by John Gunnar and Gilbert Faries, lifelong residents in the James Bay area and experienced goose hunters. They stated that, when the first geese arrive in the spring, many of them are very tame and curious. Gunnar volunteered the opinion that the first arrivals are the nonbreeding geese (yearlings). He recalled that on one occasion, while he was in the Partridge Creek area, a flock of inquisitive Canada geese decoyed within 10 feet of his head, and he expressed the belief that the white garment he wore at the time was responsible for their curious behavior.

Similar lack of wariness in the other species of geese has been noted. Brandt (1943) says of the white-fronted goose at Hooper Bay, Alaska: "And immediately after the lifting of the ice embargo these groups disintegrated into mated pairs, excepting *small* bunches of bachelor males. These free-lance gallants, often in company with like possibly rejected suitors of other species of geese, spend their time moving abstractedly around in inquisitive flocks, *and are ludicrously easy to decoy*."*

Of the blue goose, Soper (1930) writes: "With the breeding birds resuming, or commencing nesting duties large numbers of nonbreeding geese were left to fly aimlessly about in carefree existence during the brief span of the arctic summer. These were the restless and irresponsible flocks and individuals which from now on were to be observed in the Camp Kungovik locality."

The higher mobility of yearling geese as compared with that of nesting pairs is a factor that may make the young birds readily available to Indians. Nesting adults are known to be extremely wary and secretive, and, unless they are especially sought after, their presence may be known only by chance. Lack of wariness on the part of yearling geese apparently lasts until they begin to band together. In the summer, large flocks, believed to be comprised mainly of yearlings, are extremely wary.

CRIPPLING LOSSES

As crippling losses are a component of hunting mortality, they should be considered a part of the total yearly allowable kill in any game species. Whether a goose ends up on the hunter's table or dies of wounds and furnishes a banquet for some scavenging predator, the net loss to the flock is the same. Reduction of the crippling loss must always be an objective if maximum utilization of a game species is to be achieved.

For many years, waterfowl shooting has been known to produce a considerable loss of unretrieved cripples—a loss that is high

* Italics by the authors of this paper. Boardman Conover, who was in the Hooper Bay area with Brandt, has informed the authors that many flocks exhibiting this kind of behavior were composed of nonbreeding yearlings.

in proportion to the number of birds bagged. In most cases the crippling loss reported for ducks amounts to at least 30 per cent of the number of birds bagged and in some situations one duck is lost for every one bagged (Errington & Bennett 1933, Hawkins & Bellrose 1939, Baumgartner 1942, Hochbaum 1944). In Michigan about 10 per cent of 105 ducks trapped and examined carried shot (Whitlock & Miller 1947), but what percentage of these ducks died later as a result of the prolonged effect of carrying shot is not known. Recent fluoroscopic studies made by the Illinois Natural History Survey of ducks trapped at Spring Lake on the Mississippi River and at Lake Chautauqua on the Illinois River revealed that approximately 25 per cent of the mallards migrating through these areas carry lead shot in their bodies as a result of shooting.

Goose shooting at Horseshoe Lake, 1940–1945, resulted in crippling losses similar to those reported to occur in duck hunting. To anyone who observed the shooting at clubs bordering the refuge at Horseshoe Lake in the years of this study, it was apparent that the height at which a goose flew over the hunters seldom determined whether it was shot at. The situation was aggravated by the heavy concentration of hunters; hunters in the first line of pits or blinds attempted to "reach" approaching geese before the birds flew over the next line of pits. Novice goose hunters usually underestimated distances, while expert shooters, disgusted with the ease with which geese leaving the refuge could be killed, sometimes found sport in attempting to "scratch down" the high birds.

High shooting, some observers believed, saved large numbers of geese by frightening them off before they could fly within killing range. This was undoubtedly true during the early part of a season when the geese were not working out of the refuge in great numbers, or in years when low kills were made, but late in a season when geese were so numerous in flight over club grounds that the majority of hunters, even those who indulged in high shooting, got their limits, or in a year of high kill rate when the season was limited by a predetermined kill, high or indiscriminate shooting was a factor certain to cause needless crippling and increase the total loss.

In 1944, a questionnaire was circulated among goose hunters to obtain their own appraisal of their shooting. During the 21-day season, 103 hunters were asked questions about the following items: number of shells fired, estimate of geese lightly hit, number of geese severely crippled and not retrievable, and the number of geese bagged. An analysis of the accumulated data shows that the average bag per hunter-day was 1.69 geese. Since the average hunter success for all clubs in the vicinity for the entire season was 1.44 geese per hunter-day, it can be assumed that a fairly representative group of hunters was sampled.

The 103 hunters reporting estimated that with 1,374 shells they had bagged 286 geese and had severely crippled 51 geese; the number of geese crippled was equivalent to 18 per cent of the number bagged. This percentage probably represents the minimum crippling loss. The hunters reported that they had lightly hit an additional 176 birds, or a number equivalent to 61 per cent of the number bagged. Thus, according to their own estimates made the day of hunting or a day after, these hunters hit, with varying degrees of severity, and did not recover, a number of geese equaling 79 per cent of the number that they recovered. However, this figure is so high as to cast some doubt on its validity.

In 1945, Arthur S. Hawkins, then of the Illinois Natural History Survey, and the authors observed the shooting at several clubs and made on-the-spot tallies of the number of geese bagged and the number crippled but not recovered. The tally of crippled birds included only those that had been obviously and severely hit, but others may have suffered mortal body wounds without exhibiting a noticeable reaction to their wounds at the time of being shot. The hunters under observation bagged 253 geese but failed to recover an additional 62 badly crippled birds, most of them able to fly well enough to regain the lake within the refuge boundary, but so severely crippled as to be unable to survive the winter. Thus, in addition to each four geese bagged, ap-

proximately one additional goose died as a result of shooting—a minimum crippling loss of 25 per cent. At a few clubs the ratio of birds crippled to birds bagged frequently exceeded a ratio of one to one. Two instances of extreme crippling were observed: in one, four geese were crippled and none bagged, and, in the other, seven were crippled and six bagged.

From the various data presented above, we conclude that a conservative figure for the over-all loss owing to crippling at Horseshoe Lake is at least 30 per cent of the total bag. Crippling data are lacking from other areas in the flyway, but it is doubtful if the rate attained at Horseshoe Lake was exceeded. Where shooters are widely spaced and are not competing with each other to knock down the same high-flying birds, there is relatively less wild firing and hence less crippling.

Since crippling is more or less directly related to the number of shells fired, information was sought on the number of shells the average hunter expended to secure one goose. The hunters canvassed by questionnaire in 1944 reported that they fired an average of 4.8 shells per goose bagged.

In 1945, data of a similar nature were obtained by an examination of shooting pits at the end of the first day of hunting. Of the 42 pits examined at two club shooting grounds bordering on Horseshoe lake, the average pit contained 37 recently fired shell casings. As each of the hunters at these clubs killed his limit of two geese, and as no more than two hunters were permitted in each pit, the average number of shells fired to kill one goose on opening day in 1945 was nine.

How does this score at Horseshoe Lake, where goose shooting was relatively easy, compare with goose-shooting scores elsewhere? On the basis of his goose-hunting experiences in the West, Major Askins (1945), a noted authority on arms, believes that one goose to three shells, when distances are less than 80 yards, is about the best score an average hunter can expect. Most of his shooting was of the pass variety, and he states that it is doubtful if his score was better than one bird in four shots.

Geese wounded near Horseshoe Lake generally attempted to regain the lake either by flying or by eluding the hunter on the ground. Since hunters were not permitted to recover cripples that entered the refuge, club owners, at the opening of the 1943 season, were required to erect a 2-foot woven-wire fence between the pits and the lake to aid hunters in retrieving wounded geese that had been knocked down in the fields. Through this device, hunters secured a fair number of birds that would otherwise not have been recovered.

Crippled geese within the refuge were usually found apart from the flying birds, sometimes gathering in flocks of 10 or more. The strongest cripples swam about in the lake, where they sought shelter close to shore among the cypresses and snags, fig. 42, but the weaker ones rested on the lake shore. Few badly shot geese recovered from their wounds; many survived for a time, but in their weakened condition they became victims of predators. Raccoons consumed many dead geese (Yeager & Elder 1945). Although unable to catch healthy birds, these animals apparently sought out and killed many of the cripples, the remains of which were usually found along the shore line or on logs some distance from shore. A few carcasses were pulled under water and eaten by turtles. Skeletons of many geese have been observed on the lake bottom in years when cripple surveys have been made on ice. Undetermined numbers of geese sought shelter and died in parts of the lake that were inaccessible to man because of the large number of dead trees and fallen logs. Some cripples were caught by foxes and dragged into the woods on the refuge, where they were devoured; others died on hunting lands away from the lake. Consequently, a count of skeletons and carcasses around the shore line and on the island and club grounds represented only a portion of the total loss.

To determine at least the minimum number of unretrieved geese that died of wounds, counts were made of goose carcasses along both island and outer shore lines of the lake, as well as on the grounds of the principal goose clubs. The total counts of carcasses each winter, from 1940–41 through 1945–46, are given in table 20. Not all carcasses counted, of course, represented cripples that had died,

Table 20.—Number of carcasses of Canada geese counted on and near the Horseshoe Lake Game Refuge, 1940–41 through 1945–46.

SEASON	TOTAL CARCASSES COUNTED	GEESE FOUND DEAD PER 100 BAGGED AT LICENSED CLUBS AROUND REFUGE	INCLUSIVE DATES OF COUNTS
1940–41	466	3.61	January 19–20
1941–42	—	—	—
1942–43	421*	6.70	October 20–December 20
1943–44	1,048	9.39	December 17–28
1944–45	555	7.75	November 24–February 8
1945–46	648	14.58	December 6–31

* Estimated by W. H. Elder, then of the Illinois Natural History Survey, from counts on 10 sample quarter-mile strips of refuge shore line.

as some deaths were due to lead poisoning and disease. Data for the several years in table 20 are not directly comparable because the amount of outer shore line and the number of clubs surveyed for cripples varied annually. In general, coverage was increasingly extensive and thorough in successive years.

The legs and feet of the crippled geese, which seemed to be choice items of food to predatory animals, either were eaten where the birds were found or were carried off. A tally of 391 carcasses in 1945, a little over a month after the close of shooting, showed that only 21 per cent still retained both legs and that 5 per cent had but one leg. Many of these carcasses were fresh or only partially eaten when counted, and the number of legs eventually consumed by predators during the winter was estimated to be nearly 100 per cent. Because of the scarcity of legs, few carcasses yielded bands, a tally of which, when compared with the known kill and band recovery from hunters, would have permitted a fairly accurate appraisal of the crippling loss.

An analysis of our data on unretrieved cripples that later died indicates that adults succumb less quickly after being wounded than do juveniles. A week after the close of the 1944 season, during which 9.4 juveniles were bagged for every adult, the ratio of juveniles to adults found dead along the shore line of one club adjoining the refuge was 32:1. A month after the close of the season the ratio was down to 1.5:1.0. In a similar count a week after the close of the 1945 season, during which 4.1 juveniles were bagged per adult, the ratio of juveniles found dead to adults found dead was approximately 3:1.

MISCELLANEOUS MORTALITY FACTORS

Although no attempt was made to investigate all causes of death in the Canada goose population of the Mississippi valley flyway, a few mortality factors, in addition to shooting, were studied.

Lead Poisoning

Lead poisoning in Canada geese has been recorded from widely separated parts of the country: near Galveston, Texas; Currituck Sound, North Carolina (Grinnell 1901); Barry County, Michigan (Pirnie 1935); St. Clair Flats, St. Clair County, Michigan (Howard 1934); and Columbia County, Wisconsin (Adler 1944).

Because Canada geese are chiefly grazers, they are less apt to ingest lead shot than are ducks, which secure much of their food off the lake bottoms by straining great quantities of mud through their bills to extract seeds. Among geese at Horseshoe Lake, deaths resulting from lead poisoning were most frequently observed in late winter and early spring during the period of study. Mainly responsible for this seasonal mortality from lead was, of course, the great abundance of lead shot available toward the close of the hunting season on the surface of cultivated fields over which shooting had been heavy. Diminishing food supplies as the season

advanced increased the likelihood that geese would pick up shot in fields planted to winter wheat, one of their principal foods in the Horseshoe Lake area. In areas where the ground held much moisture and the wheat plant was devoured down to the roots, some soil and probably any shot that happened to be present were ingested. Geese at the refuge were observed to devour considerable quantities of soil at times, particularly in winter. In certain farmed feeding areas, holes as much as 6 or more inches deep and several times as wide were created by the geese in their ostensible search for food. This type of feeding increased the likelihood of the birds occasionally swallowing lead shot.

"Tip-up" feeding by Canada geese in the water of the Horseshoe Lake area was observed in late winter. This habit may have been a response to a reduced food supply on land. In 1942, a slough on the west side of the lake was a favored "tip-up" ground. Dr. William H. Elder, while with the Illinois Natural History Survey, when surveying this area for cripples, found 13 dead or dying geese on the ice or close to the shore line. Of 23 geese autopsied by Dr. Elder in late winter, 20 were found to have died of lead poisoning, 18 of these containing shot in their gizzards.

Paul S. Smith of the United States Fish and Wildlife Service, who conducted a series of tests on one of the most heavily shot club grounds, found about one lead shot per square foot of top soil, 1 inch in depth. Only the fact that the grounds of hunting clubs were cultivated each year prevented losses due to lead poisoning from assuming greater proportions. The potential danger from lead shot increased each year of the study, and the proximity of heavily shot fields to such an important concentration area as the Horseshoe Lake Game Refuge constituted a significant hazard to the geese wintering there.

Starvation

A Canadian Indian whose hunting grounds lie in the Lawapiskau River* country related that during late springs, when snow remained on the ground for some time after the arrival of Canada geese, he found dead birds that were in a very emaciated state, a condition that he attributed to a lack of available food. Because it is likely that, as a result of disease, lead poisoning, or crippling, a few geese succumb soon after their arrival on the breeding grounds, it is impossible to assess from this single report the importance of starvation as a cause of death in Canada geese. Nevertheless, there is some evidence that a food shortage in late spring may result in death of the weakest birds. In the second week of May, 1947, when the rivers and creeks were frozen and the country was still under several feet of snow, geese shot by Indians at the south end of James Bay were reported as having only willow catkins in their gizzards.

Bound Crop

Occasionally Canada geese were found in the vicinity of Horseshoe Lake in a thin, weakened state and with greatly distended crops. Examination of these individuals revealed that an impacted crop was often the primary cause of their condition, and, though operative measures were tried, few of these geese had sufficient stamina left to survive. Their crop contents usually consisted of a tightly packed mixture of wheat browse, corn,

Fig. 65.—Esophagus, proventriculus, and gizzard of a Canada goose found dead on the Bright Land Farm near Barrington, Illinois. Death in this case was due to lead poisoning from 38 shot found in gizzard. Food impaction is the result of lead poisoning, which often causes paralysis of the digestive tract in Canada geese and other waterfowl. (Photograph by Charles W. Kossack.)

* This river flows into James Bay 20 miles south of the Albany River.

and cowpeas, or soybeans, and frequently leaves and portions of the stems of the two legumes. In some of these, bound crop may not have been the direct cause of loss of weight and strength; instead it may have been the result of partial paralysis and weakness resulting from lead poisoning, fig. 65.

C. E. Laughery, formerly refuge manager at the Horseshoe Lake Game Refuge, informed us that geese with bound crops were most frequently found in years when several weeks after most of the local corn crop had been utilized or removed from the fields, fig. 66. While consumption by geese of shattered and otherwise wasted soybeans may seem desirable, these beans may sometimes have contributed to a number of deaths resulting from bound crop.

In the winter of 1943–44 in particular, Paul S. Smith, when surveying the vicinity of the refuge, found a number of dead geese, their crops tightly packed with soybeans. These birds were said to differ

Fig. 66.—Canada geese in a harvested soybean field near Horseshoe Lake, autumn 1946.

a considerable acreage on the refuge was planted to cowpeas. Cowpea fields attract large numbers of geese long after the bulk of the crop has been consumed. A few geese, while searching for peas, evidently consume fibrous and relatively indigestible portions of the plant. The presence of such material in the crops of geese may be responsible for impactions.

In recent years, soybeans were planted extensively in southern Illinois, and the geese tended to utilize this crop to a greater extent each year. There was frequently much wastage in harvesting these beans; many fields in the vicinity of Horseshoe Lake were not combined until an appreciable portion of the crop had been lost through shattering. As a result, beans in abundance were available to geese for from the crop-bound birds described above in that they were particularly heavy and fat. Probably in the winter certain geese fed more extensively on soybeans than on other foods and, as soybeans have a high protein and fat content, these individuals became heavier than the average goose of the area. Apparently these geese died after drinking water when their crops were crammed with beans. The pressure resulting when the beans imbibed water and swelled may have been the direct cause of death in such cases; the mechanism of the lethal effect is not known to us.

Geese frequently stuff their crops tight with corn, but in only one instance was corn suspected of being an indirect cause of death. This individual with an overloaded crop, fig. 67, became agitated in

Fig. 67.—The Canada goose is a voracious eater. This individual with an overloaded crop became frightened when a game technician entered the trap in which it had been caught. It had extreme difficulty in breathing and died a few minutes later.

the trap and died shortly thereafter, exhibiting the syndrome typical of anoxia.

Rough tests of the swelling properties of dry soybeans and corn revealed that the beans present a much greater hazard as food for geese than does the corn. Soybeans and corn were soaked in water for intervals varying from 30 minutes to 6 hours. Water displacement measurements showed that the soybeans increased their bulk at a rate approximately three times the rate corn increased its bulk. At the end of 3 hours, soybeans had increased their bulk by 85 per cent and corn by 30 per cent. These data and field observations suggest that soybeans and cowpeas may not be ideal crops to plant for the express purpose of providing food for wintering concentrations of Canada geese.

Predators

The red fox is probably the only predator at Horseshoe Lake that is capable of catching sound, healthy geese. Remains of geese found in cornfields late in the autumn point to predation by foxes, but probably most carcasses represented secondary predation involving birds crippled during the hunting season.

In each year covered by this study, a pair of bald eagles nested on the island in Horseshoe Lake, and both adults and juveniles were observed regularly throughout the autumn and winter periods. In the autumn of 1945, the eagle population on the refuge numbered at least five. Eagles were frequently seen feeding on crippled geese that had died, and in December, 1945, several eagles were observed by Paul S. Smith to attack a live goose (probably a weak cripple) that was frozen to the ice by its feet and breast feathers. Eagles were never seen to attack a sound, healthy goose.

Bald eagles are reported to feed on wounded geese in the Port Joli area of Nova Scotia, and never to be absent from the area as long as the geese remain (Tufts 1932). A discussion of predators on the breeding grounds will be found in the section on "Productivity."

Diseases

Only two diseases were investigated at Horseshoe Lake: tracheitis and aspergillosis.

Tracheitis.—In January, 1945, a number of geese trapped were found to have wheezy voices, indicative of a congested tracheal condition. Two of these birds eventually died, and the lungs and trachea of one were sent to the Department of Animal Pathology and Hygiene, University of Illinois, for examination. The cause of death was diagnosed as tracheitis, pulmonary congestion, and edema.

The symptoms of the disease as observed at Horseshoe Lake were a voice pitched higher than normal, a distinct "wheeze," and heavy, spasmodic breathing, accompanied by a forward throw of the head and open mandibles as the bird gasped for air, fig. 68. As the disease progressed, the effort attendant upon the intake of

Fig. 68.—Canada goose near death from tracheitis. Symptoms of this disease are a forward throw of the head and neck and gaping as the bird gasps for air.

air became increasingly spasmodic and violent because of the whitish exudate that accumulated in the trachea at the junction of the bronchi.

Both field experience and laboratory findings indicate that tracheitis is infectious, but the nature of the infectious agent is uncertain. Graham & Thorp (1931) have reported that a Canada goose from a farm flock had clinical symptoms analogous to acute laryngotracheitis in domestic fowl. However, autopsy of the goose revealed that the lung contained foci of mycotic pneumonia.

