

Little or no soil movement was experienced on these burns. Sites selected for wildlife habitat burns should not have steep slopes, should have a considerable amount of sandy soil mixed with clay and have an overstory that will produce a light fall of leaves and needles to help protect the soil during the winter.

Prior to preparing the burning prescription, each area is examined closely by the District Ranger and State Wildlife Biologist. This is done to: determine the wildlife needs; select a site which will respond to these needs after burning; and, to prescribe the kind of fire needed to accomplish these objectives.

Like other tools, fire has several disadvantages. Experienced personnel are needed. Weather conditions must be right. Scattered desirable species, particularly mast-producing hardwoods, are often lost or reduced to browse in the form of sprouts. One must often make a choice, browse or mast.

On areas such as old home sites, crabapple stands, chinquapin ridges, abandoned orchards, or areas having fire-susceptible species that are a good source of wildlife food, fire should be excluded.

SUMMARY

Prescribed burning on the Francis Marion National Forest in loblolly and longleaf pine stands results in a favorable response of desirable legumes and other forbs preferred by deer, turkey and quail the first few years. As the rough builds up, the woody plants and grasses dominate the forest floor. For maximum wildlife habitat improvement, burning frequency should be three years or less. Careful techniques of burning are necessary to prevent acceleration of needle cast and premature accumulation of the smothering duff and litter.

Prescribed fire can be used successfully in the piedmont areas of the Sumter National Forest. The results are similar to those experienced in the coastal plain. However, the interval between fires can be extended one to two years longer in most cases and still retain favored wildlife food plants even for quail.

Fire should be excluded from areas such as old home sites, which are rich in a variety of wildlife food plants and are susceptible to fire.

All burning on the National Forests in South Carolina to improve wildlife habitat is carried out with the cooperation of the South Carolina Wildlife Resources Department and our District Rangers.

Our end objective is to maintain wildlife populations to provide good hunting for our sportsmen.

CHANGES IN THE MIGRATION AND WINTERING HABITS OF CANADA GEESE IN THE LOWER PORTION OF THE ATLANTIC AND MISSISSIPPI FLYWAYS—WITH SPECIAL REFERENCE TO NATIONAL WILDLIFE REFUGES

BY DONALD J. HANKLA

Assistant Regional Supervisor, Division of Wildlife Refuges
and

ROYSTON R. RUDOLPH

Assistant Regional Supervisor, Division of Wildlife Refuges
Bureau of Sport Fisheries and Wildlife
809 Peachtree-Seventh Building
Atlanta, Georgia 30323

INTRODUCTION

Many interesting and important changes have occurred in recent years in the migration and wintering habits of Canada geese in the lower portion* of the Atlantic and Mississippi Flyways. The purpose of this

* For the purpose of this paper, the lower portion of the Mississippi Flyway includes the States of Arkansas, Kentucky, Tennessee, Alabama, Mississippi, and Louisiana; the lower portion of the Atlantic Flyway includes Maryland, Virginia, North and South Carolina, Georgia, and Florida.

paper is to record the major changes that have occurred, suggest what caused them, and document the current status of the more important flocks in the lower portion of the two flyways.

PROCEDURE

The data for this paper were largely obtained from midwinter waterfowl survey records, national wildlife refuge narrative reports, band recovery analyses, correspondence from State Game and Fish Departments, and from "Canada Geese of the Mississippi Flyway" by Hanson and Smith (1950).

Midwinter waterfowl surveys were not begun until 1936, and most of the national wildlife refuges that conduct active Canada goose management programs were not established until after 1937. Since there are few reports available which suggest population levels as they existed prior to 1936, this paper must necessarily deal with population changes that have occurred since that time. In evaluating refuge and State-wide population data, it was recognized that survey techniques and procedures were not well refined during the early years and even now are subject to some error. The data that are presented, therefore, should be looked upon as being a rather rough index to population levels.

DISCUSSION

Atlantic Flyway

Florida: The northwest Florida coast in the vicinity of the St. Marks National Wildlife Refuge and Apalachee Bay is the southernmost wintering area used historically by Canada geese in the Atlantic Flyway. There is no indication that significant numbers of geese ever used other areas of the State.

While flyway-wide goose populations have soared to new heights and goose management (at least in some areas) has been "refined" almost to cookbook status, the St. Marks flock stands out as a classic and frustrating example to remind us that we still have a long way to go before we master the art of goose management. Once numbering a healthy 25 to 30 thousand birds, the St. Marks flock is now considered to be little more than a remnant flock, with only 6,300 geese recorded during the 1967 midwinter inventory.

No reliable information is available regarding the size of this flock prior to establishment of St. Marks National Wildlife Refuge in 1931. Early refuge records indicate that peak populations on the refuge increased from several thousand in the early 1930's to 6,500 by 1940, and to 15,000 by 1945. During the period up to 1945 few estimates are available concerning numbers of geese using areas off the refuge. It is known, however, that this wintering flock used almost exclusively the coastal marshes and bays from Alligator Point eastward to Rock Island, a distance of some 55 miles. St. Marks Refuge occupies most of this coastal strip and thus held most of the geese. There is little indication that this flock of birds made any significant use of agricultural fields for feeding purposes before 1945.