Aspergillosis.—The manifestations of aspergillosis in waterfowl have been adequately described by Phillips & Lincoln (1930). While outbreaks are known to occur occasionally in duck populations (Phillips & Lincoln 1930; Pirnie 1935; Bellrose, Hanson, & Beamer 1945), only one instance of its occurrence in Canada geese in the wild has been recorded previously (Dow 1943).

At Horseshoe Lake on November 7, 1946, a juvenile Canada goose was found in a much weakened condition. Within a day it was dead, and autopsy revealed that the typical nodules associated with *Aspergillus* infections were present throughout the body cavity, fig. 69, left. In December 1946, a second juvenile goose was found dead from an *Aspergillus* infection. Postmortem examination of this specimen by the Department of Animal Pathology and Hygiene revealed that the air sacs were partly, or in some cases completely, filled with a fungus growth, fig. 69, right, that upon cultural examination presented the characteristics of *Aspergillus fumigatus*.

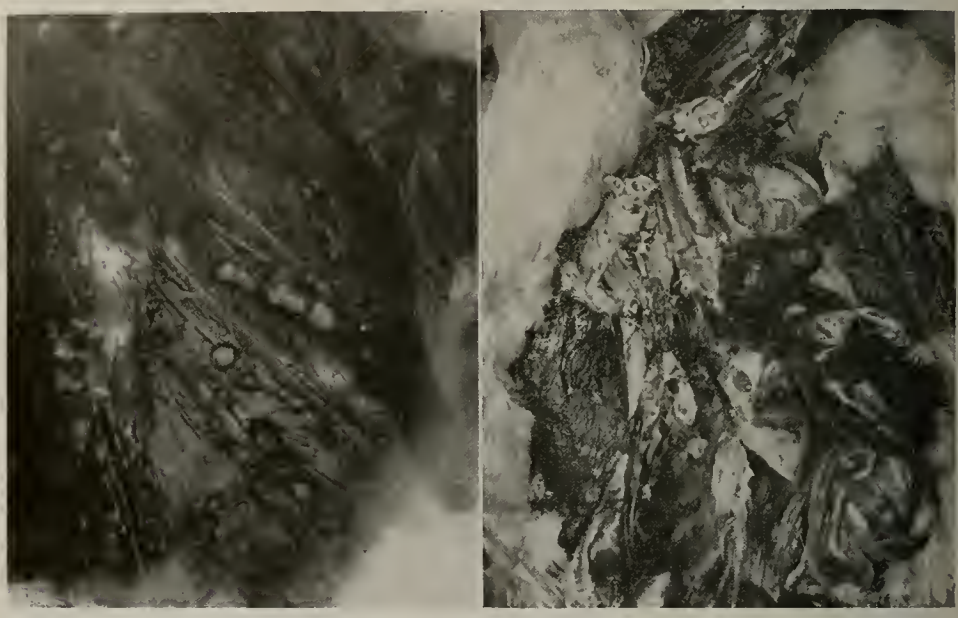

Fig. 69.—Aspergillosis in Canada geese. The nodules of *Aspergillus* infection shown in the illustration at left are on the lateral wall of the body cavity. In the goose shown in the illustration at right, the air sacs are the principal foci of infection. Both specimens were juveniles.

Parasites

Both internal and external parasites were taken from Canada geese wintering at Horseshoe Lake.

External Parasites.—Four species belonging to four different genera of chewing lice or Mallophaga were taken from Canada geese at Horseshoe Lake. Specimens of *Trinoton querquedulae* Linnaeus collected in the winter of 1945–46 were identified by Dr. Carl O. Mohr, then of the Illinois Natural History Survey staff. The following species, collected from a dead goose in 1934, were identified by R. O. N. Malcomson: *Anatoecus*

ferrugineus Giebel, *Esthiopterum crassicorne* (Scopoli), and *Ornithobius goniopleurus* Denny.

Internal Parasites.—Flukes were frequently encountered in the cloacae of Canada geese at Horseshoe Lake when examinations were made for sex and age. A number collected in the winter of 1945–46 were referred to Dr. L. J. Thomas of the Department of Zoology, University of Illinois, for identification. In his report he identified these specimens as *Echinostoma revolutum* and *Prosthogonimus* sp.; specific identification in the latter genus was impossible because of the poor condition of the specimen.

PRODUCTIVITY

It is important to know several months in advance the probable population of any game species at the start of a hunting season in order to determine what hunting restrictions will be necessary in that season. Populations of nonmigratory game can be estimated or inventoried before the hunting season more easily than can those of such migratory species as the Canada goose, which nests in comparatively inaccessible regions. Because of the length of time generally required before they can be officially approved, hunting regulations for migratory waterfowl must be decided upon while the actual size of the fall population is still an unknown. Thus, it is desirable to be able to forecast the population accurately from data obtained during the previous season. Forecasts can be made more easily for a population of limited size and distribution, such as the Horseshoe Lake goose flock, than for immense, continent-wide populations.

To interpret and predict population trends from flocks on their wintering areas, such questions as these must be answered: What is the age ratio, within the flock, of juveniles to adults? What are the survival rates of various age and sex groups? How long do geese live? How many or what percentage of a population attain breeding age? What is the ratio of males to females? Does a disproportionate kill occur in the various sex and age groups? Answers to these questions have been sought in studies of the Canada goose at Horseshoe Lake and on the breeding grounds, and in records of geese banded at the Miner Sanctuary.

Breeding Potential

The theoretical capacity of a species to produce young is determined by mating habits, age at reproductive maturity, ratio of males to females, and number of young produced per season. Information in the literature on these subjects is briefly summarized to aid in interpreting the significance of related data from the Mississippi flyway.

Mating Habits.—The Canada goose is monogamous and, judged from the habits of captives, fig. 70, remains paired to the same mate as long as both are alive. In captivity, individuals have been known to re-pair after the death of a mate (Montgomery 1938), although in some cases several years may elapse before remating takes place (Miner 1923). Remating experiments with Canada geese by Charles Kossack and Carleton Beckhart at the Bright Land Farm near Barrington, Illinois, have shown that a very high percentage of captives will remate the first spring following separation from their mates.

Reproductive Maturity.—At least 2 years are required for the Canada goose to reach sexual maturity in the wild, and in captivity the age of maturity is often 3 years and sometimes 4 (Dutcher 1885, Bailey 1913, Taverner 1922, Wilfrid 1924, and Forbush 1925). Studies made by the Illinois Natural History Survey of the semicaptive flock at the Bright Land Farm revealed that 25 per cent of the geese bred during their third year (Elder 1946).

Definite information on Canada geese breeding in the wild at 2 years of age is lacking. If the presence of an open oviduct is a sign of sexual maturity or an indication that eggs have been produced, data from Horseshoe Lake indicate that in the wild practically all females are productive at 2 years of age. However, until further information is available, inclusion of all wild geese in their third year of life in the breeding component of the population must be considered tentative. Of 54 females banded as juveniles and retrapped and examined at Horseshoe Lake in their

Fig. 70.—Female Canada goose and newly hatched young on the Bright Land Farm near Barrington, Illinois. (Photograph by Charles W. Kossack.)

second winter, all possessed closed oviducts (at about 1½ years of age); but of 18 females retrapped and examined in their third winter (at about 2½ years old), all but one possessed open oviducts (Hanson 1949*a*).

The duration of fertility is probably not a factor limiting the productivity of Canada goose populations, as captives have been known to raise young at ages that far exceed the length of life of most individuals in the wild, few of which live longer than about 5 years (see section on "Population Survival").

Sex Ratios.—Sex ratios of Canada geese as they were obtained from trapping and from bag inspection in the vicinity of Horseshoe Lake are given in tables 21 and 22. In the juvenile age class, trap data for the period of study indicate a slight but statistically significant excess of males; bag data, on the other hand, indicate no

Table 21.—Number of male and female juvenile Canada geese newly trapped and banded and number examined in bag at or near Horseshoe Lake, 1940–41 through 1946–47.

Season	Geese Banded			Geese Inspected in Bag		
	Total Number Banded and Sexed	Number Females	Per Cent Females	Total Number Inspected	Number Females	Per Cent Females
1940–41	143	68	47.6	213	110	51.6
1941–42	272	128	47.1	50	37	74.0
1942–43	619	284	45.9	549	254	46.3
1943–44	1,379	634	46.0	354	140	39.5
1944–45	607	272	44.8	379	184	48.5
1945–46	196	106	54.1	689	341	49.5
1946–47	296	102	34.5	—	—	—
Total	*3,512*	*1,594*	—	*2,234*	*1,066*	—
Average			45.4			47.7

significant variation from a 1:1 ratio. In the adult age class, according to trap data, there is a significant preponderance of males, but bag data fail to show a significant deviation from a balanced sex ratio.

Which of the ratios for the adults in table 22 more nearly represents the actual sex ratio for that age class in the population? Trap ratios might be more nearly correct because observations of banded birds (banded on left or right foot according to sex) feeding around the traps have revealed no greater wariness on the part of either sex. On the other hand, a preponderance of males would not be surprising, as a disproportionate loss of females could be expected to occur during the breeding cycle. The validity of the adult bag ratio as a representation of the actual sex ratio in the adult group is questionable because it indicates that the ratio of the sexes in this older age group is more evenly balanced than the ratios for the juveniles found from either trapping or bag inspection. The actual sex ratio in the adult population may lie somewhere between the two figures given in table 22.

Number of Young.—Five eggs represent about the average clutch size of the Canada goose in the wild, according to other observers. At Honey Lake, California (Dow 1943), 169 nests examined in 1939 contained an average of 5.09 eggs per nest, and 249 nests examined in 1940 contained an average of 5.10 eggs. A study of goose nesting at the Bear River marshes of Utah revealed an average of 4.88 eggs per clutch for 84 nests (Williams & Nelson 1943).

Table 22.—Number of male and female adult Canada geese newly trapped and banded and number examined in bag at or near Horseshoe Lake, 1940–41 through 1946–47.

Season	Geese Banded			Geese Inspected in Bag		
	Total Number Banded	Number Females	Per Cent Females	Total Number Inspected	Number Females	Per Cent Females
1940–41	170	81	47.6	55	22	40.0
1941–42	124	47	37.9	29	11	37.9
1942–43	404	187	46.3	212	104	49.1
1943–44	950	416	43.8	90	50	55.6
1944–45	246	82	33.3	40	20	50.0
1945–46	114	49	43.0	168	84	50.0
1946–47	205	67	32.7	—	—	—
Total	*2,213*	*929*	—	*594*	*291*	—
Average			41.9			48.9

The number of eggs produced by captives is surprisingly close to the production attained by wild birds. In 1942, 54 pairs of Canada geese on the Bright Land Farm produced 260 eggs, or an average of 4.81 eggs per pair. Several people experienced in raising Canada geese have stated that the number of eggs laid may vary with the age of the birds. Dutcher (1885) cites a game breeder on Long Island who claimed that 4 eggs are laid the first year of breeding, 5 the second, and 6 or 7 thereafter. Miner (1923) also states that "a young goose will lay four eggs the first year [of laying] and usually five the second."

Actual Productivity

The number of young birds brought to the flying stage is always somewhat less than the theoretical maximum. Fertility of Canada goose eggs is evidently high. In California and Utah, an egg fertility of 93 and 94 per cent, respectively, was found. However, flooding, predators, and other agents may destroy as high as 40 to 48 per cent of the nests in California (Dow 1943) and thus reduce production of young. Consequently, the annual production for all pairs that nest may average only 2.48 to 2.84 goslings per pair, or about 50 per cent of the number of eggs produced. In Utah, 84 nests studied yielded an average of 3.9 goslings per nest (Williams & Marshall 1938). Second nestings are sometimes attempted, a factor that would somewhat increase the average annual productivity per pair.

Information volunteered by the Indians at Moose Factory, Fort Albany, and Attawapiskat suggests that the red fox is the predator most destructive to Canada goose nests in the James Bay area. The extent to which foxes are harmful to goose nests is probably inversely related to the population levels of other prey species. In 1946, a year during which foxes were abundant, but snowshoe hares, muskrats, grouse, and ptarmigan were low in numbers, Indians reported finding many Canada goose nests destroyed by foxes. When interviewed in the summer of 1947, one Indian said, "The foxes are now low in numbers. Let's wait and see what kind of luck the geese have in raising young this year."

These attitudes by a native people, who are the keenest of observers, should be given careful consideration. Recent studies have generally confirmed the belief that predators have little effect in controlling the numbers of cyclic prey species, but in the case of Canada geese we are dealing with a bird that is normally of secondary importance as a prey species and that at present is not known to be cyclic. If geese and other waterfowl are subject to increased predation by foxes when these animals are at the peak of their cycle, it is conceivable that the numbers of waterfowl could be measurably affected by fox predation.

A few Indians that remain in the interior occasionally take goose eggs, but as the greater number of the Indians are at the coastal posts, fig. 55, during the nesting season, the importance of Indian predation is negligible.

Juvenile mortality in Canada geese appears to be small. In Utah a 3 per cent decrease in average brood size occurs over a period of a month (Williams & Marshall 1938). Little is known concerning predation on broods, but in one recorded instance in British Columbia ring-billed gulls devoured a brood of newly hatched goslings (Munro 1936).

The scarcity of natural enemies in the James Bay muskeg area normally insures small losses of goslings to predators; coyotes are absent, wolves almost nonexistent; lynxes, minks, martens, fishers, and otters are generally scarce, and wolverines are extremely rare. Probably foxes, abundant at the peak of their cycles, are predators of consequence only in years in which populations of snowshoe hares and other prey species are low. Great horned owls are fairly common and may account for the loss of a few young geese.

Data From Horseshoe Lake

The degree to which goose productivity measurements at Horseshoe Lake are a valid measure of the actual productivity of the Horseshoe Lake flock on the breeding grounds is dependent upon the magnitude of the losses between the James Bay area and Horseshoe Lake (see section on "Annual Bag").

The autumn kill by the Canadian Indians is small, fig. 61, so that, even if more

Fig. 71.—Type of trap used to catch Canada geese at Horseshoe Lake. Trap consists of eight wood and wire frames roofed over with twine netting and supported with guy wires. Open ends are closed off by tripping a pipe-weighted, twine curtain from a blind.

young than adults are killed in proportion to their numbers, the ratio of juveniles to adults in the flocks is not changed appreciably by the time the geese migrate southward. The scarcity of band recoveries between James Bay and southern Canada further indicates that the flocks are still largely intact when they reach the northern border of the United States. From fig. 38 it is evident that the majority of the geese have arrived at the Horseshoe Lake Refuge by November 1. As the bulk of the kills north of the refuge are made after this date, fig. 62, most of the flocks that arrive at the refuge have been only moderately depleted by shooting; band recoveries indicate that total hunting losses between the Canadian border and Horseshoe Lake are usually 5 to 6 per cent of the southward bound population. Because of the small migration losses in the population, the over-all ratio of young

Fig. 72.—Canada geese feeding into drop curtain trap at Horseshoe Lake.

to old in the flocks as they arrive in southern Illinois probably does not differ greatly from ratios existing at the time the family groups start their southward migrations; therefore, we believe that age and sex ratios at Horseshoe Lake furnish reasonably accurate measures of actual productivity ratios in most years.

Trapping data and data from bag inspection and band recoveries combined have been used in measuring production of the Canada geese wintering at Horseshoe Lake.

The age ratios of the geese caught in traps are believed to be fairly representative of the untrappd population for the following reason: No significant difference was observed in the wariness of geese of the various age classes as the birds entered the traps (many geese were color-banded to indicate age classes). Many catches consisted of individuals that had entered the traps, fig. 71, as parts of a busily feeding wedge; such catches would not represent selective trapping, fig. 72.

The ratio of juveniles to adults during the early part of the autumn no doubt differs to some extent from the ratio after the hunting season because of the proportionately greater kill of juveniles, table 23, but we are not able to demonstrate the extent of this difference from the data at hand.

The total annual catch since the winter of 1943–44, excluding repeats, includes a large percentage (5.4, 22.5, 42.7, and 30.0 per cent, table 1) of geese trapped and banded in previous years (trap returns), many of which are accompanied by their unbanded young. Therefore, the ratio of juveniles to adults among the newly banded birds, table 23, is not indicative of the age ratios in the flock as a whole, as it necessarily excludes the many banded adults that returned to the traps.

The ratio of juveniles to adults for entire-season catches is given in table 24. The figures for the season catches in this instance include the geese trapped in a specified season but banded in a previous season (trap returns) as well as the newly banded birds, but they exclude birds banded and retrapped in the same season (repeats). These data more nearly represent the actual juvenile-adult ratio in the flock than do the data on newly banded geese given in table 23.

Data from bag inspection are indicative of true flock ratios only when they are corrected for differential hunting vulnerability of the juveniles by means of trap and band-recovery data. Age ratios derived directly from band-recovery data do not accurately reflect the age ratios in the total population for the same reason that the age ratios of unbanded geese in the hunters' bag do not, namely, that the banded juveniles are shot more heavily in proportion to their actual numbers than are the banded adults. However, age ratios derived from band recoveries can be used to correct bag ratios for the disproportionate kill of juveniles as follows: (1) Determine the relative vulnerability to shooting of the juveniles and the adults. (2) Use the vulnerability quotient of the

Table 23.—Number of juvenile and adult Canada geese newly trapped and banded and number examined in bag at or near Horseshoe Lake, 1940–41 through 1946–47.

Season	Geese Banded			Geese Inspected in Bag		
	Total Number Aged	Number Juveniles	Per Cent Juveniles	Total Number	Number Juveniles	Per Cent Juveniles
1940–41	313	143	45.7	284	226	79.6
1941–42	398	274	68.8	79	50	63.3
1942–43	1,023	619	60.5	761	549	72.1
1943–44	2,329	1,379	59.2	173	158	91.3
1944–45	853	607	71.1	500	452	90.4
1945–46	310	196	63.2	857	689	80.4
1946–47	502	296	59.0	—	—	—
Total	*5,728*	*3,514*	—	*2,654*	*2,124*	—
Average			61.3			80.0

Table 24.—Productivity of the Horseshoe Lake flock as shown by trapping and bag-inspection ratios.[1]

Season	From Trapping					From Bag Inspection
	Total Number of Individuals Trapped of Known Age-Class and Sex[2]	Number of Breeding Adult Females Trapped[3]	Number of Juveniles Trapped	Juveniles per 100 Adult Females	Juveniles per 100 Yearlings and Adults	Juveniles per 100 Yearlings and Adults
1940–41	313	—	143	—	84	—
1941–42	408	—	274	—	204	—
1942–43	1,054	—	619	—	142	—
1943–44	2,462	—	1,379	—	127	126
1944–45	1,101	136	607	446	123	—
1945–46	541	88	196	223	57	—
1946–47	717	114	296	260	70	—
Total	*6,596*	*338*	*3,514*	*929*	*807*	
Average				325	114	

[1] See page 168 for explanation of reasons figures in this table differ from those in table 23.
[2] Numbers in this column include returns (geese banded in previous years).
[3] About 2½ or more years old at time of trapping.

juveniles to correct bag ratios for the disproportionate numbers of juveniles lost through shooting.

The vulnerability quotient of the juveniles is obtained by the following formula, suggested by Frank C. Bellrose:

$$\text{Vulnerability quotient } V = \frac{\dfrac{\text{Number of band recoveries from juveniles}}{\text{Number of juveniles banded before end of hunting season}}}{\dfrac{\text{Number of band recoveries from adults}}{\text{Number of adults banded before end of hunting season}}}$$

Data that are perhaps numerous enough to use in determining the vulnerability of the juveniles as compared with the vulnerability of the adults are available only for the 1943 hunting season.

In 1943:

$$V\,\frac{\text{Juvenile}}{\text{Adult}} = \frac{\dfrac{81}{754}}{\dfrac{6}{466}} = 8.34$$

According to these calculations, at Horseshoe Lake in 1943, the juveniles were 8.34 times as vulnerable to shooting as were the adults. With this figure available, it is possible, assuming the vulnerability quotient to be a true measure of vulnerability of the juveniles, to correct the age ratios obtained from bag inspection, which, by virtue of the higher vulnerability of the juveniles, is weighted in favor of this group as compared with the adult group in the total surviving population.

To correct age-ratio data obtained from bag inspection, it is assumed that the following formula is true, in which V is the vulnerability quotient calculated above from the trap and hand-recovery data.

$$\text{Ratio } \frac{\text{Juveniles in population}}{\text{Adults in population}} = \frac{\text{Number of juveniles in bag}}{\text{Number of adults in bag} \times V}$$

To solve for the juvenile-adult age ratio in the surviving population in 1943, the proper values from table 23 and the calculated V above are substituted in the formula.

$$\text{Ratio (1943)} \frac{\text{Juveniles}}{\text{Adults}} = \frac{158}{15} = \frac{10.53}{8.34} = 1.26$$

Then the corrected age ratio is 1.26 juveniles to 1.0 adult.

The ratio of juveniles to adults found above from corrected bag ratios for 1943 is close to the age ratio found from trapping for 1943 (127 juveniles to 100 adults, table 24). Over a 7-year period the juvenile age class comprised about 53 per cent of the birds in the Horseshoe Lake flock, table 24.

Not only is it important to know what percentage of the flock is composed of juveniles each year for a significant analysis of productivity; it is important to know also the production of young in relation to the number of mature females—birds that are 2½ or more years old when wintering at Horseshoe Lake. By relating productivity to only the sexually mature females, compensation can be made in statistical analyses of the flock for annual changes in the percentage of nonbreeding yearlings as well as for changes in ratio of adult males to adult females.

These productivity figures will be at variance with the impression that the average hunter gets from the flock at Horseshoe Lake. This hunter, on viewing the impressive concentration of geese at Horseshoe Lake, thinks that the total number of mated pairs in the flock in the following spring will equal the total population divided by two. Since he has heard that geese annually lay 5 or 6 eggs, he assumes that there will be an impressive increase for the next hunting season, and, thinking in terms of himself, anticipates more shooting. When informed that the flock may be even smaller in numbers at its peak in the autumn than it was at the close of shooting the previous year (as actually happened in the autumns of 1944 and 1945), in spite of the young added to the flock as a result of the breeding season, he may be dubious as to the competence of his informer.

The layman often fails to take into account the fact that Canada geese do not

Table 25.—Age and sex composition of the Horseshoe Lake flock, 1944–45 through 1946–47, as shown by trap catches of unbanded and previously banded geese.

Age and Sex Classification	Season						All Seasons	
	1944–45		1945–46		1946–47		Total Number Trapped	Per Cent
	Number Trapped	Per Cent	Number Trapped	Per Cent	Number Trapped	Per Cent		
Adult males[1]								
2½ years or more	212	19 3	118	21.8	221	30.8	551	23 4
1½ years (yearlings)	96	8 7	75	13.9	44	6 1	215	9 1
Total	*308*	*28.0*	*193*	*35.7*	*265*	*35.9*	*766*	*32.5*
Adult females[2]								
2½ years or more	136	12 4	88	16.3	114	15 9	338	14.3
1½ years (yearlings)	50	4 5	64	11.8	42	5.9	156	6.6
Total	*186*	*16.9*	*152*	*28.1*	*156*	*21 8*	*494*	*20.9*
Juveniles								
Males	335	30 4	90	16.6	194	27.1	619	26.3
Females	272	24 7	106	19.6	102	14.2	480	20.3
Total	*607*	*55 1*	*196*	*36.2*	*296*	*41.3*	*1,099*	*46.6*
Grand total	*1,101*	*100 0*	*541*	*100.0*	*717*	*100.0*	*2,359*	*100.0*

[1] Aging techniques separating yearling males from males 2½ years old or older in fall and winter, about 85 per cent accurate.

[2] Aging techniques separating yearling females from females 2½ years old or older in fall and winter, about 90 per cent accurate.

breed until they are at least 2 or 3 years old, and that at least one-half of the birds he sees will still be sexually immature in the spring; that an excess of males exists in the birds of breeding age, table 25; that members of broken pairs may be slow to mate; that some pairs each year are not successful in rearing a family; and that natural losses as well as the Indian kill are taking place in the intervening months. The actual number of sexually mature females upon which production in the coming spring is dependent may comprise only a small segment of the winter flock, in some years as low as 12 to 17 per cent, table 25.

A rapid method of distinguishing yearlings from older geese, for use on live birds in the field, was not developed until the fall of 1944 (Hanson 1949*a*). Since the more nearly complete data from 1944–45 through 1945–46 were collected during and after hunting seasons in which higher rates of loss occurred among juveniles than among adults, the actual ratios of juveniles to breeding females existing *before* the shooting began would be somewhat higher than those indicated in table 24; the trap ratios in table 24 differ from the indicated ratios or percentages in table 23 only in the respect that the ratios in table 24 are based on the entire catch (exclusive of repeats) rather than on newly banded birds alone.

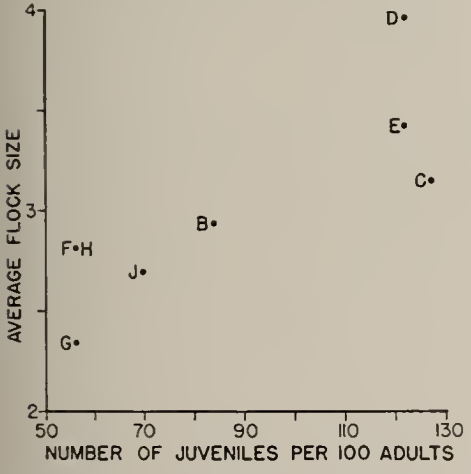

Fig. 73.—Relation of average flock size to productivity. Note that the average size of flocks in southern Wisconsin after light hunting losses was identical with the size of average flocks at Horseshoe Lake prior to hunting. *B-H* were derived mainly from data in fig. 64 and table 24. *J* represents data for 1946–47, shown in table 24 but not in fig. 64.

Theoretical vs. Actual Productivity

Data in the literature and from the captive flock at Bright Land Farm indicate that each pair of Canada geese would produce about 5 juveniles annually if all eggs laid were fertile, if all hatched, and if the young were raised to maturity without loss. Actual annual productivity, however, as indicated by the average brood sizes found in Utah and California, appears to be in the neighborhood of 3 to 4 young per nesting female or per pair. We have computed the ratio of juveniles to breeding females in the Horseshoe Lake flock as found from trapping. It was assumed that all females are sexually mature at about 2 years of age. The productivity of these females was computed from figures in table 24 to be, in 1944–45, 4.46, in 1945–46, 2.23, and, in 1946–47, 2.60 young per adult female.

Flock Sizes

Several decades ago, Phillips (1916) recorded his observations on the sizes of goose flocks in Massachusetts and presented evidence to show that in most instances these flocks were single families or groups of families. For flocks of less than 10 individuals, groups of six and seven individuals were most numerous; for flocks numbering between 10 and 30, groups that were multiples of five were most frequent. Unbroken families as large as 10, two adults and eight young, have been observed by the Miners at their refuge.

Flock counts have been made at Horseshoe Lake since 1941. Our analysis of these counts is limited to flocks of nine or less in number, because in this area a group of nine birds is the largest that we have observed to behave as a family unit. All individuals in this family, which were color-banded and of known age and sex, were repeatedly observed or trapped together.

Family-flock sizes at Horseshoe Lake and other areas for which we have data are shown in fig. 64. The frequency with which each family-flock size occurs is ex-

pressed as a percentage of the total observations.

From these data we suggest:

1. That the average family-flock size in late summer or early autumn may furnish a rough index of the age ratio within a large population, fig. 73; from this ratio the success of nesting the previous spring may be inferred, *A* and *D* in fig. 64.

2. That the average family-flock size in middle or late autumn, when compared with similar data gathered the same year before the opening of the hunting season, is indicative of the degree to which family groups have been broken through shooting. (Compare *F* and *G* in fig. 64.)

POPULATION SURVIVAL*

One of the objectives of the Canada goose research program reported in this paper was to determine through trapping and banding the annual mortality rate and the average longevity of Canada geese in the Horseshoe Lake flock in the period 1941–1946 and to compare the annual mortality data derived from the banding at Horseshoe Lake with similar data derived from the banding of Mississippi flyway geese at the Jack Miner Sanctuary in the period 1925–1944.

Definition of Terms

In the following discussion, *age class* refers to a group of geese, all of them hatched in a given year. A *banding class* includes all geese banded in a given season regardless of age at time of banding. The computed percentage of geese of a banding class alive each year in a series of successive years following banding comprises a *survival series*. This series may be computed from data in a *band-recovery series* (recoveries of bands from birds reported dead in any of several successive years after banding) or from data in a *trap series* (returns of banded birds to the traps in any of several successive years).

* The senior author is responsible for this section. As he carried out the trapping program at Horseshoe Lake and the compilation of the Miner recovery data in Ottawa, Canada, he is fully conscious of the inadequacies and bias in the data on which the following discussion is based. These inadequacies and bias do not permit the data to be treated by the customary methods. The methods used by-pass some of the shortcomings of the data, but, in the final analysis, the results presented only produce an approximation of the true picture. The reader should bear this point in mind in evaluating the results presented. It was deemed advisable to exploit the data as far as possible rather than disregard them altogether because of an acute awareness of their vagaries.

Table 26.—Hypothetical catches of Canada geese to illustrate difference between a trap series and a return series.

Season	Number of Geese Banded	Number of Banded Geese Returning			
		From 1 Year Ago	From 2 Years Ago	From 3 Years Ago	From 4 Years Ago
1942–43	*80*				
1943–44	100	*40*			
1944–45	100	55	*20*		
1945–46	**100**	**50**	**25**	***10***	
1946–47		50	25	10	*5*

NOTE.—The trap series is represented by boldface figures, to be read horizontally from left to right; the return series is represented by *italic* figures, to be read diagonally from left to right.

The difference between a trap series and that which we are here calling a *return series*, a series used by Leopold *et al.* (1943) to compute longevity and population turnover in ring-necked pheasants, is shown in table 26. The per cent of annual decrease in a population is here referred to as the *annual mortality rate*. The per cent of the population surviving from any 1 year to the year following is the *survival rate*. The *survival index* is the average of the survival rates for the first 3 years after banding.

Mortality

Survival rates or mortality rates in waterfowl may be computed from banding data by using either trap returns of survivors or band recoveries from dead birds. Reliability of calculations in either case increases as the number of bandings increases.

Mortality rates in the Horseshoe Lake flock were calculated from data obtained from both trap returns and band recoveries.* In juvenile-banded birds, mortality rates for the first year following banding were computed from age ratios derived from trapping and from census data.

Mortality Calculated From Trap Returns.—Mortality rates of the Horseshoe Lake flock as obtained from trap returns were derived both from returns of birds banded as juveniles, and therefore

* In the computations included in tables 34–41, band recoveries from the breeding grounds are not included because often the years of recovery are not known with certainty.

Table 27.—Approximate mortality of juvenile Canada geese during the first year after banding (year 0–1) at Horseshoe Lake, as determined by censuses and age ratios from trapping, 1943–44 through 1946–47.

Year Class	Estimated Size of Horseshoe Lake Flock*	Per Cent Juveniles in Trap Catches (See Table 24)	Calculated Number of Juveniles in Flock	Per Cent Yearlings in Trap Catches (See Table 25)	Calculated Number of Yearlings in Flock	Per Cent Survival of Juveniles of Previous Year
1943–44..	53,000	56.0	29,680			
1944–45..	40,500	55.1	22,316	13.2	5,346	18.01
1945–46..	29,100	36.2	10,534	25.7	7,479	33.51
1946–47.	31,000			12.0	3,720	35.31
Total...			*62,530*		*16,545*	
Average						26.46

*Method of estimating flock described on page 119. Per cent of error in censusing would be approximately the same for each year.

of a known age class, and from returns of birds of all ages, tables 27–33. They are based on the assumption that the number of individuals from each age class and banding class that return to the traps in any trapping season is approximately proportional to the total number alive of those same age and banding classes in the entire population. Thus, when trap returns in the same year of any two or more age or banding classes of geese banded in previous, successive years are expressed as percentages of each of the respective original bandings, the difference between these percentages is a measure of annual mortality. Average mortality rates in tables 30 and 33 are weighted averages based on data from bandings and trap returns in all years represented.

The method of deriving the weighted survival series is explained in footnotes to tables 29 and 32. The difference between successive survival series figures is a measure of annual mortality.

When the numbers of geese of different but successive banding classes retrapped in any one later year are expressed as percentages of the original bandings, annual mortality rates, tables 30 and 33, can be calculated by the following formula:*

$$\text{Per cent mortality for year 1} = \frac{\text{Per cent returns in year 1} - \text{Per cent returns in year 2}}{\text{Per cent returns in year 1}}*$$

Because this method of computing mortality rates involves measuring the difference between the rates at which samples of two age or banding classes banded in successive years return to the traps in a later year, it cannot be used to compute mortality during the year of banding.

Age ratios secured from trapping at Horseshoe Lake, table 27, are perhaps sufficiently representative of the population to be useful in calculating the approximate survival of geese in their first year of life. It has been noted, however, that geese that have been attracted to the traps and banded as juveniles are more apt to return to the traps as yearlings the following year than are the geese banded as adults or yearlings. This tendency often

Table 28.—Trap returns of Canada geese banded as juveniles at Horseshoe Lake, 1940–41 through 1946–47.

Season	Number of Juveniles Banded	Returns in Designated Year Following Banding						Total
		1–2	2–3	3–4	4–5	5–6	6–7	
1940–41	143							
1941–42	274	1						1
1942–43	619	8	2					10
1943–44	1,379	67	13	3				83
1944–45	607	87	20	7	2			116
1945–46	196	106	35	8	5	0		154
1946–47		39	56	16	7	3	2	123
Total	*3,218*	*308*	*126*	*34*	*14*	*3*	*2*	*487*

* Year 1 in formula represents any banding year except year of banding (as 2-3 in table 29); year 2 represents the next successive year (as 3-4 in table 29); returns for the same trapping season are used in making calculations, as 3.23 and 2.55 for 1944–45, table 29.

results in catches that are composed of disproportionately large numbers of banded yearlings in relation to the actual numbers of this age class in the untrapped portion of the population, with the result that calculated mortalities for yearlings, although seemingly very high, may be below the rates that actually occur in that age group in the unbanded segment of the population.

In table 28 the actual number of trap returns from geese banded as juveniles at Horseshoe Lake is given, and in table 29 these numbers have been converted into percentages of the original bandings. For example, 67 geese banded as juveniles in the trapping season of 1942–43 and 13 geese banded as juveniles in the season of 1941–42 were trapped in the winter of 1943–44, table 28. Expressed as percentages these returns were 10.82 and 4.74 per cent of the original bandings (619 and 274, respectively), table 29.

The survival series figures in tables 29 and 32 were derived from the weighted average per cent returns of geese of consecutive year classes, beginning with year 1–2 (first trapping season after year of banding). Tables 28, 29, and 30 include only juvenile-banded geese; tables 31, 32, and 33 include both juvenile-banded and adult-banded birds.

A more nearly accurate picture of survival in age classes than that given by table 29 begins with the 26.46 year-of-banding survival figure, table 27. Survival in subsequent years was derived from the weighted average per cent returns in table 29 through the formula explained in footnote 4 of that table; the survival series figure for the year previous to year 1–2 is assumed to be 26.46. For example, 9.57 : 4.17 :: 26.46 : x; x is 11.53, the survival series figure for the year 1–2. The entire survival series is 26.46, 11.53, 3.90, 3.73, 1.99, 3.87, fig. 74. The weighted average survival rates, as calculated from this survival series by the method suggested

Table 29.—Trap returns of Canada geese banded as juveniles at Horseshoe Lake, expressed as percentages of original bandings, 1940–41 through 1946–47.

Season	Per Cent of Geese Returning in Designated Year Following Banding					
	1–2	2–3	3–4	4–5	5–6	6–7
1940–41	—					
1941–42	0.70					
1942–43	2.92	1.40				
1943–44	10.82	4.74	2.10			
1944–45	6.31	3.23	2.55	1.40		
1945–46	17.46	2.54	1.29	1.82	0.00	
1946–47	19.90	9.23	1.16	1.13	1.09	1.40
Weighted average per cent returns[1]	9.57	4.17	1.41	1.35	0.72	1.40
Weighted survival series, no. 1[2]	51.40	22.40	7.57	7.25	3.87	7.52
Weighted average survival rates, no. 1[3]	51.40	43.58	33.79	95.77	53.38	194.32
Weighted survival series, no. 2[4]	43.57	14.73	14.10	7.52	14.62	—
Weighted average survival rates, no. 2[5]	43.57	33.81	95.72	53.33	194.41	—
Survival index, 42.92[6]						

[1] Total of weighted average per cent returns, 18.62. Figures in this category were derived from table 28. The total number of trap returns for each year is expressed as a percentage of the total number of bandings they represent. For example, 308 (returns for year 1–2) equals 9.57 per cent of 3,218 (bandings, 1940–41 through 1945–46); 126 (returns for year 2–3) equals 4.17 per cent of 3,022 (bandings, 1940–41 through 1944–45).

[2] Figures in this category were derived by finding what per cent the weighted average per cent returns for each year are of the weighted average per cent returns for all years involved (18.62). Example: for year 4–5, the figure 7.25 was derived by finding what per cent 1.35 is of 18.62. The indicated increase for year 6–7 obviously is based upon insufficient data.

[3] The figure in this category for year 1–2 was derived as explained for the figure directly above it. Figures for subsequent years were derived by finding the per cent of survival from year to year, as indicated by the weighted survival series no. 1. Examples: 22.40 is 43.58 per cent of 51.40; 7.57 is 33.79 per cent of 22.40.

[4] Figures in this series were derived by the following formula, in which *a*, *b*, and *c* are any consecutive years: *weighted average returns in year b: weighted average returns in year c:: survival series no. 2 figure for year a: survival series no. 2 figure for year b (x)*. Example: 1.41 : 1.35 :: 14.73 : x; x = 14.10. The survival series no. 2 figure for the year previous to year 1–2 is assumed to be 100.

[5] The figure in this category for year 1–2 was derived as explained for the figure directly above it. Figures for subsequent years were derived by finding the per cent of survival from year to year, as indicated by weighted survival series no. 2. Examples: 14.73 is 33.81 per cent of 43.57; 14.10 is 95.72 per cent of 14.73.

[6] Average of weighted average survival rates no. 1 for the first 3 years.

Table 30.—Annual mortality rates (per cent) of juveniles in the Canada goose flock at Horseshoe Lake, 1940–41 through 1946–47. (See formula, page 173, and data in table 29, top).

Season	Mortality Rate in Designated Year Following Banding				
	0–1[1]	1–2	2–3	3–4	4–5
1940–41	—				
1941–42	—				
1942–43	—	52			
1943–44	82	56	56		
1944–45	66	49	21	45	
1945–46	65	85	49	—41[2]	100
1946–47	—	54	87	3	3
Weighted average mortality[3]	*74*	*56*	*66*	*4*	*47*

[1] Figures in this column calculated from figures in column 7, table 27.
[2] Increase in population indicated; inadequate data.
[3] Figures derived by subtracting from 100 each of weighted average survival rates mentioned in text, page 175.

Table 31.—Total catches and trap returns of banded Canada geese of all ages at Horseshoe Lake, 1940–41 through 1946–47.

Season	Number Caught and Banded of All Ages	Geese Returning in Designated Year Following Banding						Total
		1–2	2–3	3–4	4–5	5–6	6–7	
1940–41	315	—						
1941–42	402	6						6
1942–43	1,036	14	4					18
1943–44	2,329	99	20	14				133
1944–45	853	194	37	10	7			248
1945–46	310	131	84	11	5	0		231
1946–47	—	65	72	55	12	7	4	215
Total	*5,245*	*509*	*217*	*90*	*24*	*7*	*4*	*851*

in footnote 5 of table 29, are 26.46, 43.58, 33.82, 95.64, 53.35, and 194.47. The survival index, not entirely comparable to survival indices in tables 29 and 32, is 34.62.

The weighted average mortality rate for each year of life following banding can be derived from the weighted survival series after computing the per cent of

Table 32.—Trap returns of banded Canada geese of all ages at Horseshoe Lake, expressed as percentages of original bandings, 1940–41 through 1946–47.