During the 1946-47 season an abrupt change occurred in the behavior of this wintering flock, setting the stage for the problems that were to follow. During early January, 1947, geese in unprecedented numbers pulled out of the coastal area to feed in the agricultural fields north of the refuge and in the Tallahassee area. This changing pattern, which continued to develop strongly for the next several years, is believed to have been a response to changes in land use practices in north Florida and south Georgia during and following World War II. Probably the most important changes were a large increase in peanuts and other attractive crops, the increased use of mechanized equipment, and the combining of small fields into large open blocks. In combination with numerous natural and man-made lakes, these changes provided very attractive habitat which effectively broke the historic attraction of natural habitat found along the coastal marshes and bays.

Midwinter inventory figures (Table I) indicate the Florida population continued to build during the late 1940's and early 1950's, reaching post-

TABLE I. COORDINATED MILVINTER WATERFOWL SURVEY DATA FOR CANADA GEESE IN 14 MISSISSIPPI AND ATLANTIC FLYWAY STATES, 1936-1967

Year	Alabama	Mississippi	Louisiana	Arkansas	Tennessee	Kentucky	Illinois	Missouri	Maryland	Virginia	N. Carolina	S. Carolina	Georgia	Florida
1936	0	100	38,395	1,700	0	Flood	2,080	5,000	17,600	7,200	56,510	0	850	14,000
1937	200	0	31,250	459	Flood	13,300	13,300	-	11,082	10,600	81,681	19	600	9,600
1938	125	4,850	84,925	2,840	1,350	-	22,300	7,000	9,344	14,000	119,939	89	815	1,800
1939	0	0	88,250	1,498	2,755	500	22,300	24,000*	9,314	19,400	163,708	0	2,351	13,500
1940	155	3,000	55,680	9,098	4,800	2,450	26,000	2,066	72,971	28,925	209,826	124	1,689	9,513
1941	495	36,800	42,645	16,625	-	1,463	15,100	1,907	69,800	24,050	188,850	-	2,094	18,245
1942	975	40,200	37,645	19,825	1,550	1,601	33,518	3,288	47,100	26,900	165,974	400	3,730	16,100
1943	260	22,530	21,725	2,900	1,511	511	19,233	19,457*	60,840	40,900	205,321	200	3,385	14,000
1944	425	13,900	16,379	5,750	1,000	3,720	37,043	3,300	59,500	28,200	236,650	180	1,568	13,101
1945	525	9,500	14,265	10,560	600	2,281	32,528	5,400	92,160	17,600	150,000	485	1,900	20,000
1946	1,500	1,600	20,000*	5,367	50*	1,200	22,410	665	50,314	16,600	139,900	250	1,000	18,700
1947	1,500	3,990	8,065	8,000	3,550	1,230	31,619	2,370	38,050	20,000	80,500	325	782	17,500
1948	4,300	5,500	10,000	9,000	2,500	1,500	47,264	9,330	42,130	20,000	106,400	300	1,000	10,000
1949	6,000	7,250	10,000	12,000	9,400	7,210	90,414	7,841	101,325	34,150	139,000	700	600	18,000
1950	7,600	5,200	31,500	1,900	2,100	5,800	90,942	24,125	87,700	44,800	120,400	1,700	800	16,700
1951	9,800	4,600	22,600	10,000	11,700	16,300	99,173	38,759	57,000	24,100	148,300	1,000	1,500	21,300
1952	10,100	2,800	10,300	6,500	18,000	41,400*	129,722	16,365	53,471	40,000	154,900	1,500	1,200	27,800
1953	13,500	900	12,100	400	14,300	10,300	143,026	34,369	220,530	40,000	151,400	2,000	2,000	47,000*
1954	13,200	1,700	5,200	4,000	25,800	6,000	150,280	29,697	148,150	34,700	107,700	3,500	1,100	25,600
1955	22,048	1,559	5,860	2,605	15,224	8,271	173,534	42,050	260,033	52,235	157,700	3,200	950	19,145
1956	19,377	726	11,630	3,700	17,100	8,213	190,943	25,577	223,816	50,700	185,868	6,135	141	26,750
1957	17,300	1,100	7,200	1,800	26,800	9,700	227,825	18,736	180,800	30,600	103,100	7,600	0	18,600
1958	28,602	1,692	10,505	4,061	25,010	42,390	114,815	31,264	95,510	27,770	146,875	11,275	206	17,815
1959	32,300	1,400	8,400	2,700	38,400	15,200	204,000	22,703	69,200	27,000	152,000	11,800	0	13,000
1960	28,500	700	8,400	2,700	23,700	19,100	111,209	34,549	137,700	31,500	148,200	19,400	Tr	11,100
1961	42,500	1,000	9,500	3,200	33,300	4,000	162,900	52,806	241,300	49,900	189,100	15,800	200	8,200
1962	47,400	600	4,521	3,531	33,400	10,400	158,700	56,079	192,900	26,200	128,100	16,400	100	8,300
1963	50,200	700	5,200	4,250	36,820	12,600	196,127	98,686	196,600	49,700	149,500	33,600	200	7,000
1964	60,100	1,800	7,800	5,500	49,200	14,800	177,000	91,817	221,900	31,300	162,200	44,400	600	4,400
1965	41,200	900	7,100	10,900	63,800	18,900	185,652	86,660	242,000	36,600	99,500	26,800	500	7,000
1966	46,000	1,100	6,800	8,500	57,700	9,600	95,265	105,361	352,700	44,000	91,500	29,900	500	6,000
1967	40,000	600	6,000	3,100	74,700	12,100	165,268	136,151	356,900	35,600	65,900	25,300	500	6,300

* Figures shown are believed to be in error

season peaks of over 27,000 in 1952 and 26,000 in 1956. During the same period peak refuge populations declined from 15,000 to 12,000; thus in most years more than one-half of the population did not use the refuge.

As could be expected, the development of this use pattern in areas that had never wintered geese before resulted in a great increase in hunting pressure and kill. Landowners began modifying their farming practices to make their areas more attractive to geese. In addition, a portion of St. Marks Refuge was opened to public waterfowl hunting from 1953 until 1960. We believe this increase in kill on the Florida wintering grounds, combined with that already taking place along the migration routes to the north, resulted in an excessive harvest of this flock. Also, the shift in feeding habits from natural to agricultural foods had made this flock vulnerable to "short-stopping" on goose management areas to the north. These two factors are believed to be the primary reasons for the rather sharp decline in this flock which started in 1957 and has continued to the present time.

In addition to the declining population, there has been a decided and unique change in the migration pattern of the St. Marks flock. Based on band recovery data during the period 1930-1939, it is apparent that geese formerly reached Florida via two routes, one in each flyway. One route was across Illinois, Kentucky, Tennessee, Alabama, and southwest Georgia; the other was down the Atlantic coast and across Georgia. Band returns during the 1960's indicate that the St. Marks flock now migrates almost exclusively down the Atlantic Flyway by way of the Maryland Eastern Shore and eastern North Carolina.

Georgia: There are no known records which indicate that Georgia was ever an important Canada goose wintering area. Hanson and Smith (1950) reported a number of recoveries of Jack Miner banded geese during the 1929-44 period in the Piedmont and mountain regions of central and north Georgia. This substantiates the reports of "oldtimers" that a number of small flocks (50 to 300 birds) once wintered along the upper Savannah, Flint, Oconee, and Ocmulgee rivers. These birds have since been eliminated with the exception of one small flock on the Savannah River.

Southwest Georgia has historically played host to flocks of migrant geese enroute to the St. Marks area of north Florida. Burleigh (1958) reports flocks in migration over south Georgia towns in 1908, 1925, 1927, and 1930. There is little evidence that geese wintered in southwest Georgia at the time of these observations. During the late 1940's and early 1950's, however, a number of small flocks of geese, apparently intercepted enroute to Florida, regularly wintered in this section of Georgia. The abrupt decline of these birds in the mid-1950's closely paralleled the decline in the Florida wintering population.

South Carolina: A striking change has occurred during the past 30 years in the number of geese wintering in South Carolina. Although there has been a slight decline in the wintering population in South Carolina during the past three years, there are many times more wintering geese in the State now than there were at any time prior to 1950. Table I depicts the increase in wintering birds in South Carolina since 1936 when there were no Canada geese reported as wintering in the State. Table II reflects the number of Canada geese that have wintered

TABLE II—A FOUR-YEAR INTERVAL COMPARISON OF STATEWIDE WITH NATIONAL WILDLIFE REFUGE CANADA GOOSE WINTERING POPULATIONS IN SOUTH CAROLINA, 1943-1967.

	1943	1947	1951	1955	1959	1963	1967
Cape Romain							
NWR	60	450	60	0	200	200	80
Carolina Sandhills							
NWR	0	50	25	225	600	800	1,300
Santee NWR	10	275	500	1,000	9,318	31,000	22,700
Statewide	200	325	1,000	3,200	11,800	33,600	25,300

on the Santee, Carolina Sandhills, and Cape Romain National Wildlife Refuges during the 1943-67 period.

The origin of the Santee flock is not definitely known although the small wintering flocks reported in South Carolina by Hanson and Smith (1950) are believed to have served as a nucleus. The Santee flock is unusual in that it is the most southern wintering flock in the two eastern flyways that has increased in size during the period when other deep South flocks have declined alarmingly.

Band return information from Santee-banded birds indicates that the total harvest of birds from this flock has been minimal with the greatest kill occurring in the Maryland and Delaware area. Only a small number of recoveries were recorded from North Carolina and the local area around Santee Refuge. The distribution pattern of recovered bands indicates that the Santee flock funnels southward into the Chesapeake Bay-Eastern Shore area of Maryland and in travelling southward bypasses the important goose wintering area around Mattamuskeet in eastern North Carolina.

North Carolina: North Carolina has a long history as a Canada goose wintering area. In 1936, when the first midwinter waterfowl survey was conducted in the flyway, there were 56,510 Canada geese (Table I) reported in the State. This number grew to 236,650 in 1944. Since that time the number of wintering birds has fluctuated between 80,500 and 189,100, but not until 1965 was there a serious decline that has been of a continuous nature. In that year, the number of geese in the State during the midwinter survey was 99,500. In 1966 there were only 91,500 at the time of the midwinter survey. In 1967 the number had declined to 65,900, the second lowest number recorded since annual midwinter surveys began 31 years ago.