Season	Per Cent of Geese Returning in Designated Year Following Banding					
	1–2	2–3	3–4	4–5	5–6	6–7
1940–41	—					
1941–42	1.90					
1942–43	3.48	1.27				
1943–44	9.55	4.97	4.44			
1944–45	8.33	3.57	2.49	2.22		
1945–46	15.36	3.61	1.06	1.24	0.00	
1946–47	20.97	8.44	2.36	1.16	1.68	1.27
Weighted average per cent returns[1]	9.70	4.39	2.20	1.37	0.98	1.27
Weighted survival series, no. 1[2]	48.72	22.05	11.05	6.88	4.92	6.38
Weighted average survival rates, no. 1[3]	48.72	45.26	50.11	62.26	71.51	129.67
Weighted survival series, no. 2[4]	45.26	22.68	14.12	10.10	13.09	—
Weighted average survival rates, no. 2[5]	45.26	50.11	62.26	71.53	129.60	—
Survival index, 48.03[6]						

[1] Total of weighted average per cent returns, 19.91. Figures in this category were derived from table 31. The total number of trap returns for each year is expressed as a percentage of the total number of bandings they represent. For example, 509 (returns for year 1–2) equals 9.70 per cent of 5,245 (bandings, 1940–41 through 1945–46); 217 (returns for year 2–3) equals 4.39 per cent of 4,939 (bandings, 1940–41 through 1944–45).
[2] Figures in this category were derived by finding what per cent the weighted average per cent returns for each year are of the weighted average per cent returns for all years involved (19.91). Example: for year 3–4, the figure 11.05 was derived by finding what per cent 2.20 is of 19.91. Indicated increase for year 6–7 is based upon insufficient data.
[3] The figure in this category for year 1–2 was derived as explained for the figure directly above it. Figures for subsequent years were derived by finding the per cent of survival from year to year, as indicated by the weighted survival series no. 1. Example: 22.05 is 45.26 per cent of 48.72; 11.05 is 50.11 per cent of 22.05.
[4] Figures in this series were derived by the following formula, in which *a*, *b*, and *c* are any consecutive years: *weighted average returns in year b: weighted average returns in year c:: survival series no. 2 figure for year a: survival series no. 2 figure for year b (x)*. Example: 1.37:0.98::14.12:x; x=10.10. The survival series no. 2 figure for the year previous to year 1–2 is assumed to be 100.
[5] The figure in this category for year 1–2 was derived as explained for the figure directly above it. Figures for subsequent years were derived by finding the per cent of survival from year to year, as indicated by weighted survival series no. 2. Examples: 22.68 is 50.11 per cent of 45.26; 14.12 is 62.26 per cent of 22.68.
[6] Average of weighted average survival rates for the first 3 years.

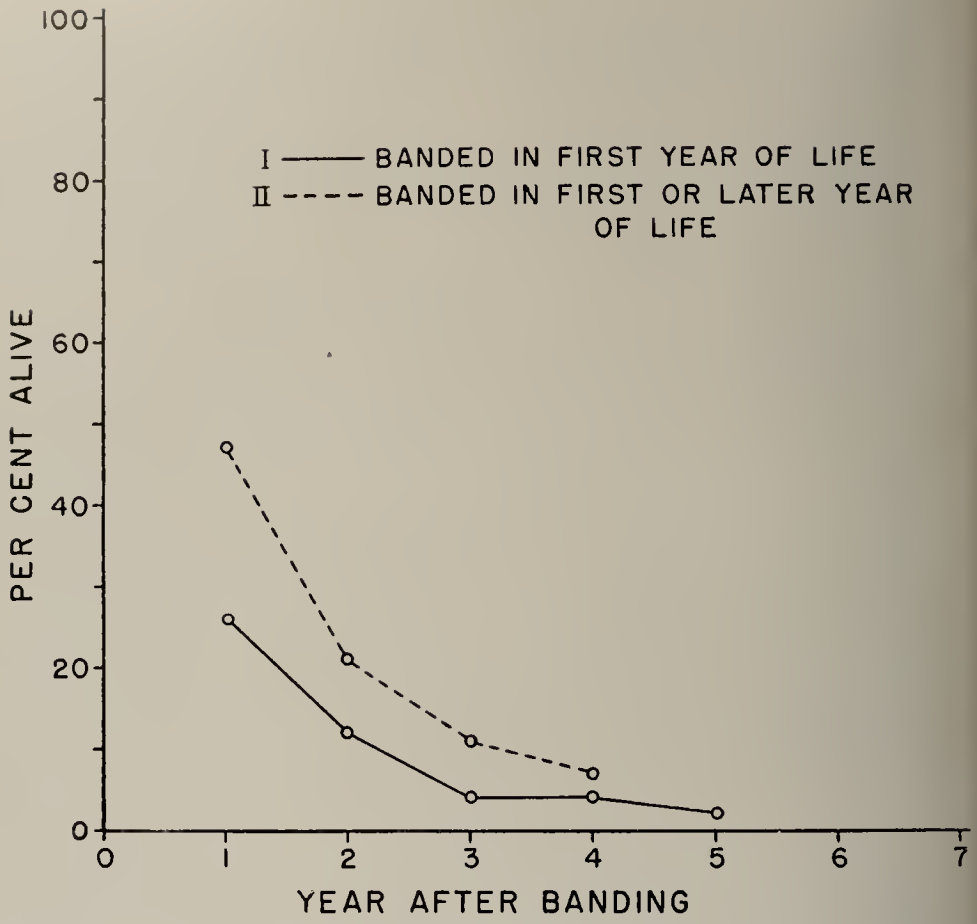

Fig. 74.—Survival of two groups of Canada geese, one banded in first year of life and one banded in first or later year of life. Curve I figures are from page 174; Curve II figures are from table 32, survival series 1.

geese remaining alive in each successive year. The survival rates cited above indicate that an average of 74 per cent of the original bandings disappeared by the end of the year of banding, 56 per cent of the survivors were lost during the second year after banding, 66 per cent the third year, 4 per cent the fourth year, and 47 per cent the fifth year, table 30.

Data on returns from banded geese of all ages, that is, the combined returns of birds banded as juveniles, yearlings, and geese of unknown age, have been treated in the manner described above, tables 31, 32, and 33. The survival series obtained, 49–22–11–7–5, table 32 and fig. 74, is believed to represent the approximate rate at which the average banding class in the Horseshoe Lake flock disappeared during the first 5 years of life following banding in the trapping seasons 1940–41 through 1946–47. The disproportionate loss of juveniles that usually occurs, in large part from shooting, does not weight this portion of the survival series, since the series is based on the total per cent of the geese returning to the traps 1 or more years after banding. The weighted average per cent return, 9.70, table 32, of geese the first year after the year of banding necessarily represents birds that are at least 1½ years of age.

The calculation methods discussed above leave much to be desired, particularly those involving mortality rates of the juveniles during the first year of life after

Table 33.—Annual mortality rates (per cent) in the Canada goose flock wintering at Horseshoe Lake, 1940–41 through 1946–47. (See formula, page 173, and data in table 32, top.)

Season	Mortality Rate in Designated Year Following Banding				
	1–2	2–3	3–4	4–5	5–6
1940–41	—				
1941–42	—				
1942–43	63				
1943–44	48	11			
1944–45	57	30	11		
1945–46	76	71	−17[1]	100	
1946–47	60	72	51	−45[1]	24
Weighted average mortality[2]	*55*	*50*	*38*	*28*	*−30*[3]

[1] Increase, instead of decrease, indicated because of disproportionate return to traps of banding class.
[2] Derived from table 32 by subtracting each survival rate no. 2 figure from 100.
[3] Figure based on insufficient data.

banding as derived from census data and trap-age ratios. However, we know, because of the heavy kills made at Horseshoe Lake and the high differential vulnerability of juveniles, that the juvenile component of the population suffered tremendous annual hunting losses during the period of field work.

The computed average mortality rate of 74 per cent during the first year following banding, table 30, is probably not far from the average mortality rate that actually occurred.

The fate of each banding class could not be traced through successive years because it was obviously impossible to trap all the banded survivors, and it was equally impossible to correct for the number of banded survivors that could not be retrapped, since the banded population was never well intermixed in the

Table 34.—Number of band recoveries from Canada geese banded at Kingsville, Ontario, and recovered in the states of Michigan, Wisconsin, Ohio, Indiana, Illinois, Iowa, Kentucky, Tennessee, Missouri, Arkansas, Mississippi, and Louisiana. (Autumn bandings only.)

Year Banded	Recoveries in Designated Year Following Banding												
	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13
1925	(9)	6	10	6	*3*	**4**	0	0	3	0	0	0	0
1926	(12)	11	5	*3*	**3**	0	0	0	0	0	0	0	0
1927	(2)	3	*4*	**3**	0	0	0	1	0	0	0	0	0
1928	(7)	*23*	**8**	0	7	2	0	0	3	0	1	1	0
1929	(7)	**13**	1	4	1	0	0	1	0	0	0	0	0
1930	(20)	4	8	7	*9*	**3**	1	0	0	0	2	0	0
1931	(1)	35	*26*	*12*	**3**	1	1	2	3	2	0	1	0
1932	(21)	31	*10*	**1**	3	1	1	2	2	0	0	1	0
1933	(25)	*24*	**3**	2	3	3	6	1	0	0	0	0	0
1934	(*18*)	**6**	1	**4**	2	6	3	0	1	1	0	0	
1935	(1)	1	2	1	*0*	**2**	1	0	0	0	0		
1936	(1)	10	7	*6*	**8**	2	1	1	2	0			
1937	(9)	17	*34*	**21**	5	7	6	8	0				
1938	(2)	*13*	**9**	2	2	9	0	3					
1939	(7)	**35**	11	3	9	4	0						
1940	(32)	11	4	2	*3*	**1**							
1941	(2)	12	12	*9*	**6**								
1942	(4)	9	*6*	**0**									
1943	(10)	*11*	**7**										
1944	(*6*)	**15**											

Notes on Table 34

Numerals indicating recoveries made during the year of banding are enclosed in parentheses.

Solid horizontal lines divide this table into four 5-year periods, treated in several tables following.

Recoveries for the years above the broken horizontal line are considered complete; they are treated in table 35 and expressed graphically in fig. 75.

Figures to the left of the single vertical rule are treated in table 36 and expressed graphically in fig. 76.

Figures to the left of the double vertical rule are treated in table 40 and expressed graphically in fig. 79.

Italicized figures and those above to the next solid horizontal line are treated in table 37, and the resultant survival series is shown graphically in fig. 77.

Boldface figures and those above to the next solid horizontal line are treated in table 39, and the resultant survival series is shown graphically in fig. 78.

Table 35.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, in the autumn, 1925–1932. The recoveries are for 12 years, including the year of banding.[1]

1925–1932 Bandings	Recoveries in Designated Year Following Banding												
	0[2]	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Bands recovered	0	79	126	72	36	29	11	3	6	11	2	3	3
Bands not recovered	381	302	176	104	68	39	28	25	19	8	6	3	0
Survival series[3]	100	79	46	27	18	10	7	7	5	2	2	1	0
Survival rate[4]	.....	79	58	59	65	57	72	89	76	42	75	50	0

[1] Data in this table were derived from table 34; included are the sums of figures in table 34 *for the period 1925–1932* in the several columns representing year of banding and years 1–2 through 11–12 following banding.
[2] Time of banding. The 381 in the column below represents the total of the number of bands recovered in the 12 years included in the table. No correction made for differences in times of banding in year 0–1.
[3] Survival series figures are derived by finding the total number of bands recovered and then calculating what percentage the number of *bands not recovered* in each year is of the total number of recoveries; for example, for year 1–2, the number 176 is divided by 381 to give 46.
[4] Survival rate figures are derived by calculating what percentage the number of *bands not recovered* in each year is of the number of *bands not recovered* in the preceding year; for example, for year 2–3, the number 104 is divided by 176 to give 59.

flock as a whole. The reasons that the banded component was not well intermixed were (1) the tendency of many banded individuals to use the same sector of the refuge during the season of band-

Table 36.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, by three 5-year periods, 1925–1939. The recoveries are for 6 years and include the year of banding.[1]

	Recoveries in Designated Year Following Banding						
1925–1929 Bandings	0[2]	0–1	1–2	2–3	3–4	4–5	5–6
Bands recovered	0	37	56	28	16	14	6
Bands not recovered	157	120	64	36	20	6	0
Survival series[3]	100	76	41	23	13	4	0
Survival rate[4]	—	76	53	56	56	30	
1930–1934 Bandings							
Bands recovered	0	85	100	48	26	20	14
Bands not recovered	293	208	108	60	34	14	0
Survival series[3]	100	71	37	20	12	5	0
Survival rate[4]	—	71	52	56	57	41	
1935–1939 Bandings							
Bands recovered	0	20	76	63	33	24	24
Bands not recovered	240	220	144	81	48	24	0
Survival series[3]	100	92	60	34	20	10	0
Survival rate[4]	—	92	65	56	59	50	

[1] Data in this table were derived from table 34; included are the sums of figures in table 34 *for three 5-year periods*, 1925–1939, in the several columns representing year of banding and years 1–2 through 5–6 following banding.
[2] See footnote 2, table 35.
[3] See footnote 3, table 35.
[4] See footnote 4, table 35.

Table 37.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, by 5-year periods, 1925–1944. The recoveries are for the year of banding and parts of the 4 years following.[1]

	Recoveries in Designated Year Following Banding					
1925–1929 Bandings	0[2]	0–1	1–2	2–3	3–4	4–5
Bands recovered	0	37	43	19	9	3
Bands not recovered	111	74	31	12	3	0
Survival series[3]	100	67	28	11	3	0
1930–1934 Bandings						
Bands recovered	0	85	94	44	19	9
Bands not recovered	251	166	72	28	9	0
Survival series[3]	100	66	29	11	4	0
1935–1939 Bandings						
Bands recovered	0	20	41	43	7	0
Bands not recovered	111	91	50	7	0	0
Survival series[3]	100	82	45	6	0	0
1940–1944 Bandings						
Bands recovered	0	54	43	22	11	3
Bands not recovered	133	79	36	14	3	0
Survival series[3]	100	59	27	11	2	0

[1] Data in this table were derived from table 34; included are figures obtained by adding each column of figures in each of four 5-year periods from top downward through the *italicized* figures. For instance, for year 3–4 in the first 5-year period, the figures 6 and 3 are added.
[2] See footnote 2, table 35.
[3] See footnote 3, table 35.

ing, as well as during subsequent banding seasons, and (2) the tendency of some individuals to establish a trap habit that persisted in later years.

For several reasons it seemed desirable to make an "across the board" treatment of the trap data, that is, an analysis of mortality from annual random samplings of the retrapped banded survivors. Tables 28–33, referring to trap returns, should be read horizontally; they should not be read diagonally, as they would be if a single banding class were followed through the years.

A few geese banded at Horseshoe Lake winter in parts of the Mississippi flyway other than at this lake, and while some disperse to other flyways, table 4, there is no evidence that this dispersal to a different wintering range is greater during any particular year than in others, a factor that might otherwise seriously influence the validity of our survival series.

Mortality Calculated From Band Recoveries.—The survival rate measured by the use of band recoveries is based on the assumption that the unbanded segment of a population disappears at approximately the same rate as the banded segment and that year-to-year differences in the numbers of banded birds reported dead in successive years is indicative of the annual mortality of the entire population. However, unless all banding is completed before the opening of the hunting season, the first-year recoveries will be too few and the entire survival series too high. This criticism is valid for the survival series in tables 36 and 37, in which first-year recoveries are included in the computations to make relative comparisons of survival rates.

In the computation of a survival series from band recoveries, the recoveries may be treated in either of two primarily different ways: (1) the recoveries for each year may be expressed as a percentage of the number of geese banded; or (2) the recoveries may be totaled to give the hypothetical original number of banded birds alive at the start of the first year following banding, and then the number of re-

Table 38.—Recoveries in the Mississippi River valley of bands from Canada geese of all age classes banded at Horseshoe Lake, 1940–41 through 1944–45.

Trapping Season	Recoveries in Designated Year Following Banding					
	0–1[1]	1–2	2–3	3–4	4–5	5–6
1940–41	—	15	7	11	3	2
1941–42	—	10	10	7	1	
1942–43	—	40	17	10		
1943–44	—	39	36			
1944–45	—	15				
Bands recovered	—	119	70	28	4	2
Bands not recovered	223	104	34	6	2	0
Survival series[2]	100	47	15	3	1	0

[1] Year of banding; recoveries in this year not included in calculations in table.
[2] Survival series calculated as described in footnote 3, table 35.

Table 39.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, in four 5-year periods, 1925–1944. The recoveries are for parts of the first 5 years following the year of banding.[1]

	Recoveries in Designated Year Following Banding					
1925–1929 Bandings	0–1[2]	1–2	2–3	3–4	4–5	5–6
Bands recovered	—	56	27	12	6	4
Bands not recovered	105	49	22	10	4	0
Survival series[3]	100	46.7	21.0	9.5	3.8	0
1930–1934 Bandings						
Bands recovered	—	100	47	20	12	3
Bands not recovered	182	82	35	15	3	0
Survival series[3]	100	45.0	19.2	8.2	1.6	0
1935–1939 Bandings						
Bands recovered	—	76	52	28	8	2
Bands not recovered	166	90	38	10	2	0
Survival series[3]	100	54.2	22.9	6.0	1.2	0
1940–1944 Bandings						
Bands recovered	—	58	29	11	9	1
Bands not recovered	108	50	21	10	1	0
Survival series[3]	100	46.3	19.4	9.3	0 9	0

[1] Data in this table were derived from table 34; included are figures obtained by adding each column of figures in each of four 5-year periods from top downward through the **boldface** figures. For instance, for year 3–4 in the first 5-year period, the figures 6, 3, and 3 are added.
[2] Year of banding. Recoveries in this year not included in calculations in table.
[3] Survival series calculated as described in footnote 3, table 35.

In the computation of a survival series from band recoveries, the recoveries may be treated in either of two primarily different ways: (1) the recoveries for each year may be expressed as a percentage of the number of geese banded; or (2) the recoveries may be totaled to give the hypothetical original number of banded birds alive at the start of the first year following banding, and then the number of re-

coveries reported during each succeeding year after banding is subtracted from the number of banded geese unrecovered and presumably alive the preceding year; then the number of geese unrecovered and assumed to be alive in each year is expressed as a per cent of the total recoveries, table 35. The second method must be used for recovery data from bandings at Kingsville, Ontario, because the size of the original banding is not known with certainty and because an unknown portion of the bandings listed in table 2 were Mississippi Valley geese; presumably the remainder represented the Southeast population.