The reasons for the decline are not clearly understood although there are a number of contributing factors. A sharp increase in the wintering population in Maryland and Delaware suggests that many geese which formerly wintered in North Carolina have been influenced by an abundance of attractive agricultural and aquatic foods, protected feeding and resting areas, mild weather, and comparatively light shooting pressure to winter in Maryland and Delaware.

While these generally favorable conditions have prevailed in Maryland and Delaware, habitat conditions in North Carolina have deteriorated, particularly in the historically important Lake Mattamuskeet area. Corn crops are being harvested early to avoid the hurricane season. As a result, little waste grain is left in the fields by the time geese arrive. Kill surveys have shown that hunting pressure is heavy on geese wintering in North Carolina. It is suspected that the total flyway harvest on that segment of the population wintering in North Carolina is excessive.

The decline in North Carolina has reached serious proportions. Corrective action will have to be taken in North Carolina if the trend is to be reversed. The birds that are wintering to the north will not be easily influenced to winter farther south. A suggested solution to increasing the number of wintering birds in North Carolina is to improve habitat conditions and to reduce the harvest of those birds which are presently wintering in the State, thereby permitting the population to rebuild.

It is probable that the decline in numbers of wintering birds in North Carolina would have occurred sooner and in more severe proportions had it not been for the national wildlife refuges in that State. The Mattamuskeet, Pungo, Pea Island, Swanquarter, and Mackay Island National Wildlife Refuges have made, and are continuing to make, a significant contribution to the habitat needs of geese. Wintering numbers on North Carolina refuges are shown in Table III.

Band returns from North Carolina banded geese reflect a close tie with geese using the coastal areas of Virginia, Maryland, and Delaware. Band recoveries and periodic inventories give the impression that one continuous wintering ground exists between eastern North Carolina and the north end of Chesapeake Bay. This total population has been described by Hanson and Smith (1950) as the South Atlantic population.

TABLE III—A COMPARISON OF STATEWIDE MIDWINTER POPULATIONS WITH NATIONAL WILDLIFE REFUGE JANUARY POPULATIONS IN NORTH CAROLINA AT FIVE-YEAR INTERVALS, 1939-1967.

	1939	1944	1949	1954	1959	1964	1967
Pungo							11,200
Mackay Is.						500	600
Swanquarter		200	25	3,500	3,500	800	1,000
Pea Island		12,000	15,000	8,800	6,800	6,051	5,500
Mattamuskeet	22,000	50,000	70,000	50,000	65,000	65,000	25,000
Statewide	163,708	236,650	139,000	107,700	152,000	162,200	65,900

Virginia: Midwinter survey records indicate that Virginia has been a relatively important Canada goose wintering area for many years. The State reportedly had about 7,200 geese when the midwinter survey was first taken in 1936. This number gradually increased to 40,900 in 1943, declined to 16,600 in 1946, increased to 55,235 in 1955, and has since declined to 35,600 in 1967.

Virginia is a middleground between two important Canada goose wintering areas; the Maryland Eastern Shore and Mattamuskeet Lake in North Carolina. Virginia, therefore, plays host to birds ranging out from both Maryland and North Carolina.

There is at least one Virginia-based flock that has been relatively stable. This flock, centered on the Presquile National Wildlife Refuge on the James River, has maintained a population of 7,000 to 10,000 birds for the past seven years. Band returns indicate that the Presquile Refuge is a winter terminus. While birds range up and down the James River from Presquile, none venture farther south. The Presquile geese and other scattered flocks using inland portions of Virginia were considered by Hanson and Smith (1950) to be a part of the Southeast population.

A moderate number of Canada geese migrate along the Atlantic shore of Virginia but few winter there. The Chincoteague National Wildlife Refuge lies just south of the Maryland-Virginia line on Assateague Island. Several thousand geese migrate through this refuge each fall but only a few hundred are winter residents.

It is concluded that no significant changes have occurred in the number of geese wintering in Virginia in recent years. Virginia has not contributed to the decline of geese farther south, at least not to a significant degree.

Maryland: Maryland has long been an important Canada goose wintering area. When the first midwinter waterfowl survey was made in 1936 there were 17,600 Canada geese recorded in the State. Since that time the number of wintering birds has fluctuated greatly, but the general population trend in the State has been sharply upward. The greatest number of birds ever recorded during any midwinter survey in Maryland was 356,900 in 1967.

In studying the year-to-year changes in the wintering population of Maryland and Delaware, it is quite evident that some of the recorded increases might not have come about entirely as a result of natural production by the flock that wintered in the State the previous year. The large differences that occurred during some years were either the result of interceptions of migrating birds or survey errors.