For the purpose of comparing mortality in another segment of the Mississippi Valley population since 1925 with mortality in the Horseshoe Lake flock, recoveries of geese banded at the Jack Miner Bird Sanctuary in the autumn were used, table 34. Although band recoveries from geese of unknown age at the time of banding do not give a precise picture of population mortality in Canada geese because of the differentially high kill of the juveniles by hunters, they suffice as a basis for a com-

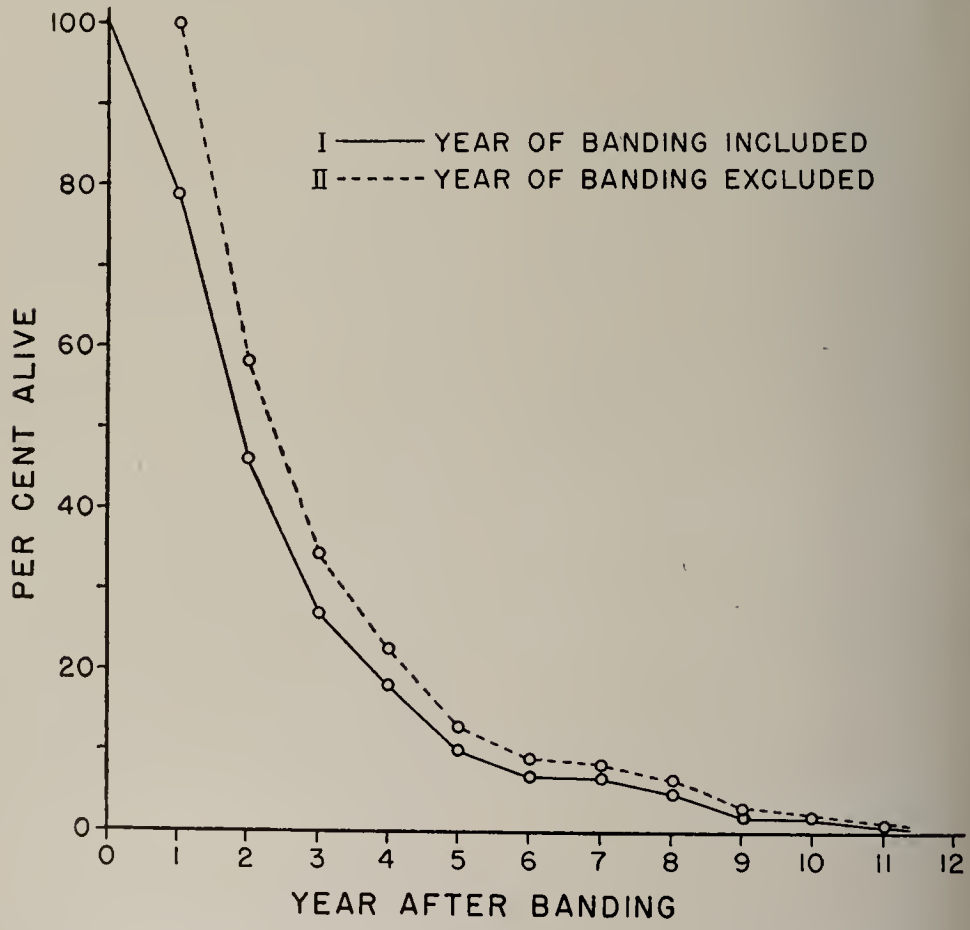

Fig. 75.—Average survival of Mississippi Valley Canada geese, as measured by band recoveries from geese banded at the Jack Miner Bird Sanctuary, Kingsville, Ontario, in the autumn, 1925–1932. Curve I includes band recoveries made during the year of banding; curve II excludes recoveries made during the year of banding. Curve I (data from table 35) starts with an expression (100 per cent) of the total number of recovered bands; curve II (data from table 41) starts with an expression (100 per cent) of the total number of recovered bands that were on geese alive at the beginning of the year following banding.

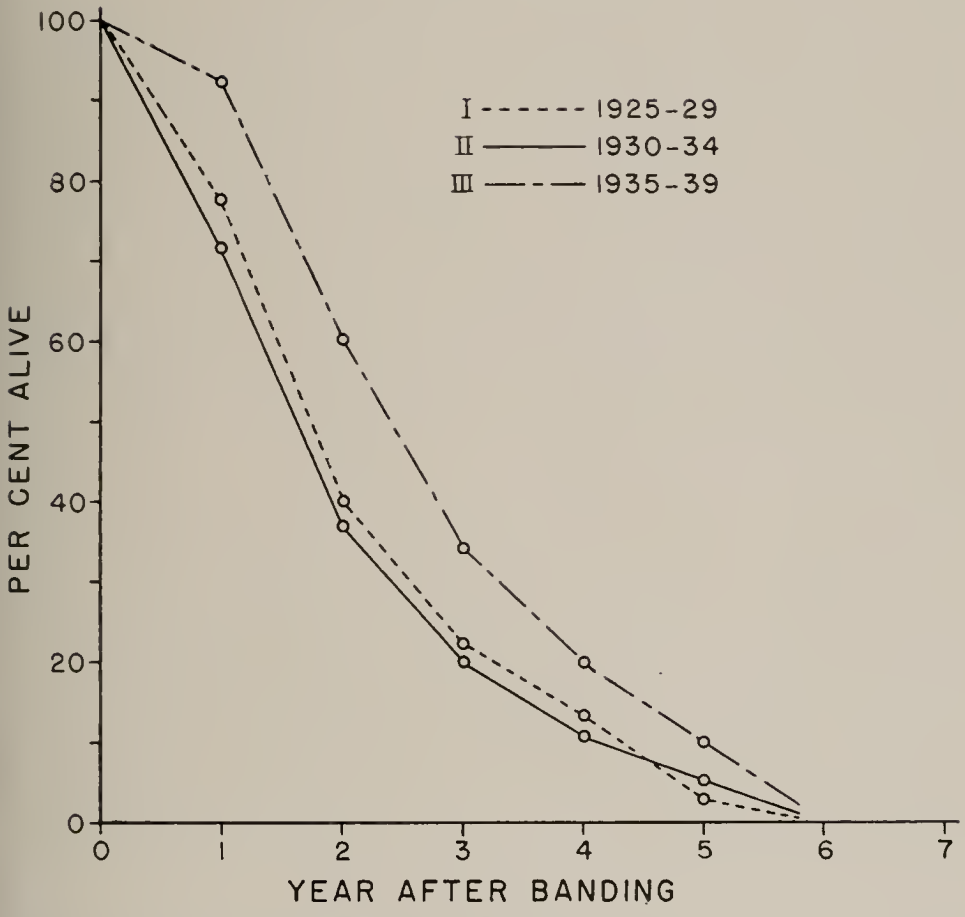

Fig. 76.—Average survival of Mississippi Valley Canada geese, as measured by band recoveries from geese banded at the Jack Miner Bird Sanctuary, in the autumn, 1925-1939. That part of each curve representing the year of banding shows a higher rate of survival than actually occurred, as in the data (from table 36), which represent the number of bands recovered and not the number of bands applied; no correction was made for the varying lengths of exposure to guns experienced by geese banded at various times in the season of banding.

parison of mortality rates in different years. As no individuals from the Miner autumn bandings have been reported shot in the Mississippi River valley later than 12 years after banding, recoveries of geese banded in 1925–1932 may be considered nearly 100 per cent complete by 1944. These data, summarized in table 35 and presented graphically in fig. 75, curve I, show that maximum survival in Canada geese in the Mississippi River valley under moderate hunting pressure is about 12 years.

Since about 93 per cent of the bands in the 12-year series were recovered by the end of the sixth or seventh years after banding, table 35, no great error would result from basing an analysis of mortality from 1925 through 1939 on the number of banded geese reported dead by the end of the sixth or seventh years. Recoveries of birds banded in those years are grouped by three 5-year periods. These 5-year data groups are set off by horizontal lines in table 34. In table 36, they have been summarized. The survival curves based on these data are shown graphically in fig. 76.

In order to compare the survival of geese banded at the Miner Sanctuary in

1940–1944 with the survival achieved by geese banded by the Miners in previous years, it was necessary to use an incomplete band-recovery series, derived from table 34, as explained in a footnote to table 37. The groupings for this analysis are summarized in table 37 and the computed survival curves are shown in fig. 77.

First-year survival data obtained from recoveries of geese banded at the Miner Sanctuary in the autumn are not an accurate representation of average first-year survival for Mississippi flyway geese as a whole. Whereas most bandings of waterfowl yield the greatest number of recoveries during the year of banding, the largest number of recoveries from Miner bandings have been received in most instances the year following the year of banding, table 34. One reason for this situation may be that the geese that are trapped and banded represent those that remain at the sanctuary the longest; this explanation is supported by migration data. Late south-bound migrants tend to remain longer in the more northerly sectors of the autumn and winter range than do the early migrants. Furthermore, most of the geese banded at the Miner Sanctuary in the autumn are trapped in November and December, when the hunting season in the northern and central zones of the

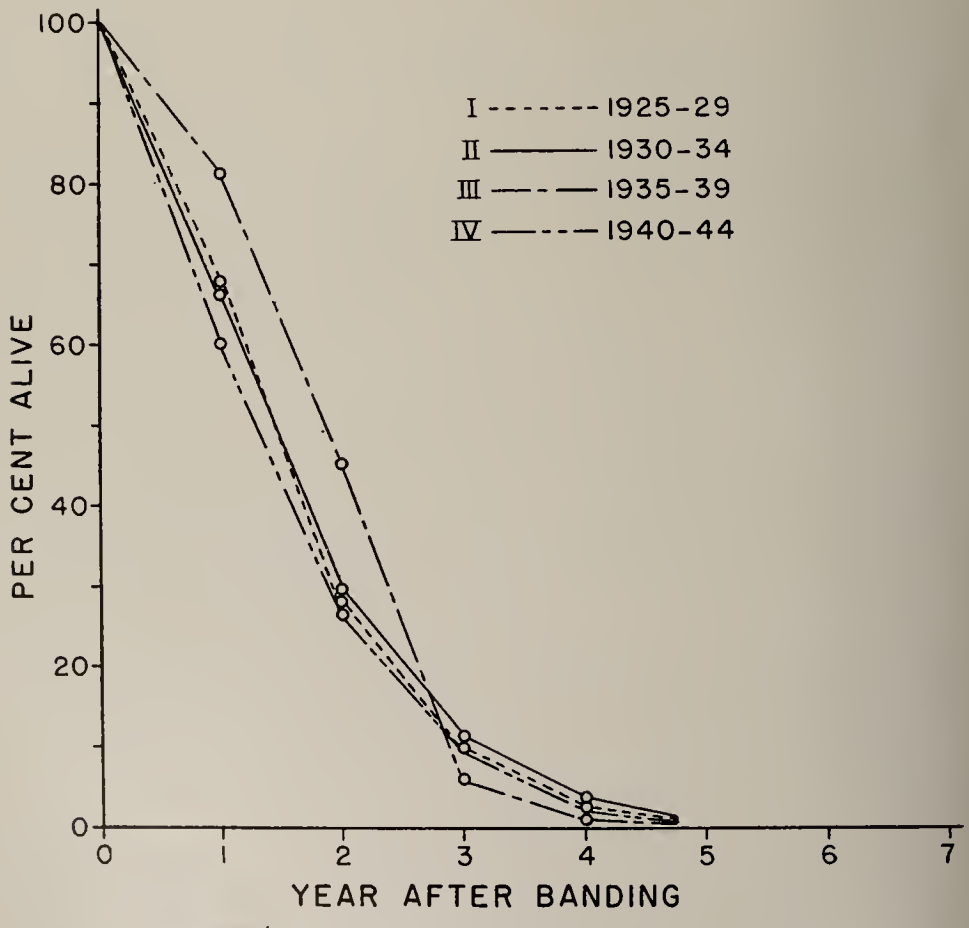

Fig. 77.—Comparative survival of Mississippi Valley Canada geese in four 5-year periods. Curves are based on band recoveries from geese banded at the Miner Sanctuary in the autumn (data from table 37, which include recoveries in year of banding). Curves start with an expression (100 per cent) of total number of bands recovered, not total number placed on geese.

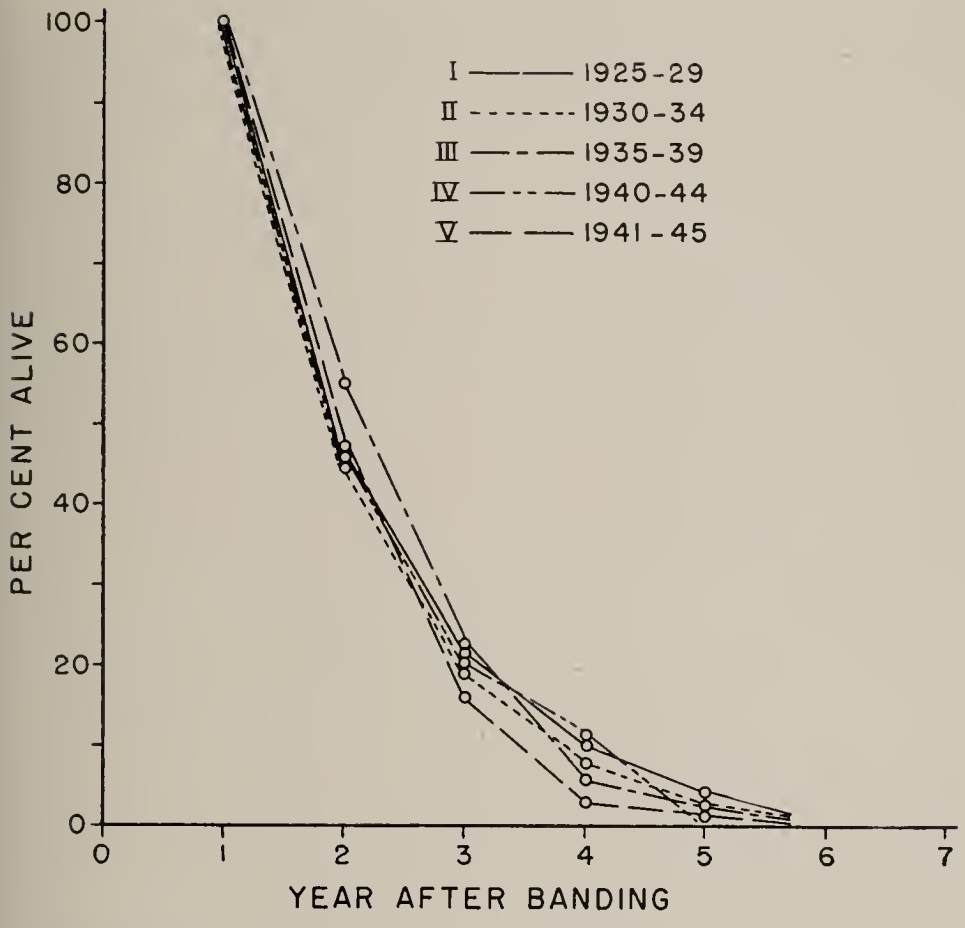

Fig. 78.—Comparative survival in three 5-year periods of Mississippi Valley Canada geese that were at least 1½ years old (the year after being banded). Curves I–IV are based on data from table 39, bandings at Kingsville, Ontario. Curve V is based on data from table 38, bandings at Horseshoe Lake. All curves start with an expression (100 per cent) of the total number of recovered bands that were on geese alive at the beginning of the year following banding.

Mississippi flyway is at least half over. Nevertheless, these data demonstrate something of the magnitude of the *relative* differences of survival of the various quinquennial groupings, either graphically or expressed as survival indices.

Because the Canada goose population wintering at Horseshoe Lake constitutes a somewhat different representation of the Mississippi Valley population than do the geese banded in the autumn at the Miner Sanctuary (demonstrated by the fact that geese banded at Horseshoe Lake are shot farther north on the breeding range than are geese banded at Kingsville, Ontario, fig. 7), it is of interest to compare the band-recovery data from these two banding stations through the season 5–6 after banding, the last season for which data are available for both stations.

When this comparison of mortality rates is made, it is desirable to omit recoveries made during the season of banding, since the time of banding, the location of the banding station, and the circumstances immediately following banding are not comparable. The recovery data from the Horseshoe Lake flock are

given in table 38 and the recovery data from the Miner bandings for a comparable number of years are summarized in table 39. The survival series derived from tables 38 and 39 are presented graphically in fig. 78.

Inspection of the curves in fig. 78 reveals that the differences between curves I and IV are not so great as between comparable curves shown in fig. 77. The probable explanation is that all recoveries shown graphically in fig. 78 represent geese at least 1½ years old, whereas the survival series that includes recoveries during the season of banding are in part from juvenile geese. Since the latter age class is far more vulnerable to shooting than older geese, recoveries from a banded population that includes juveniles would naturally reflect more sensitively the severity of hunting losses in various seasons. For this reason curve V in fig. 78, which is based on data presented in table 38, does not adequately reflect the tremendous and disproportionate kill of juveniles in the vicinity of Horseshoe Lake from 1943 through 1945.

In table 40, recoveries of bandings, 1925–1939, complete through season 6–7 after banding, but omitting recoveries the

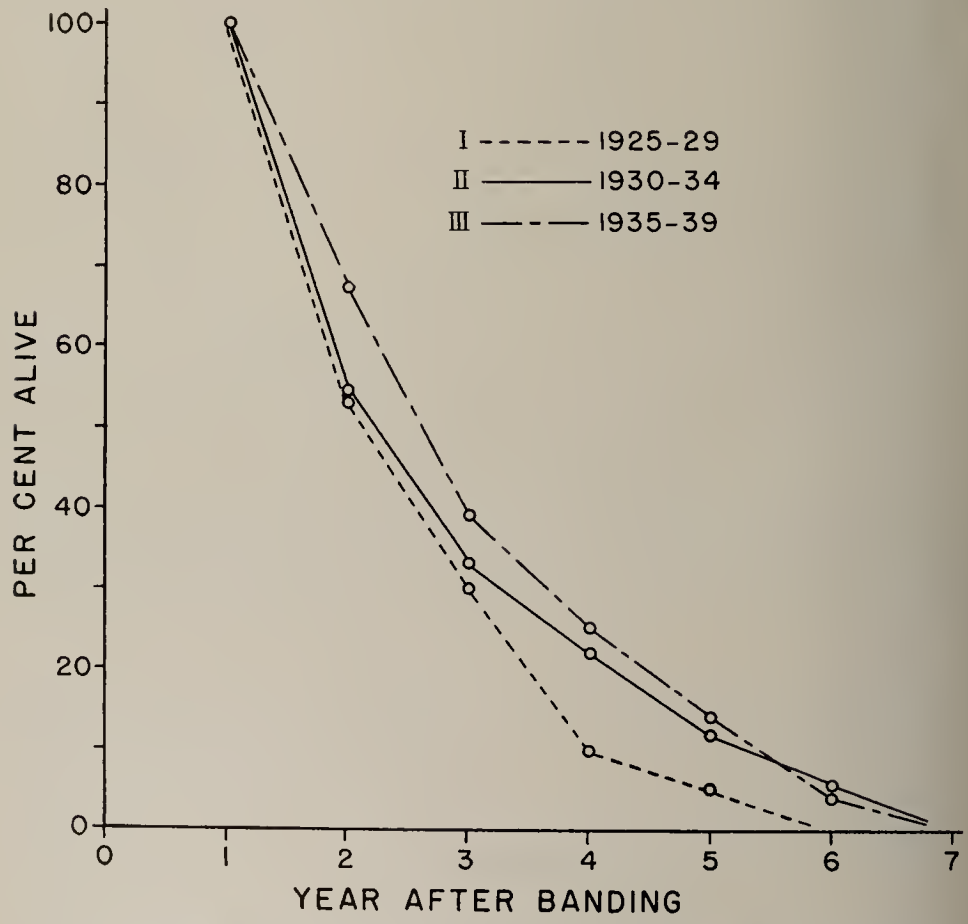

Fig. 79.—Comparative survival (in four 5-year periods) of Canada geese that were at least 1½ years old (the year after being banded). Curves are based on recovery data from table 40, bandings at Kingsville, Ontario. All curves start with an expression (100 per cent) of the total number of recovered bands that were on geese alive at the beginning of the year following banding.

Table 40.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, in three 5-year periods, 1925–1939. The recoveries are for the first 6 years following the year of banding.[1]

	Recoveries in Designated Year Following Banding						
1925–1929 Bandings	0–1[2]	1–2	2–3	3–4	4–5	5–6	6–7
Bands recovered...	—	56	28	16	14	6	0
Bands not recovered.	120	64	36	20	6	0	0
Survival series[3].....	100	53.3	30 0	10.0	5.0	0	0
Survival rate[4].	—	53.3	56.3	33.3	50.0	0	0
Survival index, 47.6[5]..							
1930–1934 Bandings							
Bands recovered....	—	100	48	26	20	14	12
Bands not recovered...	220	120	72	46	26	12	0
Survival series[3].....	100	54.5	32.7	20.9	11.8	5.5	0
Survival rate[4].....	—	54.5	60.0	63.9	56.5	46.2	0
Survival index, 59.5[5]							
1935–1939 Bandings							
Bands recovered....	—	76	63	33	24	24	8
Bands not recovered.	228	152	89	56	32	8	0
Survival series[3].....	100	66.7	39.0	24.6	14.0	3.5	0
Survival rate[4].....	—	66.7	58.6	62.9	57.1	25.0	0
Survival index, 62.7[5]							

[1] Data in this table were derived from table 34; included are totals obtained by adding the figures in each column of three 5-year periods, 1925–1939, years 1-2 through 6-7.

[2] Year of banding. Recoveries in this year not included in calculations in table.

[3] Survival series calculated as described in footnote 3, table 35.

[4] Survival rate calculated as described in footnote 4, table 35.