Influences in Maryland and Delaware that are thought to have caused increased numbers of geese to winter in those States are:

1. The natural gregarious nature of geese, causing them to be readily decoyed;
2. The availability of attractive agricultural and aquatic foods on the Eastern Shore and in Chesapeake Bay;
3. The absence of continued disturbance from hunting (the hunting pressure on a day-to-day basis is relatively light);
4. The presence of many sanctuaries where little or no hunting is permitted (these include the major portion of Chesapeake Bay,

many private farms which permit hunting only one or two days per week, and several national wildlife refuges);

5. A change in food habits toward high energy foods such as corn and soybeans which enable birds to winter farther north.

An analysis of annual population survey reports indicates that no appreciable change in wintering numbers of geese has occurred on national wildlife refuges in Maryland over the past 10-year period. Eastern Neck National Wildlife Refuge was established only a few years ago but it winters a relatively small number of geese. National wildlife refuges in Maryland offer food to birds primarily during fall and spring migration. Agricultural foods that might attract birds to winter on refuges are normally eaten before winter arrives. Returns from geese banded on Blackwater Refuge show that there is a strong relationship between Blackwater and Mattamuskeet Refuge in North Carolina. Through the years over 14 percent of all band returns from Blackwater-banded birds came from the Mattamuskeet Refuge area.

Mississippi Flyway

Alabama: Marked changes have occurred in the migration and wintering habits of Canada geese in Alabama during the 1929 to 1967 period. Hanson and Smith (1950) reported a number of recoveries of Jack Miner banded geese in east-central and north Alabama between 1929 and 1944. While some of these birds may have been fall migrants, there is substantial evidence that scattered small flocks of geese were wintering in the State during that period, particularly on the reservoirs of north and east-central Alabama.

The number of birds wintering in Alabama grew at a very slow and erratic pace until 1946 when 1,500 were reported on the midwinter survey. The number of wintering birds had increased to 6,000 by 1949, to 13,200 by 1954, and to 32,300 by 1959. The peak wintering population occurred in 1964 when 60,100 were reported during the midwinter survey. The present level of the wintering population is estimated to be about 40,000 (Table I).

Virtually the entire wintering population is associated with the Wheeler National Wildlife Refuge and the State's Scottsboro Wildlife Management Area in north Alabama. Wheeler Refuge was established in 1938 and has been intensively managed to provide protection and attractive habitat for Canada geese. The increase in geese wintering in Alabama closely parallels the increase that has occurred on Wheeler Refuge where at present over 90 percent of the wintering population is centered.

The origin of the Wheeler and Scottsboro flock is open to speculation. One possibility is that the various small wintering flocks formerly using scattered reservoirs in north and central Alabama consolidated to form the nucleus of the Wheeler flock. On the basis of refuge reports, the Wheeler flock started with less than 100 birds and grew steadily through the years, at first very slowly. As the size of the flock increased it grew at a progressively faster rate. There were only a few years during the history of the flock when the rate of increase was greater than that expected from natural reproduction (Table IV).

TABLE IV — WHEELER NATIONAL WILDLIFE REFUGE JANUARY INVENTORY OF CANADA GESE, 1946-1967.

1946— 1,000	1954—12,000	1961—39,600
1947— 1,000	1955—20,000	1962—30,700
1948— 2,000	1956—19,650	1963—46,500
1949— 2,500	1957—16,000	1964—58,200
1950— 3,600	1958—21,000	1965—31,150
1951— 8,800	1959—30,000	1966—41,350
1952— 8,600	1960—25,000	1967—36,250
1953— 9,100		

On the basis of band recovery information, there is little evidence of any relationship between the Alabama and Florida wintering flocks.

From 14 years of banding at Wheeler, 1950 to 1964, during which time 148 bands were recovered, there were only two recoveries of Wheeler-banded birds at St. Marks. During 34 years of banding at St. Marks no more than two band returns have been obtained from north Alabama. While Hanson and Smith (1950) included both the Alabama wintering birds and the St. Marks flock in the Southeast population, their analysis of Jack Miner banded geese suggests little relationship between the wintering geese of these two States. They reported many Miner-banded geese taken in Alabama but "singularly few" recoveries in Florida.

The breeding grounds and migration route of Alabama-banded geese are fairly well defined. A number of recoveries have been obtained from the southwest James Bay area of Canada denoting what is believed to be the breeding grounds for the Alabama flock. The flock migrates southward through Michigan, Ohio, and Indiana. Wheeler-banded geese have been taken through hunting or retrapping in southwest Michigan, at Kingsville, Ontario, and at Pymatuning, Pennsylvania. There are scattered recoveries in Indiana and Ohio, and groups of recoveries in the Green River area of Kentucky and in the Chickamauga Refuge area of east Tennessee.

The establishment and growth of the Wheeler flock is indicative of what can happen if protection, food, and water are provided at the winter terminus, and if harvest rates are kept below the annual production rate. It is believed that as harvest rates continue to increase along the migration route, the Wheeler flock will decline. The solution to the maintenance of the flock at a high level is a controlled rate of harvest along the entire migration route.

Louisiana: A very pronounced change has occurred during the past 30 years in the number of Canada geese wintering in Louisiana. Based on midwinter survey reports, Louisiana wintered more Canada geese than any other State in the Mississippi Flyway prior to 1944. During that year Louisiana was surpassed by Illinois, and the number of birds wintering in Louisiana has been steadily declining since. Presently there are only 6,000 Canada geese wintering in the State.