[5] Average of first 3 years of survival rate.

year of banding, are treated by 5-year groups. These data are shown graphically in fig. 79. Survival indices from these recovery data can be regarded as a fair approximation of average survival during at least the first 3 years of adult life after banding. However, the most nearly accurate survival index for 3 years of adult life (actually from at least 1½ to at least 4½ years of age) after banding, 60.7 per cent, is obtained from the complete recovery series, table 41 and fig. 75, curve II. A survival index for years of this study, an index calculated from trap returns rather than band recoveries and for the Horseshoe Lake flock, 48.03, is obtained from the data given in table 32. For purposes of comparison, survival indices obtained from the data discussed above are summarized in table 42. The converse of a survival index is a mortality index, that is, the average of mortality rates for 3 consecutive years. Mortality indices also are given in table 42.

Mortality data are available for only a few other game species. Leopold *et al.* (1943) have shown that in an unshot pheasant population a year class is reduced to zero in 5 years, and that the average annual mortality of a year class is about 70 per cent, a mortality rate that compares closely with that found for the Hungarian partridge and for the California quail by Emlen (1940). In contrast to these rates, annual mortality in many passerine birds appears to be between 50 and 55 per cent (Farner 1945).

Leopold *et al.* (1943) have stated that after a pheasant reaches its first winter its chance of survival apparently does not improve with age; that is, the survival rate is constant. The data presented by Buss (1946) do not agree with this conclusion. Because geese are longer lived than pheasants and acquire wariness and habits of survival value with age, it seems reasonable to assume that greater experience and learning with increased age in Canada geese would improve the individual's chance of survival. Band recoveries, as well as observations of living birds, have already shown that, insofar as shooting is concerned, juveniles have a greater mortality rate than adults. To discover whether mortality rates of Canada geese undergo change with increasing age after the first year of life, recoveries in table 41 have been plotted logarithmically, fig. 80. Losses prior to 1½ years of age are indicated in fig. 80 by a dotted line. The curve is "completed" only in order to obtain visual appreciation as to what its approximate shape might be if it were based on adequate and complete data for the entire life span. The curve suggests some improvement of survival with in-

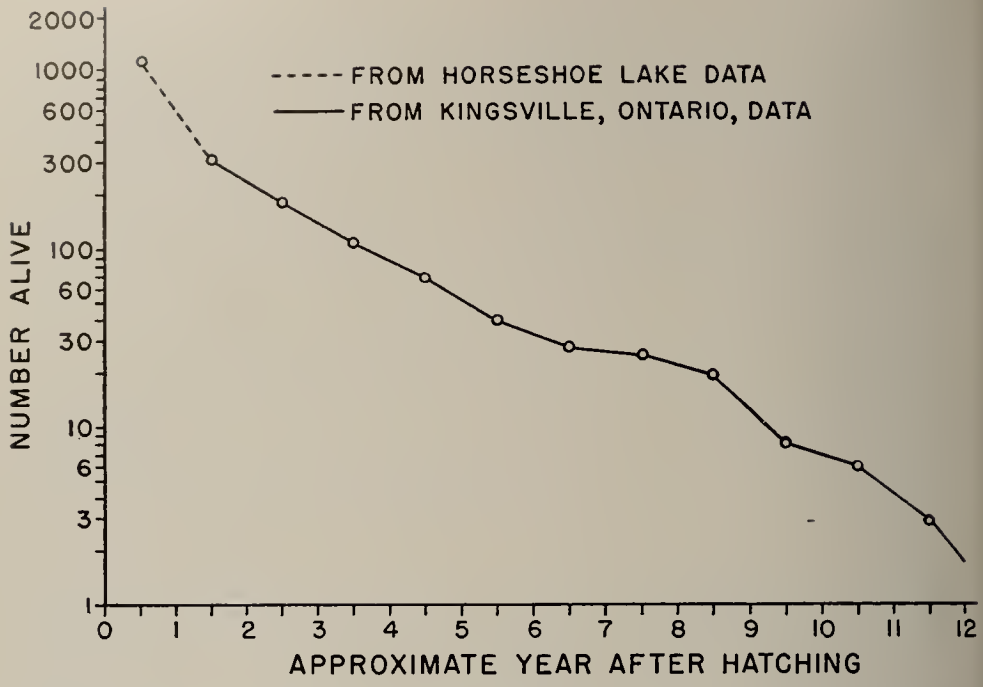

Fig. 80.—Approximate survival curve (semilogarithmic) for the Canada goose population of the Mississippi flyway, as indicated by age ratios and censuses of geese at Horseshoe Lake, 1940–1947, and by band recoveries from geese banded at Kingsville, Ontario, 1925–1932. Because geese banded at Kingsville were of unknown age at time of banding, the curve may be only a rough approximation of the actual survival curve.

creasing age after about the fifth or sixth year of life, but the evidence is not conclusive. The decreasing reliability of data 5 or 6 years after banding, the varying take by hunters from year to year, and the fact that the data represent, in the first place, geese of unknown ages tend to obscure the actual picture.

Longevity

Geese as a group are noted for being long lived, particularly in captivity;

Table 41.—Recoveries in the Mississippi River valley of bands from Canada geese banded at Kingsville, Ontario, in the autumn, 1925–1932. (Data from table 34.) This table differs from table 35 in that here the band recoveries from the year of banding are not included.

1925–1932 Bandings	Recoveries in Designated Year Following Banding											
	0–1[1]	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Bands recovered	—	126	72	36	29	11	3	6	11	2	3	3
Bands not recovered	302	176	104	68	39	28	25	19	8	6	3	0
Survival series[2]	100	58	34	23	13	9	8	6	2	2	1	0
Survival rate[3]	—	58	59	65	57	72	89	76	42	75	50	0
Survival index, 60 7[4]												

[1] Beginning of year following year of banding. The 302 in this column represents the total of the number of bands recovered after this time in the period included in the table.
[2] See third footnote to table 35. In the table above, recoveries in the year of banding are excluded, and the total number of recoveries considered is 302 instead of the 381 in table 35.
[3] See fourth footnote to table 35.
[4] Average of first 3 years of survival rate.

Table 42.—Survival indices of Canada geese banded at Kingsville, Ontario, in the autumn, and at the Horseshoe Lake Game Refuge.

BANDING SEASONS	AGE AT BANDING	BANDING STATION	SURVIVAL INDEX*	MORTALITY INDEX	KIND OF DATA USED	REFERENCE
1925–1932	All ages	Miner Sanctuary	60.7	39.1	Band recoveries	Table 41
1925–1929	All ages	Miner Sanctuary	47.6	52.4	Band recoveries	Table 40
1930–1934	All ages	Miner Sanctuary	59.5	40.5	Band recoveries	Table 40
1935–1939	All ages	Miner Sanctuary	62.7	37.3	Band recoveries	Table 40
1940–1947	All ages	Horseshoe Lake	48.0	52.0	Trap returns	Table 32
1940–1947	Juveniles	Horseshoe Lake	34.6	65.4	Trap returns and age ratios	Page 175

* These survival indices are an average of survival rates for years 1–2 through 3–4 and were derived as indicated in the "Reference" column of this table. They are slightly lower than if derived from a complete band-recovery series. The mortality index is derived by subtracting the survival index from 100.

Flower (1925) records that two Canada geese lived to be 29 years of age and a third 33 years. McAtee (1924) learned of one pair of Canada geese that were mated for 42 years and another pair for over 20 years. Wilfrid (1924) reported a gander he believed to be at least 40 years old at the time of the bird's death, and Leffingwell (1890) reported "as a matter of history" a captive bird that was killed when it was 80 years old. Doubtless there are other records in the literature that compare with these. Several instances of Canada geese, once used for decoys and later kept as pets, that attained ages of at least 20 years have been reported to the authors of this paper.

In the wild, few Canada geese approach these ages. The greatest age attained by a wild Canada goose, to our knowledge, is at least 22 years. This goose was banded at the Miner Sanctuary in the spring of 1923 and retrapped in the spring of 1932 and again in the spring of 1944. The life span of the average wild Canada goose after banding, however, proves to be only a few years, generally less than 3, but as Austin (1942) has pointed out, "It is of little importance biologically speaking how long members of a species live providing their life span is long enough for a generation to reach and maintain sexual maturity in order to duplicate the achievement of its predecessor."

In most instances, our data are inadequate to compute average longevities with accuracy. The complete recovery series, table 35, are of limited usefulness, since the geese involved were of unknown age when banded. These data are further complicated by the fact that the number of recoveries during the season of banding are not representative of usual first-year mortality. Average longevities calculated from data collected for the present study would be misleading. While average longevities derived from adequate data would serve ideally to compare the survival of individuals of different bandings, for the present study the survival indices shown in tables 29, 32, 40, 41, and 42 are useful and are more appropriate. From these indices and from other data, it seems obvious that few Mississippi Valley Canada geese live longer than 3 or 4 years after being banded.

An approximation of the longevity of juvenile geese banded at Horseshoe Lake in the years of this study may be obtained through computations beginning with the following formula:

$$S = \frac{f_1 y_1 + f_2 y_2 + f_3 y_3 \text{ etc.}}{N}$$

S stands for average survival after banding; f_1, f_2, etc. represent, for each age-class involved, the mortality frequency in each of successive years as computed from the survival series on page 174: 26.46, 11.53, 3.90, 3.73, 1.99 (mortality frequencies:* 73.54, 14.93, 7.63, 0.17, 1.74); y_1, y_2, etc. represent the number of years (1 through 5) following banding applicable to each mortality frequency; N represents the sum of the mortality frequencies. The mean death date of geese banded at Horseshoe Lake was about midway between mean banding dates.† Hence, the value calculated for S, 1.4 years, is corrected by subtracting 0.5 to give average survival after banding, 0.9 year.

As juveniles at Horseshoe Lake were about 0.5 year old when banded, this figure is then added to 0.9 to give the average longevity, 1.4 years. Thus, it might be said that the average banded juvenile goose and presumably the average juvenile in the unbanded Horseshoe Lake population in the years of this study did not live long enough to produce one brood of young.

DISCUSSION

It is axiomatic that the sound management of a wildlife species must in the last analysis rely on carefully gathered scientific data. Waterfowl studies usually concern migratory species for which it is difficult to secure adequate data from all parts of the range. The range of most waterfowl species is immense, and some populations shift their distribution within a flyway from year to year because of changing food, water, and weather conditions.

The aim of most broad studies of waterfowl species probably would be to gather

* Derived by subtraction: 100.00–26.46, 26.46–11.53, 11.53–3.90, etc.

† Mean banding date about December 1.

information that would allow management of the species concerned on a flyway basis, as recently suggested by Gabrielson (1944). Because Canada geese tend to exhibit a greater adherence to their ancestral range than do ducks, management by flyways for this species is more suitable than it would be for most other waterfowl. In fact, the fairly restricted range of the various Canada goose populations in eastern North America, as shown earlier, suggests the need for certain management measures for individual population ranges rather than for an entire flyway. Although additional information concerning the Mississippi Valley goose population is needed, enough is now available to permit this population to be managed primarily as individual population units.

Status

In 1946, 14 states of the Mississippi flyway (Michigan, Wisconsin, Minnesota, Ohio, Indiana, Illinois, Iowa, Kentucky, Tennessee, Missouri, Mississippi, Alabama, Arkansas, and Louisiana) were closed to the hunting of Canada geese. The closed season of an entire flyway was the first of its kind in the history of this species of waterfowl. The only similar actions ever taken were those closing the shooting seasons on snow geese and brant in the Atlantic Coast states. Snow-goose hunting has been prohibited there since 1931, and brant hunting for more than half of the years since 1933.

The closed season on Canada geese in the Mississippi flyway in 1946 was believed necessary for a number of reasons: an alarming decrease in the number of these geese in the Mississippi flyway from 1940 to 1945, as indicated by January inventory data; markedly increased kills beginning in 1939, particularly in the region of Horseshoe Lake; a disproportionate kill of juvenile birds and an apparent decreased productivity in 1945, as indicated by research at Horseshoe Lake.

The peak number of geese at Horseshoe Lake dropped from about 50,000 in 1943–44 to 26,000 in 1945–46. That this decrease represented a real decrease in the flyway population and was not due to bypassing of the area by flocks is shown not only by flyway censuses but by band-recovery records. These records indicate that since 1932 many of the geese that formerly used the Mississippi River from Cairo, Illinois, to Baton Rouge, Louisiana, have concentrated in a much smaller area centering on Horseshoe Lake, probably because of the refuge there and the large amount of grain available to the geese.

Known bags and careful estimates of kills indicate that, in the years just previous to 1946, an average of about 20 per cent of the Canada goose population wintering at Horseshoe Lake was bagged annually, and that the total annual kill in the area averaged about 27 per cent of the population. In view of the fairly low productivity of the Canada goose, it is obvious that a reasonable kill in this area was greatly exceeded. Population declines at Horseshoe Lake and in the Mississippi flyway as a whole showed that flock mortality from all causes combined had been excessive, and, as hunting losses are one type of mortality that can be controlled, it was evident that closing the entire flyway to shooting was the most effective management measure that could have been employed.

Evidence of increased shooting pressure on Canada geese in years just previous to 1946 is illustrated by the survival curves, fig. 77, representing data computed from band recoveries from geese banded at the Jack Miner Bird Sanctuary, Kingsville, Ontario. These data show that the annual survival rate for that portion of the population migrating through the Kingsville area was lower in the 5 years beginning in the fall of 1940 than in any comparable period in the previous 15 years, fig. 77. Chiefly responsible for this lower survival rate were the heavy kills made at Horseshoe Lake; band recoveries show that the survival rate of the Horseshoe Lake flock was well below the average for the entire Mississippi Valley population. In fact, the survival series for the Horseshoe Lake flock was lower during the period 1940–1945 than it was in the entire Mississippi Valley population in the years in which baiting and the use of live decoys were permitted, tables 10, 37, and 38.

Moffitt (1935) was concerned over the future of a flock nesting in California when he realized an 11.5 per cent first-season recovery rate from his bandings. Unpublished studies by Cecil S. Williams

of the United States Fish and Wildlife Service at the Bear River marshes, Utah, indicate that the Great Basin population he dealt with could show a first-year band-recovery rate of 16 per cent and a total band-recovery rate of 25 per cent and still increase. Total recoveries from Horseshoe Lake bandings were at only about half the rate of total recoveries reported for the Great Basin, but other data indicated a heavy kill rate and a decline in the Horseshoe Lake population in the years just previous to 1946. While Williams' data establish the fact that the Canada goose could withstand heavy shooting losses in the Great Basin, conditions vary too widely in the various flyways to predict on the basis of data from one area (Utah) what the conditions are in another (Horseshoe Lake).

Interpolating from fig. 74, curve I, which is based on a survival series obtained for the Horseshoe Lake flock, it appears that only about 16 per cent of the juveniles reaching Horseshoe Lake during the period of field work for this study lived long enough to see a brood of their young on the wing.

When a major portion of the annual kill of a Canada goose flock is at the expense of one age group, data on the total number of birds bagged do not reveal the true impact of the kill upon the total population. At Horseshoe Lake the juveniles made up the major part of the kill in the period covered by this study, tables 43 and 44. In the autumn of 1943, the juveniles made up 56 per cent of the population, while 91 per cent of the hunter's bag consisted of juveniles. In that year, 37 per cent of the juvenile population at Horseshoe Lake was bagged. The following year, the 1943 generation (then yearlings) comprised only about 29 per cent of the total adult birds. The effect of this differential kill is also shown by trap-age ratios of banded survivors in later years. In table 43, returns for the years 1943–1947 of geese banded during the autumn and winter season previous to

Table 43.—Juvenile-adult ratios of Canada geese at Horseshoe Lake, 1942–43 through 1946–47, arranged to show the effect of a differential kill on survival. (See table 23.)

Season	Juveniles Per 100 Adults Banded	Juveniles Per 100 Adults in Bag	Number Returning to Traps 1 Year Later			
			Age Class	Number	Per Cent of Original Banding	Yearlings Per 100 Adults
1942–43..	153	259	Juvenile	67	10.82	137
			Adult	32	7.92	
1943–44..	145	1,053*	Juvenile	87	6.31	56
			Adult	107	11.26	
1944–45..	246	942	Juvenile	106	17.46	173
			Adult	25	10.08	
1945–46..	172	410	Juvenile	39	19.90	87
			Adult	26	22.81	

* Although this figure is based on a smaller sample than in most other years, field observations and data collected subsequently indicate that it is a close approximation of the actual kill ratio.

Table 44.—Calculated kill of juvenile Canada geese at Horseshoe Lake, 1942–43 through 1945–46, exclusive of crippling losses.

Season	Number of Juveniles in Flock (See Table 27)	Total Kill, All Ages	Per Cent of Bag Made up of Juveniles	Calculated Number of Juveniles in Bag	Per Cent of Total Juveniles in Flocks Bagged by Hunters Near Horseshoe Lake
1942–43.....	32,450	6,529	72.1	4,707	14.5
1943–44.....	29,680	12,062	91.3	11,013	37.1
1944–45.....	22,316	7,807	90.4	7,058	31.6
1945–46.....	10,534	5,244	80.4	4,216	40.0

each of these years are given. In the autumn of 1942, when only 2.59 juveniles were shot for every adult, the survival rate of juveniles was evidently favorable to this age class as 10.82 per cent of the total banded juveniles returned to the traps in the following year as compared with 7.92 per cent of the adults, or a ratio of 1.37 juveniles to 1.0 adult.

In contrast to this survival picture is the highly differential kill that occurred in 1943 when the ratio of juveniles to adults shot at the hunting clubs surrounding the refuge was 10.53 to 1.0, table 43. The next year the return to the traps was only 0.56 juvenile (then yearling) to 1 adult. Despite the fact that juveniles bore the brunt of the kill in 1944, table 44, the net loss to the juvenile segment of the population was somewhat less, with the result that the ratio of juvenile (then yearling) to adult returns in the traps a year later, in 1945–46, was 1.73 to 1.0, table 43.

A relatively high kill of juveniles coupled with a year in which productivity is low is almost certain to place a goose population in a hazardous position. Banding at Horseshoe Lake indicated a decrease in productivity in 1945 from the productivity in 1944, table 43. The relatively small number of young produced in 1945 may have been related in part to the cold weather in the spring of that year; the productivity of mallards also was greatly reduced in that year. A depressive effect on the intensity of mating or on nesting success in many species of birds has been attributed to late and cold springs. The following species said to be affected thus might be cited: Canada goose (Johnson 1947); arctic tern (Lack 1933); eiders and loons (Bird & Bird 1940); moor hen (Huxley 1932); and house wren (Kendeigh 1942).

However, it is conceivable that part of the decrease in productivity in 1945 may have been apparent rather than real. Undoubtedly juveniles contribute a larger proportion of the kill during migration than do the adults, but the extent to which shooting north of the Horseshoe Lake Game Refuge is selective of juveniles is not known. Because the kill between the refuge and the Canadian border in 1945 was much larger than usual, the age ratios in the southward-bound flocks may have been significantly altered by shooting in that particular year.

The subject of cycles in waterfowl is still largely an unexplored field. It does not appear to be known generally that, in the arctic, geese, ducks, and loons may be subject to nonbreeding years (Manniche 1910, Bertram, Lack, & Roberts 1934, Bird & Bird 1940). Keith (1937) writes, ". . . . 1936 was a 'non-breeding year' [in Northeast Land, Spitzbergen Archipelago] when large numbers of Ducks and Geese failed to nest; and in other parts of the Arctic it had always before been found that the Divers [loons] were also affected by these years and that of them too only a small proportion were breeding." As nonbreeding of waterfowl has been reported only from high arctic areas, it is debatable whether the Canada goose populations dealt with here are similarly affected.

At present, low productivity in blue geese and snow geese appears to be confined to summers in which inclement weather directly affects the success of nesting (Soper 1930). In the opinion of Berry (1939), "climate is of the utmost importance in limiting the survival rate of goslings on the northern breeding grounds."

A year of low productivity in Canada geese should be of particular concern to the administrators who seek to influence the kill by hunting regulations, for the reason that the young birds bear a double responsibility. Being more vulnerable to shooting than the adults, they must contribute a disproportionate share of the kill, and, secondly, they must survive in sufficient numbers to help reproduce an equivalent of the annual loss in the breeding population. Even in a year when the production of young was not significantly low, 1943, shooting losses in the Horseshoe Lake area were so severe and so greatly at the expense of the juveniles that only a small proportion of this generation survived to reach the minimum breeding age of 2 years.