Historically, there were three regions in Louisiana which furnished important wintering habitat for Canada geese: the coastal marshes in southwest Louisiana, the Delta marshes at the mouth of the Mississippi River, and the Mississippi River in northeast Louisiana. Changes in the wintering population of geese using the latter area are similar to those that have occurred in Mississippi and are, therefore, discussed under Mississippi.

Many of the geese which wintered at the mouth of the Mississippi and in the southwest coastal marshes of Louisiana were associated with both State and national wildlife refuges. Delta National Wildlife Refuge, located at the mouth of the Mississippi, offered good protection and preferred habitat for Canada geese during the early years. Approximately 7,000 geese wintered in the refuge marshes in 1942 and again in 1945. Beginning in 1946, however, the number began to decline, and by 1954 only 300 Canada geese were observed in the area. During the past few years less than 50 Canadas have been recorded at Delta Refuge during the midwinter survey.

The Lacassine National Wildlife Refuge, located in southwest Louisiana, recorded no Canada geese when established in 1937. However, by 1944 as many as 10,000 were observed on the refuge. During the 1951-53 period 20,000 were estimated to be present. Since 1953 the number of wintering birds has declined appreciably, and in January, 1967, the Lacassine flock was estimated to contain only 1,200 birds.

The Sabine National Wildlife Refuge, also in southwest Louisiana, furnished valuable habitat and protection for Canada geese until the 1950's. Since then the flock wintering on and in the vicinity of the refuge has declined rather severely. In 1940 a total of 9,146 Canadas were recorded on Sabine. During the survey made in January of 1967 only 500 Canadas were present.

Despite the protection of State and Federal refuges, numerous large-

scale transplant attempts, and a State-wide closed season on Canada geese since 1962, the Louisiana population has continued to decline.

Band recovery information indicates that a major portion of what was once a large southwest Louisiana wintering population is now wintering in Missouri. On the basis of midwinter surveys, there is strong indication that the flock which once wintered along the lower Mississippi River in Louisiana is now wintering at least as far north as southern Illinois. A change in feeding habits from natural to agricultural foods and excessive harvest of the Louisiana population may have been important factors in the decline of these geese.

Mississippi: The role that Mississippi has played as a Canada goose wintering ground was much more important in the past than it is today. There is evidence, in addition to the midwinter surveys which date to 1936, that the State at one time wintered a relatively large number of birds. Mr. Nash Buckingham (1966, personal correspondence) reported that a number of delta lakes on the east side of the Mississippi River, between Memphis and Vicksburg, were the centers for wintering flocks of Canada geese between 1890 and 1927. It is reported that these geese browsed on switch willows, rested on the sandbars and mudflats, and grazed in pastures and grain fields nearby. Special mention was made of flocks in the Tunica Cutoff area, on Flower Lake, on Beaverdam Lake, and on the numerous bars that formerly dotted the Mississippi River. Lake Washington, south of Greenville, was another important goose wintering center in the early 1800's according to a history of that lake written by a resident of Washington County, Mississippi. Hanson and Smith (1950) reported the entire west boundary of the State of Mississippi as a Canada goose wintering ground. To suggest what caused the geese that formerly wintered in Mississippi to shift their wintering grounds to the north is conjecture. There were probably a combination of factors which influenced the 30,000 to 40,000 geese (Table I), which reportedly were wintering in Mississippi in 1941 and 1942, to choose new wintering grounds. A decrease in corn acreage in Mississippi is given as one important reason. State records show that the acreage of corn grown in Mississippi decreased from 2,963,000 acres in 1939 to 764,000 acres in 1962. Similar decreases are believed to have occurred in northeast Louisiana during the same period.

Harassment from military aircraft flying out of Greenville Air Force Base during World War II is suggested as a factor which may have influenced some of the geese along the Mississippi River to change their wintering grounds. Apparently it was a favorite sport of pilots to buzz goose flocks along the Mississippi and drive them until they dispersed.

Another opinion expressed by a Mississippi resident as to why larger numbers of geese no longer winter in the State has to do with the reduction of flooding along the Mississippi. Cut-offs have been created in the river where at one time there were long bends. Supposedly the cut-offs, as well as numerous flood control projects, permit flood waters to recede more rapidly, thus lessening the frequency and severity of floods. Geese were apparently attracted to flooded farm lands in the delta or to the crops that could not be harvested as a result of floods.

It is the opinion of the authors that the geese that formerly wintered along the lower Mississippi were influenced to winter farther north by attractive habitat and the decoying effect of other geese. Mechanical corn harvesters are believed to have been a strong influence in the shift of geese to the north. Whatever the cause, the decline in numbers of wintering geese in Mississippi has been a drastic one—only 600 birds were recorded during the 1967 midwinter survey. These include a small migrant flock on Sardis Reservoir, a few on the Noxubee and Yazoo National Wildlife Refuges, and a small number that winter on a private farm in the southwest part of the State.