Management

What can be done to insure the future of the Mississippi Valley geese? Until recent years, two prime measures for con-

serving waterfowl, hunting regulations and refuges, have been fairly successfully used in the management of this group. As applied to the population of geese dealt with in this report, it is apparent that these measures were not very effective in the period of field work.

In Canada.—Several factors minimize the need for any immediate change in measures relating to the Mississippi Valley population while in Canada. The relatively inaccessible nature of the Canadian breeding grounds insures adequate protection for the flock during the actual breeding season.

The kill in Canada is not excessive, and a reduction of the early spring kill on the breeding grounds would be difficult because much of this kill is virtually necessary for the survival of native Indians. Furthermore, our kill and population data indicate that the annual rate of kill (the percentage of birds taken from the returning population in the spring) by the Indians is relatively constant. In general, only when there is an actual increase in the Canada goose population does a significant increase in the number of these geese bagged by Indians occur. This relatively constant relationship is evidence that the goose kill by natives cannot be considered the direct cause of any considerable population decrease that might be reported in the United States from any of the annual January inventories.

In the United States.—In 1944 and 1945, when season bag limits were imposed for Alexander County, Illinois, table 10, it was a relatively easy matter to limit the kill of geese in the Horseshoe Lake area to approximately the predetermined figures. The facility with which the day-to-day kill can be tallied is perhaps the outstanding advantage of encouraging a portion of the flock to utilize the refuge there. The season bag limit in the above instances was determined by the trend of the population in prior years, but, to be fully effective, management should anticipate future trends based upon the current composition of the population. With the data at hand on the Canada

Table 45.—Calculated losses and reproductive gains for the Horseshoe Lake Canada goose flock between the autumn of 1944, and the autumn of 1945.[1]

CLASSIFICATION	TOTAL ADDED (YOUNG PRODUCED)	TOTAL LOST	BALANCE (TOTAL SURVIVING)
Flock arriving at Horseshoe Lake in the autumn of 1944 (includes 6,885 yearling and older females)			40,500
Number lost from hunting at Horseshoe Lake (includes 525 yearling and adult females)		10,550	
Maximum number flying north in spring (includes 6,360 females older than 1½ years of age)			29,950
Kill by Indians in the Hudson-James Bay area[2] (includes 277 females 2 or more years of age)[3]		2,100	
Natural losses for year at 18 per cent of 40,500 (includes estimated 1,000 adult females)[4]		7,290	
Total yearlings and adults alive after breeding season (includes 5,083 adult females)			20,560
Number of young brought to flying stage (3 per adult female)	15,189		
Approximate total at start of autumn migration			35,749
Kill by hunters in flyway north of Horseshoe Lake (at 6 per cent of southward flight)[5]		2,135	
Number calculated to arrive at Horseshoe Lake in 1945			33,614
Actual number to arrive at Horseshoe Lake in 1945 (inventory figure, January, 1946, plus total hunting loss in area)			29,100

[1] In most cases calculations are based on actual data, in others on estimates.
[2] Proportional share of total kill suffered by the Horseshoe Lake flock.
[3] Vulnerability of yearlings 2.8 times that of older geese; kill of adult females should not exceed 13 per cent of the total loss.
[4] The loss rate from natural causes tends to be inversely related to the losses from hunting.
[5] The kill of Canada geese between the Canadian border and Horseshoe Lake was particularly heavy in 1945; hence, the actual kill for that area probably exceeded 6 per cent of the southward flight. For reasons explained in footnote on page 150, the actual kill rate in this area in most years is probably closer to 8 or 10 per cent of the southward flight.

goose in the Mississippi River valley, it is possible to arrive at a practical estimate of the maximum kill that can be tolerated.

A method by which management of the Mississippi Valley population might proceed is best illustrated by a concrete example, table 45. Similar calculations based on sex and age ratios from trapping, and made by the authors in the spring of 1945, forecast a decreased population for the autumn of 1945. Censuses during the autumn and the inventory of January, 1946, proved the accuracy of this prediction.

Since the autumn flight in any year depends to a large extent on the production of young in the spring of that year, it is necessary to know the approximate number of breeding females and to have some measure of the nesting success on the breeding grounds to predict the autumn flock population with reasonable accuracy. Inventory on the breeding grounds would be difficult because of the nature of the terrain, but the use of planes would aid tremendously in such work. For the present, and until more data are available, the average productivity of the population might be calculated on the basis of three young (brought to flying stage) per adult female.

If the flock population has been fairly stable for several years or is on the increase, a bag of 10 per cent of the number wintering in the Horseshoe Lake area might prove to be within the limits of what the flock could stand without decreasing in size. Even this kill might be too high if kills north of Horseshoe Lake were unusually large in a given autumn, if nesting success was low the previous spring, or if sex and age ratios were seriously unbalanced. When the population is very low, the kill of a single bird constitutes overshooting.

A reduction in the crippling loss would allow the season bag limit in the Horseshoe Lake area to be increased. The number of geese crippled and lost to hunters each year in the area is needlessly high. An estimate of cripples not retrieved and soon dying is placed at 30 per cent of the number of geese bagged. Certain administrative measures can be taken to reduce the per cent of cripples not retrieved. For instance, adequate spacing of pits to reduce competition among hunters would materially aid in reducing crippling losses. But a large share of the responsibility will rest with the hunter himself, who must restrain the natural desire to "give a high one a ride." Some hunters hope to bag geese with greater ease by using magnum shotguns. However, it is open to debate whether more geese are bagged than crippled by such guns because of the out-of-range shooting their possession encourages. At least in one instance a 10-gauge magnum shotgun is known to have failed to live up to its owner's expectation; a tally of empty casings from this shotgun in one pit, presumably fired to bag the limit of two geese, was 22, as against the average of 9 cartridge casings per hunter for all pits inspected.

It is clear from tables 15 and 10, showing kill and hunting regulations in the Horseshoe Lake area, that hunting restrictions were not always successful in reducing the kill to the desired extent, but, if various measures instituted to lower the annual kill had not been taken, it is probable that a large proportion of the Canada geese using the Horseshoe Lake area would have been shot by the end of 1945.

Under normal conditions, the duration of the hunting season can be expected to show a fairly direct relationship to the kill, but, when the natural wariness of the geese has been reduced, as at Horseshoe Lake, the length of the hunting season may show no correlation with the kill, figs. 52 and 53.

Pirnie (1939) has emphasized that "Changing habits of these birds [Canada geese] may create new hazards for them and require even more stringent regulations." The behavior of the Horseshoe Lake flock in recent years and its relation to shooting has already been discussed, but it should again be emphasized that restrictions alone cannot be expected to safeguard it.

Refuges form an important part of our system for the preservation of waterfowl. Whether or not any individual refuge proves of value will depend to a certain extent upon its management and also upon its size. Leopold (1931) stated the chief problem in regard to the Horseshoe Lake Game Refuge soon after this refuge was

created. "The question of whether public refuges should be surrounded by public shooting grounds is frequently debated. Horseshoe Lake in Alexander County, Illinois, is a good place to study the question."

Twelve years after this statement was published the answer was forcibly given by Gabrielson (1943). "Because of its [Horseshoe Lake Game Refuge] attractiveness to Canada geese, small size, lack of food, and peculiar relation to surrounding lands, it has become a slaughter pen rather than a refuge."

The breakdown in wariness that occurred was perhaps more serious to the future of the Horseshoe Lake flock than the reduction in its size. The steps believed necessary to re-establish wildness in the flock were as follows: (1) Establish refuge areas on the nearby islands and bars of the Mississippi River or on lands adjacent to the river; (2) disperse the geese from Horseshoe Lake to these bars and islands; that is, drive them back to their original habitat; (3) insofar as possible, reduce contact between human beings (both the public and refuge personnel) and the geese.

In the past years in which the geese used both the river bars and the refuge, they retained their natural wildness; coincident with their almost complete dependence on the refuge for food and grit, they lost much of their wildness. The river refuge might act as a final sanctuary for the flock should it be disturbed for any reason at Horseshoe Lake, and ideally it should contain the bulk of the flock at most times.

Canada geese will feed by moonlight, at daybreak, or at dusk, if they are disturbed while feeding during the day. This fact may offer a partial solution to the Horseshoe Lake problem. If the geese were permitted to feed at the Horseshoe Lake Game Refuge only during the hours of dawn and dusk, the re-establishment of wildness might occur and with it a reduction in the rate of kill. We have a precedent for such a course of action in the operation of the Miner Sanctuary, where the geese feed only in the early morning hours and at dusk, spending the remainder of their time roosting out on Lake Erie.

State regulations just previous to 1946 prohibited the placing of shooting pits within 75 to 150 yards of the boundary of the Horseshoe Lake Game Refuge. This buffer zone, which was intended to allow the geese to attain safe heights before reaching the shooting pits and blinds was unquestionably insufficient, since many of the geese leaving the refuge encountered shot pellets 75 yards away from the first line of pits. Although the Miner Sanctuary consists of only 400 acres and supports an even greater density of geese than is ever experienced at Horseshoe Lake, excessive kills have not occurred near this Canadian refuge in late years. Responsible in part for the small kills reported in the vicinity of the Miner Sanctuary is a buffer zone that surrounds the ponds and feeding grounds for a distance of a mile. When geese leave the refuge, they have sufficient space in which to gain altitude before passing over the shooting grounds.

The present food resources of the Horseshoe Lake Game Refuge are insufficient to winter more than 20,000 geese, and probably only 15,000 can be accommodated to best advantage. When the corn crop and wheat browse on the refuge are exhausted, and sometimes before this occurs, the flock feeds on unharvested and waste grain and on the green plants of winter wheat in fields of the surrounding countryside—occasionally at a considerable loss to farmers who do not rent their fields to hunters. Unless the flock is broken up and scattered to other areas in the flyway, the local food conditions must be improved, either through the acquisition of more land or by an artificial feeding program. The artificial program is wholly undesirable unless it is carried out on an isolated tract of land. On the other hand, the development of a river refuge would certainly increase the flock's usage of natural foods—the grasses, sedges, and switch willows on which the geese formerly fed.

The present size of the Horseshoe Lake Game Refuge is woefully inadequate for the geese using the area, as experiences there and elsewhere have demonstrated. A program involving purchase of additional lands has been planned by the State Department of Conservation for several years, but has been blocked by the inflated prices of lands in the area—inflated

prices resulting in part from the commercialization of goose hunting.

Census data showed that, between 1942 and 1945, the Canada goose in the Mississippi River valley suffered a marked decline in population. Kill records showed an increase in the annual bag beginning in 1939, and banding data revealed a concurrent decrease in goose survival for the same period. The conclusion must be reached that the Mississippi Valley Canada goose population was shot too heavily in that period and that stringent protection was necessary to insure perpetuation of this population.

PRESENT SITUATION

The time lapse between completion of the field work reported here and publication of this article has been sufficient to permit an evaluation of some of the measures recently taken to assure the future of the Canada goose population of the Mississippi River valley. The decision to close the valley to Canada goose hunting in 1946 was based partly on evidence gained from banding that the geese wintering at the Horseshoe Lake Game Refuge were suffering unprecedented losses from hunting and were being killed at a rate far greater than the flock could stand and still maintain its numbers. In addition was the evidence from annual inventories that the flyway population was at an alarmingly low level.

In 1947, the shooting of Canada geese was again permitted in the Mississippi River valley, but on a restricted scale. The season opened on November 4 and closed on December 3. The bag limit was reduced to one bird per day and the possession limit was also one bird. To insure against a return of heavy kills in the Horseshoe Lake region, an area in the region totaling approximately 15,000 acres was declared closed by proclamation of the President of the United States with the joint support of the Governor of Illinois. By this action, a buffer area, roughly 2 miles in depth, was created around the Horseshoe Lake Game Refuge. In 1948, the hunting season opened on October 29 and closed November 27. During this 30-day season, hunters were permitted to bag two Canada geese per day and were allowed a possession limit of two birds.

The response by the geese to greater protection has been most heartening, their comeback demonstrating both that the kill by hunters in the United States was a major suppressive factor on the population, and that this population, given opportunity, possesses strong recuperative powers. With a capital investment of 49,000* birds in the Mississippi flyway in the winter of 1945–46, interest in the form of 1946 reproduction was reinvested as capital gain by virtue of the closed season. Inventory in January, 1947, revealed a capital gain of approximately 25 per cent, table 7. This recovery by an almost bankrupt population so encouraged the committee on regulations that a dividend, in the form of an open season, was declared permissible for the autumn of 1947 and again for the autumn of 1948. The dividend in the Horseshoe Lake area in 1947 was 1,644 geese bagged by hunters; in 1948 it was 2,587 geese bagged by hunters. In addition to this number, other geese, estimated at 2,000, were shot illegally within the buffer area closed to hunting outside the refuge. We do not have the data at hand to show what the profits were to hunters in other states in the flyway, but that the goose business could afford the dividends is shown by the recent summary of capital stock given in table 46.

The recovery made by the Mississippi Valley population has not gone unnoticed by the Indians who trap and hunt on the breeding grounds before the actual commencement of nesting. In August, 1949, the senior author learned at Fort Albany that the Indians there had observed more geese in the spring of 1949 than at any other time in recent years. Similarly, questionnaire answers received from Raymond M. Alaine of Weenusk, September 21, 1949, stated that the Indians at that post had not seen as many geese in any other years of the last 10 as they did in the fall of 1948.

Future management of the Horseshoe Lake flock by the United States Fish and

* This figure includes geese from western Louisiana, birds that possibly belong to the Eastern Prairie population and that should not be included in the Mississippi Valley population. Hence, it exaggerates the size of the Mississippi Valley population for 1945-46.

Table 46.—Population of Canada geese in the Mississippi River valley in 1947–48 and 1948–49, from January inventory, except as noted.

State or Other Area	Season	
	1947–48	1948–49
Michigan	5,000	6,000
Wisconsin	4,200	4,760
Indiana	1,679	7,449
Illinois (total)	57,205	90,414
Mason County	—	960
Horseshoe Lake	—	46,000
Craborchard Lake, Williamson County	—	30,000
Lyerly Lake, Union County	—	12,450
Miscellaneous areas	—	1,004
Kentucky	1,500	7,200
Mississippi	5,500	7,250
Tennessee	2,500	9,450
Arkansas	9,000	12,000
Missouri	—	5,000*
Louisiana	10,000	10,000
Total	*96,584*	*159,523*

* Most of these geese were a part of the flock wintering in the Horseshoe Lake area.

Wildlife Service and the Illinois Department of Conservation envisions the breaking up of this concentration and dividing it among four other refuge areas: Craborchard National Wildlife Refuge, Williamson County, Illinois; Lyerly Lake State Refuge and Public Shooting Grounds, Union County, Illinois; the Mingo National Wildlife Refuge, Missouri; and the Kentucky Woodlands National Wildlife Refuge bordering the Tennessee River south of Paducah, Kentucky. To implement the dispersal of geese from Horseshoe Lake, planes, guns, bombs and various other pyrotechnic devices were used to frighten the geese in 1947, 1948, and 1949. That this dispersal program is meeting with success is evident from the data presented in table 46. Provided with these other areas, an ample food supply, and adequate legal protection, the Canada goose population in the Mississippi valley faces a future that seems assured for some years to come.

SUMMARY

1. The Horseshoe Lake Wildlife Refuge, located at the southern tip of Illinois near Cairo and created in 1927 by the Illinois Department of Conservation, totals approximately 3,700 acres.

2. Soon after the refuge was formed, increasing numbers of Canada geese, decoyed from their traditional wintering grounds along the Mississippi River by the food and protection offered, began to use this refuge. In most recent winters the refuge has attracted about 50 per cent of the Mississippi Valley Canada goose population. With the increase in the size of the flock at the refuge, there was a loss of wariness on the part of the geese, accompanied by a tremendous increase in the annual kill.

3. In the eastern half of the United States there are two subspecies of Canada geese. The easternmost race, *Branta canadensis canadensis,* comprises the geese of the North Atlantic population. The other race, *Branta canadensis interior,* which breeds principally west, south, and east of James and Hudson bays, is composed of four subgroups, each of which constitutes a separate flyway population. The four subgroups are as follows: the South Atlantic, the Southeast, the Mississippi Valley, and the Eastern Prairie.

4. The main breeding range of the Mississippi Valley geese is believed to lie within the western limits of the Paleozoic Basin west of James Bay and south of Hudson Bay. The majority of the nesting geese of this population are found in relatively restricted areas of the vast, low-lying, muskeg-covered plain of the region.

5. Aerial observations revealed that the type of muskeg attracting the greatest numbers of geese is one that is studded with potholes of a few acres to about 30 acres in size, so closely grouped that often only a narrow strip of land or floating vegetation separates one from another.

6. Most nesting pairs of Mississippi Valley geese are concentrated in production centers, but, as most of these production centers are of considerable size, scattered nesting, with one or two pairs to a small lake, seems to be the rule west of James Bay and south of Hudson Bay.

7. Before the southward migration of Mississippi Valley geese begins, about August 15, some family groups and small flocks begin a series of local flights, the termini of which are favored feeding grounds along the west coast of James Bay and the south coast of Hudson Bay, the tundra of Cape Henrietta Maria and the coastal marsh of Akimiski Island. The

tundra of Cape Henrietta Maria is favored because of the quantity of berries usually available there.

8. At least half of the Mississippi Valley geese do not fly to the coastal areas before migrating, but leave directly from their muskeg breeding grounds and strike south on a broad front. These are believed to be the geese that cross the Canadian border into eastern Minnesota and the upper peninsula of Michigan.

9. While probably at least a few Canada geese in migration pass over most areas of the Mississippi flyway each year, band recoveries and observations indicate that the following routes are most frequently used: from the Miner Sanctuary to Horseshoe Lake via Lake St. Mary, the Wabash and Ohio rivers; from Saginaw Bay southwest across the lower peninsula of Michigan to the W. K. Kellogg Bird Sanctuary area and the lower Kalamazoo River; southward along both shores of Lake Michigan. Migration through Wisconsin is principally in the eastern half of the state. The west shore of Lake Michigan is followed by appreciable numbers of geese. Two other routes appear to be favored: (1) the valley of the Wisconsin River; (2) Green Bay south to Lake Winnebago, the flight probably splitting south of Lake Winnebago, one section going to the Lake Geneva area, the other following the Rock River valley. Migration through Illinois appears to take place on a fairly broad front although the Illinois River valley is particularly favored.

10. Band-recovery data indicate that turnover in the population wintering at Horseshoe Lake is negligible. Geese that are decoyed into this refuge usually remain there for the rest of the season.

11. A portion of the Mississippi Valley geese migrating through the Kingsville, Ontario, region do not visit the Horseshoe Lake Refuge but by-pass it to the east, probably via the Tennessee River, and winter on the lower Mississippi.

12. The northward migration in spring is more nearly on a directly north and south axis than routes taken in the autumn. The flights of Mississippi Valley geese that stop at the Miner Sanctuary in the autumn do not reappear there in the spring in appreciable numbers; presumably they return to the breeding grounds by a more westerly route. The spring flights through the Kingsville region are comprised chiefly of South Atlantic geese.

13. Autumn migration of Mississippi Valley geese occurs over a 3-month period; the last geese to reach Horseshoe Lake in appreciable numbers arrive in early December. Much of the late flight represents the exodus of geese from the Miner Sanctuary when feeding there is curtailed.

14. The southward movement of the Canada geese from the breeding grounds may be compared with a segment of the concentric waves produced by an object striking the surface of a body of water. Geese that leave the breeding grounds earliest are believed to winter in the most southerly areas of the flyway. Those that leave the breeding grounds last are believed to winter in the most northerly areas of the wintering grounds.

15. In spring, the first flocks generally arrive on the breeding grounds between April 15 and 25, 2 to 3 weeks before the breakup of the major rivers.

16. Winter concentrations of Canada geese occur in the region of Kingsville, Ontario, westward to southern Wisconsin, and south to the Gulf Coast.

17. Although the Canada goose is widely reputed to be an extremely wary and difficult species to hunt, the behavior of this species at Horseshoe Lake in recent years has contradicted this reputation. Believed responsible for the high vulnerability of Canada geese to shooting in the vicinity of this refuge are the psychologically pacifying effect of large numbers of geese at rest on a relatively small area; the frequent sight of man in a benign role; and the decreased mobility of the flock when food is abundant on the refuge, as well as on adjacent hunting areas.

18. Goose hunting in Illinois, once a sport carried out in widely scattered areas of the state, is now confined largely to the Illinois River valley and the Horseshoe Lake region.

19. In the period 1944 through 1947, the kill of Canada geese of the Mississippi flyway by Canadian Indians is computed to have been between 4,000 and 5,500 or from about 8 to 10 per cent of the number of birds that attained the breeding grounds in the spring. Approxi-

mately 25 per cent of the total number of Mississippi Valley Canada geese bagged in recent years have been taken by Indians.

20. The waterfowl kill made by the Indians of the James Bay region is sometimes vital to actual survival of the Indians. Blue geese and snow geese greatly outrank the Canada goose in importance during the fall hunt along the coastal marshes; in spring, when the Indians are trapping inland along the rivers and creeks, the principal kill of Canada geese occurs, while relatively few blue geese and snow geese are shot at this time.

21. The restocking of beaver in some areas of the Canadian goose breeding range is beginning to relieve some of the hunting pressure on Canada geese.

22. The kill in the Horseshoe Lake area first began greatly to exceed what the flock could stand in 1939 when a kill of 17,300 geese was made. The average number of geese bagged in the Horseshoe Lake area in the autumns of 1939 through 1945 was about 9,800. In the autumns of 1943, 1944, and 1945 the bag amounted to 23, 19, and 18 per cent, respectively, of the number of geese that arrived at the refuge in those years.

23. The annual bag of geese in Illinois in areas other than Horseshoe Lake averaged approximately 1,100 birds in the period covered by this report.

24. Next to Illinois, Michigan made the largest kills of Mississippi Valley geese, 1938–1944; the annual bag was probably between 1,000 and 3,000 birds.

25. Bag inspections at hunting clubs near Horseshoe Lake showed that juvenile geese made up a high percentage of the total kill, 1940–1945. In 1943, juveniles were about eight times as vulnerable to hunting as adults.

26. Crippling losses among geese at Horseshoe Lake in recent years are estimated to have been equivalent to about 30 per cent of the annual bag.

27. Causes of death among Canada geese at Horseshoe Lake include lead poisoning (from ingestion of lead pellets), bound crop (perhaps a result of lead poisoning), tracheitis, and aspergillosis.

28. Sex ratios obtained from trapping geese at Horseshoe Lake show that there were slight, but statistically significant, larger numbers of males than of females in the juvenile and adult age classes, 1940–1946. Bag-inspection figures showed no significant preponderance of either sex in either age class, 1940–1945.

29. Nesting success of geese is not appreciably affected by the Canadian Indians, since the bulk of the kill is made in early spring before geese have begun to nest. Foxes may have a slight effect on nesting success when their other prey species, which appear to be cyclic, are low in numbers.

30. In 7 years of trapping and bag inspection at Horseshoe Lake, the age ratios obtained varied from 57 to 204 juveniles per 100 older geese. In 1944–45, trapping indicated that 55 per cent of the population consisted of juveniles. Trapping in the following year indicated that the proportion of juveniles had dropped to 36 per cent.

31. Average flock size, computed from frequency counts of flocks of nine or fewer geese on the wintering grounds, may provide a quick means of appraising breeding success of geese in the previous spring.

32. Low survival of Canada geese banded at the Jack Miner Bird Sanctuary, 1940–1944, is believed to have been brought about chiefly by the tremendous increase in the kills made in the region of Horseshoe Lake.

33. Mortality data calculated from trapping and band-recovery figures show that the Horseshoe Lake flock had a lower survival rate during the period of this study than did comparable banding classes from the Miner Sanctuary.

34. Mortality indices, the average of mortality rates for three years after banding, provide a possible basis for comparing mortality between different populations and banding classes of geese.

35. Survival data for the Horseshoe Lake flock, 1941–1945, indicate that the average juvenile did not live long enough to produce a brood of young.

36. In 1946, no open hunting season on Canada geese was permitted in the Mississippi River valley. In 1947, shooting on a restricted scale was permitted.

37. Increased protection of the Mississippi Valley Canada geese plus certain other management practices resulted in an appreciable gain in the population by the fall and winter of 1948–49.

APPENDIX A

THE SOUTHEAST POPULATION

ONE of the important findings from our study of the Jack Miner banding data, as they relate to the Horseshoe Lake problems, is the existence of a distinct and heretofore unrecognized group of Canada geese that winter in the inland areas of Virginia, North Carolina, South Carolina, Georgia, and Alabama and on the Gulf Coast of Florida. Because management of the Mississippi Valley goose population should be guided to some extent by a knowledge of neighboring goose populations, it seems desirable to include in this paper a brief summary of the breeding and wintering ranges, as well as the migration paths, of the Canada geese of the newly defined group, to which we have given the name Southeast population.

Breeding Range

To date there have been no recoveries of Horseshoe Lake goose bands in the Moose River district of James Bay or at the extreme south end of this bay, while fair numbers of bands have been recovered in that region from geese banded at the Jack Miner Bird Sanctuary near Kingsville, Ontario. Large numbers of Miner bands from the autumn flight have been recovered in the inland portions of the southeastern states. It appears from band recoveries that the Southeast geese nest from the country drained by the Moose River, south and east to the Nottaway or Rupert river country. In an area north of the Moose River, the breeding grounds of these geese merge with those of the Mississippi Valley population; east of the Nottaway River, or Rupert River, they merge with the nesting grounds of the South Atlantic geese, most of which migrate through the Kingsville area only in spring.

Census data on the flyway of the Southeast population are meager. Because the scattered flocks were not recognized as components of this distinct population, their significance was lost in the usual method of lumping census figures by states. Population figures presented below are from three sources: letters to Jack Miner from local sportsmen or officials; personal conversation with W. P. Baldwin, Jr., United States Fish and Wildlife Service biologist, stationed at Port Wentworth, Georgia; and records in the files of the Division of Refuges, United States Fish and Wildlife Service. Following is a summary of the wintering grounds of the Southeast population, as indicated by band recoveries and other data.

Migration Routes

In the autumn migration, the range of the Southeast population overlaps that of the Mississippi Valley population between James Bay and the Miner Sanctuary. At the latter point, however, band recoveries indicate that the birds of the Southeast population split off from the Mississippi Valley population and fan out south and southeast over a number of courses. The paucity of recoveries between the Miner Sanctuary and the eastern and southern slopes of the Appalachian Mountains suggests that most of the geese of the Southeast population make few stops en route to their wintering quarters.

The routes taken by these geese on their northward migration are probably mainly to the west of their autumn migration paths, as band recoveries show that comparatively few of the birds retrace their autumn flight through the Kingsville, Ontario, region.

Winter Concentrations

The wintering grounds of the geese of the Southeast population lie mainly in the Piedmont region east and south of the Appalachian Mountains, and in some parts of the coastal plain. The wintering range can be better understood if the distribution of the recoveries from the southeastern states in figs. 12–21 is compared with the physiographic features of these states shown in fig. 81. Band recoveries show that geese resort to nearly every river of appreciable size that dissects the Piedmont and the coastal plain, but that the numerous reservoirs are particularly favored. The coastal

Fig. 81.—Map of the wintering grounds of the Southeast Canada goose population.

wintering range of the South Atlantic geese and the inland wintering range of the Southeast population are clearly indicated in figs. 6, 12, and 14–21.

Virginia.—Band recoveries from Canada geese banded at the Miner Sanctuary in the autumn indicate that the Southeast flyway geese wintering in Virginia concentrate in certain counties bordering the James River: chiefly Fluvanna, Goochland, Henrico, and Charles City. To a lesser extent these geese use the Mattaponi, Pamunkey, Roanoke, and Rappahannock rivers.

In a letter to Jack Miner, January 8, 1945, A. W. Smith of Richmond, Virginia, stated that about 2,000 geese frequented the James River, and another flock of about 1,500 were to be found on the Pamunkey River. As many as 15,000 geese have spent the winter in the region of Hopewell, Prince George County, according to A. P. Cutchin, a deputy warden of the United States Fish and Wildlife Service in 1939 (letter to Jack Miner from A. P. Cutchin, Atlanta, Georgia, December 9, 1939).

North Carolina.—In this state, the counties adjoining the reservoirs on the Yadkin (chiefly High Rock, but also Narrows Lake and the Norwood dam impoundment), the Catawba (Oxford reservoir), and the Rocky rivers are the principal wintering grounds of the Southeast population in North Carolina, as band recoveries indicate. According to Pearson *et al.* (1942), the reservoirs of the Yadkin River form the most important of these water areas. They report that William Birsch of the United States Fish and Wildlife Service has estimated that in one year 10,000 geese wintered in that section of the state (year of report not stated).

The Canada goose population using High Rock Lake in recent years has numbered about 600, according to W. P. Baldwin, Jr., of the United States Fish and Wildlife Service. He reports that the flock wintering

along the Great Pee Dee River and at Ansonville has recently totaled about 3,000 (personal communication, March, 1949).

South Carolina.—Pickens (1928) reported the Canada goose to be a common winter resident in upper South Carolina, a statement that is amply supported by the Miner returns of autumn-banded geese. According to Ernest F. Holland, manager of the Carolina Sandhills National Wildlife Refuge (letter to the Jack Miner Bird Sanctuary, December 18, 1946), about 5,000 Canada geese used this refuge and the adjacent Great Pee Dee River basin in the late autumn of 1945. An additional 2,500 were reported using the private waterfowl refuge of Lockhart Gaddy, located near Ansonville, North Carolina. Judged from band recoveries, Lake Murray, an impoundment of the Congaree River, is probably one of the more important bodies of water for Canada geese in South Carolina. Wateree Pond, a much smaller reservoir on the Wateree River, appears to be second in importance. Other rivers used by geese are the Broad, the Saluda (Lake Greenwood), and the Savannah (from Anderson to Aiken counties).

In several years prior to the winter of 1948–49, about 200 Canada geese wintered in the vicinity of McBee in Chesterfield County and about 250 on Lake Murray (W. P. Baldwin, Jr., personal communication, March, 1949). Another 300 frequented the section of the Savannah River bordering McCormick County. The Santee Cooper Reservoir area harbored about 250 Canada geese, the Cape Romain sector of the Atlantic Coast about 500, and Winyah Bay a small but unknown number. The Winyah Bay flock may be only a segment of the Cape Romain flock that segregates out from time to time. Data on populations at the Santee Cooper and Cape Romain National Wildlife refuges in other recent years are given in table 47.

Alabama.—According to Howell (1924), Canada geese in Alabama are "probably most abundant on the Tennessee River in the vicinity of Muscle Shoals." They are "numerous every winter in the vicinity of Montgomery. On the coast they apparently are not common, though found occasionally." Since 1942, 300 to 900 Canada geese have been reported wintering in the vicinity of the Wheeler Reservoir, according to data in the files of the United States Fish and Wildlife Service.

Sixty per cent of the Miner-banded geese reported killed in Alabama were shot in Tallapoosa, Coosa, and Elmore counties. Over half of the recoveries from these three counties are from the vicinity of Martin Lake, an impoundment of the Tallapoosa River; the remaining returns from these counties are from areas adjoining the Coosa

Table 47.—Numbers of Canada geese wintering at three national wildlife refuges in the Southeast flyway, 1934–1945.

Year	Refuge					
	St. Marks		Cape Romain		Santee Cooper	
	Season	Number	Season	Number	Season	Number
1934–35	Winter	5,000	Winter			
1935–36	Winter	6,000				
1936–37	Winter	9,500				
1937–38	Winter	13,500				
1938–39	Winter	13,500	Winter	300		
1939–40	Winter	6,500	Winter	27		
1940–41	Winter	11,500	Winter	50		
1941–42	Winter	12,000				
1942–43	Winter	11,000	Winter	60	Fall	10
					Spring	20
1943–44	Winter	13,000	Winter	83	Fall	120
					Spring	50
1944–45	Winter	15,000	Winter	196	Fall	80
					Spring	50

River impoundments (Lay, Mitchell, and Jordan lakes). The flock wintering on Martin Lake numbered about 400 in the winter of 1939–40 (letter to Jack Miner from C. Robinson of Alexander City, Alabama).

Georgia.—Band recoveries from Georgia are spotty, suggesting that no great concentrations of geese occur anywhere in the state, possibly in part because of the comparative lack of large reservoirs or natural lakes. The Savannah River from Hart County to Richmond County appears to be a favored wintering area; the Ocmulgee (Lloyd Shoals Reservoir between Jasper and Butts counties), the Oconee (Washington and Laurens counties), and the Flint River (Pike, Upson, Taylor, and Crawford counties) are other sectors used by Canada geese.

Many of the recoveries from Georgia, however, may be from migrating geese rather than from wintering flocks. As a number of the recoveries are from areas of the state directly north of the St. Marks National Wildlife Refuge on the Florida Gulf Coast, it seems likely that birds en route to St. Marks contribute appreciably to the kills made in Georgia.

In 1941, 150 to 200 Canada geese were reported using Lake Harding, an impoundment created by Bartletts Ferry dam on the Chattahoochee River near West Point (letter to Jack Miner from William B. Fuller, West Point, Georgia, January 10, 1941).

Florida.—The St. Marks National Wildlife Refuge, consisting of 54,681 acres, is believed to contain the greatest single concentration of geese in the Southeast population. Although between 11,000 and 15,000 geese have wintered at this refuge since 1941, table 46, there have been singularly few band recoveries from Miner-banded geese in the surrounding country. This fact suggests that either the bulk of these geese by-pass the Miner Sanctuary on their southward migration, and hence are not banded, or that the kill in the St. Marks area is relatively small. From about 10,000 geese wintering along a 100-mile stretch of coast during the late twenties, the annual kill was said to be several hundred (letter to Jack Miner from R. G. Porter, Apalachicola, Florida, winter of 1927–28).

Future Status

Although the Canada geese of the Southeast population winter over an enormous area, extending from Virginia to Alabama and the Gulf Coast of Florida, their total number is not large. With the exception of the flock in the St. Marks area, most of the concentrations can be classified as being either small to medium in size and, in the aggregate, may match the St. Marks flock in size. Therein may lie the security of the Southeast population. The small concentrations, by virtue of their size, do not attract other than local hunters, whose kill is probably fairly light. The paucity of band recoveries from the St. Marks area suggests the possibility that the flock there is afforded adequate protection by the St. Marks National Wildlife Refuge.

In any management measures involving the Southeast population, recognition should be given to the fact that the scattered flocks are but segments of a more or less contiguous population on the breeding grounds. These segments should be carefully censused at the time of the annual January inventory and the extent of the kill in each wintering area should also be determined within fairly close limits. To help insure the perpetuation of this population, it may be necessary to declare at least a portion of all reservoirs important to wintering geese, and some adjacent land areas, inviolate to hunting.

Insofar as their habitat requirements in winter are concerned, Canada geese can be considered adaptive birds. They are quick to respond to changing agricultural practices, to the creation of reservoirs, and to the formation of new refuges by changes in their habits and their local distribution. W. P. Baldwin, Jr., reported (personal communication, March, 1949) that increasing numbers of Canada geese are wintering in northern Georgia, where they are resorting to the cultivated fields. At least some of these geese in former years must have migrated down to the St. Marks area. Such "reshuffles" in the population and the problems that arise from them should be recognized in any attempts to manage the Southeast geese.

APPENDIX B

CLASSIFICATION OF THE CANADA GEESE OF THE GENUS *BRANTA*

PROBABLY few other groups of North American birds have presented the taxonomists with greater challenge than the white-cheeked geese of the genus, *Branta*. Before the distribution and the relationships of the various races can be fully understood, much collecting and banding will have to be done on the breeding grounds. The complexity of the problem is apparent when it is realized that the race *Branta canadensis interior* alone can be broken down into four fairly distinct breeding populations. As might be expected, the literature on the genus is fairly voluminous and often contradictory. Some plumage variations once thought to have taxonomic significance have been shown to be merely variations within single populations (Taverner 1931, Elder 1946, Hanson 1949*b*). In the latest revision of the genus by Hellmayr & Conover (1948), the characters of the downy plumage were taken into consideration. This factor considerably enhances the reliability of their study over studies previously made. They list the various members of the genus as follows:

Branta leucopareia leucopareia (Brandt). Tundra goose. [The lesser Canada goose of Kortright (1942) and others.]

Branta leucopareia occidentalis (Baird). West Coast goose. [The Western Canada goose of Kortright (1942) and others.]

Branta minima Ridgway. Cackling goose.

Branta canadensis parvipes (Cassin). Lesser Canada goose. [See Aldrich (1946) regarding the resurrection of *parvipes*.]

Branta canadensis moffitti Aldrich. Great Basin Canada goose.

Branta canadensis interior Todd. Todd's Canada goose.

Branta canadensis canadensis (Linnaeus). Eastern Canada goose.

Branta hutchinsii (Richardson). Richardson's goose. [*Branta canadensis hutchinsi* of Kortright (1942) and others and sometimes known as Hutchins's goose.]

Taverner (1931) has pointed out that several of the races are markedly distinct in the field, but as skins in the laboratory they are separated only with difficulty. According to James Mark, an Indian living at Eastmain, four different kinds of Canada geese are recognized by the James Bay Indians. The bird called *Muskego nisku* by the Cree Indian, meaning "large swamp goose," is the breeding goose of the muskeg, *Branta canadensis interior*, fig. 82. The "coast goose," *Winnipego nisku*, is restricted to the James Bay coasts and observed only while on migration. It is reported as being smaller than the swamp goose, more vociferous, and having a relatively shorter neck, a description that fits the lesser Canada goose, *Branta leucopareia leucopareia*. Richardson's goose, *Branta hutchinsii* is called *Apichishkish*, meaning literally a small goose that has attained its full growth, fig. 82. The fourth kind recognized by the Indians on the south and east coasts of James Bay is described as being the largest of the group and possessing a brown breast, a feature from which it has derived its name, *Kaoosoupasawat nisku*. Geese of this kind are reported to breed farther north and are called the Fort George (Quebec) geese by the Moose Indians. The brown breast may represent staining by iron-rich waters of the areas frequented by this bird, which may possibly be *B. c. interior*.

It is of interest to note that Blakiston (1863) also reported that an Indian on the Saskatchewan River described four different kinds of "grey geese," the common gray goose, a short-necked goose, a small goose, and a large goose, descriptive names that roughly fit the forms described by the Indians of James Bay.

The chief of the Indians around Lake St. Martin, Manitoba, told Taverner

Fig. 82.—Profile views of (upper head) an interior Canada goose, *Branta canadensis interior* and (lower head) a Richardson's goose, *Branta hutchinsii*. Both specimens are juvenile males.

(Shortt & Waller 1937) that three kinds of Canada geese visit their area. The descriptions of these three varieties fit *canadensis, leucopareia,* and *hutchinsii*. According to Taverner's unpublished notes, which Shortt & Waller quote, an immense kind of Canada goose is also traditional with these Indians and "is so rare that it is known only by report. It is probably mythical."

Despite Taverner's disbelief at one time in the reality of a very large goose, Mershon (1925) leaves little doubt that a very large variety of honker existed. McAtee (1944) has also commented on records of large geese from the Plains region. Aldrich (1946) has now recognized this large race of Canada geese, giving it the name *moffitti*. Individuals of this race, presumably adult males, are known to range as high as 14 to 16 pounds, and even greater weights than these have been reported. Elder (1946) weighed 2,179 geese and the senior author weighed several thousand more geese at Horseshoe Lake, Illinois, without encountering an individual that attained the weight of 12 pounds.

In the light of our present knowledge, the very large, almost legendary Canada goose known to many Indian groups in the boreal forest of Canada might be explained by individuals of the race *Branta canadensis moffitti* that have been occasionally taken north of their normal range. Such occasional invasions of the breeding grounds of one subspecies of Canada geese by nonbreeding members of another adjacent subspecies would not be unexpected. (In the above case the invasion of the range of *B. c. interior* by individuals of *B. c. moffitti* or an even larger extinct variety.) In the summer of 1949, Peter Scott, British ornithologist, and the senior author observed several flocks of nonbreeding "honkers," *B. c. moffitti* or *interior,* in the Perry River (Northwest Territories) breeding grounds of the smaller tundra Canada goose, skins of which have been identified by the senior author as those of *Branta leucopareia leucopareia.*

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