Arkansas: Arkansas, like its neighbors to the south and east, has a long history as a Canada goose wintering ground. Wapanocca Lake in east Arkansas, now the Wapanocca National Wildlife Refuge, is reported to have wintered a flock of about 10,000 Canada geese as early as 1890. This flock, although it declined somewhat, continued to come to Wapa-

nocca until the lake went dry during the drought of 1933. The flock reportedly never returned after that year. Since establishment of the Wapanocca Refuge in 1962, from 50 to 200 migrants have wintered there annually.

A second wintering ground in Arkansas that was of more importance a number of years ago than today is the White River National Wildlife Refuge. Early records indicate that as many as 1,800 Canada geese wintered on White River Refuge in 1938. This number increased to 15,000 in 1942 when the Statewide wintering population was estimated to be 19,825. The White River flock, associated with the Eastern Prairie population which now winters primarily in Missouri, has gradually declined through the years. The 1967 midwinter survey estimates the Statewide population at 3,100 geese. Of this total 1,565 were recorded at White River, 131 at Wapanocca, 115 at Big Lake National Wildlife Refuge, and 835 at the Holla Bend National Wildlife Refuge.

Holla Bend is located in west Arkansas on the Arkansas River. This refuge, as a result of a transplant program from Swan Lake National Wildlife Refuge in Missouri, is now wintering a flock of 835 geese. It is hoped that with adequate protection and management the Holla Bend flock will increase and a new wintering ground for Canada geese will become established. There is always a danger, of course, that Holla Bend will attract and stop birds which are wintering in Louisiana, as Swan Lake Refuge has done. It could on the other hand furnish needed protection for Louisiana wintering geese and serve as a stepping-stone refuge for geese in migration to the Louisiana coastal marshes.

Wapanocca Refuge in east Arkansas is designed to serve about the same purpose as Holla Bend. It is hoped that geese will spill over from refuges in southern Illinois or will in some way be encouraged to seek wintering grounds farther south. Wapanocca, like Reelfoot Refuge in Tennessee, will serve as a stepping-stone refuge designed to provide protected habitat for geese seeking a more southerly wintering area.

Kentucky: The history of Kentucky as a wintering area for Canada geese is not as well known as for States to the south. At the present time the Ohio River bottomlands, particularly in Ballard County, are probably the most important wintering habitat in the State, with the Green River lowlands second, and the Kentucky Woodlands National Wildlife Refuge area third in importance.

The birds which winter in Ballard County trade back and forth into southern Illinois and are strongly influenced by hunting pressure and habitat conditions in the Horseshoe Lake area. Following the close of the hunting season in Illinois and Kentucky increased numbers of birds move from Horseshoe Lake to Ballard County. In recent years peak concentrations have not developed at Ballard County until late January or early February after the midwinter survey has been taken.

The Green River lowlands are important as a migration and wintering area. A number of band returns have been obtained in the Green River lowlands from Wheeler and Chickamauga banded birds.

A third area of importance is the Barkley Lake region where the now deactivated Kentucky Woodlands National Wildlife Refuge was located. The Kentucky Woodlands Refuge, until recent years, provided important migration and wintering habitat for a relatively large number of Canada geese. Peak fall populations on the refuge reached 30,000 in 1958. Winter concentrations varied considerably from year to year as follows: 10,000 in 1958, 15,000 in 1959, 4,000 in 1962, 15,000 in 1963, and 17,000 in 1964.

The Bureau of Sport Fisheries and Wildlife ceased management of the refuge in 1965 when the Land Between the Lakes national recreation area was activated by the Tennessee Valley Authority. The following year Barkley Lake was impounded and much of the habitat formerly used by the Kentucky Woodlands flock was inundated. Canada geese which had traditionally migrated through and wintered in the area decreased in numbers from 20,000 in mid-December of 1964, to 6,000 in 1965, to 3,000 in 1966. These changes were obviously caused by a decrease

in the amount of attractive, protected habitat that was available to the flock at this location.

Tennessee: If the reports of "oldtimers" are creditable, Tennessee provided migration, wintering, and production habitat for Canada geese in the early 1900's. With reference to production, apparently geese at one time nested on the cypress snags in Reelfoot Lake. On the basis of the records that are available, however, Tennessee did not become an important Canada goose wintering area until habitat management measures were undertaken on State and national wildlife refuges after 1945.

The Tennessee Game and Fish Commission initiated management on the Chickamauga and Watts Bar Refuges in east Tennessee during the 1946-1949 period and soon attracted a relatively large number of geese. While a few hundred had been known to winter along the Tennessee River in the vicinity of these refuges, it was not until improved habitat and protection was given that geese wintered there in significant numbers.

Before 1947, the total number of geese wintering on the Tennessee and Reelfoot National Wildlife Refuges in west Tennessee did not exceed 1,600. At that time there reportedly were only 3,550 geese wintering in the entire State (Table I).

In 1954 the midwinter survey revealed 14,063 Canada geese in west Tennessee and 6,657 in east Tennessee. Of the total in west Tennessee, 8,800 were on the Tennessee National Wildlife Refuge and 4,800 were on Reelfoot Refuge. Continued management and protection on these two refuges, as well as on the State-managed Chickamauga and Watts Bar Refuges, has resulted through the years in substantial increases. The midwinter survey in 1967 revealed that the State of Tennessee contained 74,400 wintering Canada geese. Of this number, 43,000 were on Tennessee Refuge and 21,500 on Reelfoot Refuge.

As suggested in the preceding paragraphs, the great increase in the number of wintering geese came about as a result of providing protection from hunting and attractive feeding and resting habitat. To say that the ancestors of the Tennessee wintering geese did or did not once winter farther south would be conjecture. It is commonly thought that the geese which winter at Reelfoot Refuge are a part of the flock which now winters in southern Illinois, but which formerly wintered along the Mississippi River to the south of Reelfoot. In addition to band recoveries, which confirm the association between Reelfoot and Horseshoe Lake geese, there is frequently a large influx of Canada geese into Reelfoot following the close of the Illinois hunting season.

The Tennessee Refuge flock is not believed to be closely affiliated with any other flock on the wintering grounds. This flock started with a very small number of birds (Table V) and has increased gradually

TABLE V — WINTER CONCENTRATIONS OF CANADA GEESE ON THE TENNESSEE NATIONAL WILDLIFE REFUGE DURING THE PERIOD 1946-1967.

1946—	28	1952—	3,400	1958—	11,700	1963—	13,500
1947—	38	1953—	6,000	1959—	160,000	1964—	26,000
1948—	600	1954—	8,800	1960—	8,500	1965—	28,000
1949—	950	1955—	5,300	1961—	11,100	1966—	31,500
1950—	2,100	1956—	6,700	1962—	10,000	1967—	43,000
1951—	3,500	1957—	6,000				

through the years. With the protected habitat available to the flock on the Tennessee Refuge, there has been only a small harvest of geese in the local area. It is believed, therefore, that a large portion of the annual increment has been applied to the growth of the flock.

While there are some unexplained increases and decreases in wintering numbers on the Tennessee Refuge, it is not believed that any appreciable number of geese has been attracted to winter at Tennessee that would have wintered farther south had the refuge not been present.

The Chickamauga and Watts Bar flocks are believed closely associated with each other and with the flock which winters on Wheeler Refuge, located on the Tennessee River some 125 miles to the southwest. Band returns indicate a substantial exchange of geese between the Chickamauga area and Wheeler Refuge. The band recovery pattern of the Chickamauga and Wheeler flocks is also quite similar leading to the conclusion that the flocks are basically one and the same with only slightly different wintering tendencies.

CONCLUSION

A State-by-State review of midwinter waterfowl inventory data, national wildlife refuge narrative reports, and band return data revealed that major changes have occurred in the migration and wintering patterns of Canada geese in the lower portion of the Atlantic and Mississippi Flyways.

Wintering population decreases occurred in Florida, North Carolina, Mississippi, Louisiana, and Arkansas. Increases occurred in South Carolina, Maryland, Alabama, Tennessee, and Kentucky. Georgia and Virginia registered no appreciable change.

Some of the suggested causes that have influenced decreases or increases are:

1. *A change in goose food habits.* Before mechanical harvesters became widely used, corn and other grain crops were generally unavailable to Canada geese. Goose foods consisted largely of aquatics, marsh plants, and green forage such as upland grasses and switch willows. Mechanical harvesters made a considerable amount of food available in inland locations where little had been previously. The decline of wintering populations in Florida, Louisiana, and Mississippi coincided with the increased availability of corn and other foods to the north.
2. *Waterfowl management areas.* The changes in wintering patterns of Canada geese have strongly paralleled the development of State and Federal goose management areas. The changes in feeding habits and the presence of attractive management areas with an abundance of quality foods not only set the stage for the interception of geese in areas north of traditional wintering grounds but also made possible the development of significant goose flocks in areas where only small wintering flocks previously occurred. The presence of national wildlife refuge areas in some deep south areas, such as Sabine and Lacassine Refuges in southwest Louisiana, White River Refuge in Arkansas, and St. Marks Refuge in Florida, are presently contributing to the preservation of remnant goose flocks which otherwise might have been completely eliminated.
3. *Hunting pressure.* In more than one State there are indications that the local kill of geese, combined with kills along the migration routes to the north, has resulted in harvests that possibly exceed the annual production of some southern wintering flocks and thus has contributed to the decline of these flocks.
4. *Disturbance.* An effect of hunting aside from kill is disturbance. It is believed that continued all-day shooting, seven days per week, disrupts the feeding and resting routine of geese to such an extent that they may be influenced to choose another wintering area. The degree to which this is true probably depends on how much protected habitat or sanctuary there is locally available.

LITERATURE CITED

- Bureau of Sport Fisheries and Wildlife. National Wildlife Refuge Annual Narrative Reports. 1938-1966. Washington, D. C.
- Burleigh, D. B. 1958. Georgia Birds. University of Oklahoma Press. Norman, Oklahoma. 746 pp.
- Davis, H. T. and D. L. Wray. 1959. Birds of North Carolina. Bynum Printing Company. Raleigh, North Carolina. 434 pp.
- Hanson, H. C. and R. H. Smith. 1950. Canada Geese in The Mississippi Flyway—With Special Reference to an Illinois Flock. Bull. Ill. Natural History Survey, Urbana, Illinois, 25(3):210 pp.