ECOLOGY OF THE MIGRATING AND WINTERING FLOCKS OF THE SMALL WHITE-CHEEKED GEESE WITHIN THE SOUTH CENTRAL UNITED STATES

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The technical names of mammals follow Miller and Kellogg (1955). All others are cited in text.

TABLE OF CONTENTS

Chapter		Page
I.	INTRODUCTION	1
II.	DESCRIPTION OF THE STUDY AREA	3
	General Description	3
	Physiography	4
	Climate	6
	Vegetation	8
III.	SPECIES DESCRIPTION	10
	General Characteristics	10
	Distribution	11
IV.	METHODS AND TECHNIQUES	13
	Trapping	13
	Banding and Color-marking	16
	Sex and Age Determinations	20
	Hunter Contacts	22
	Refuge Records	22
	Museum Collections	22
V.	RESULTS	27
	Systematics of the Branta canadensis in the Central Flyway	27
	Migration Routes and Wintering Areas	48
	Tall-grass Prairie Route	50
	Short-grass Prairie Route	72
	Areas of Co-mingling	82
	Effects of Weather on Distribution	89
	Chronology of the Fall Migration	103
	Habitat and Chronology	110
	Population Status	116
	Numbers	116
	Composition	119
	Kinds and Extent of Attrition	124

TABLE OF CONTENTS--Continued

Chapter		Page
VI.	DISCUSSION AND CONCLUSIONS.	126
	The Species Concept and Its Significance as Related to the Small White-cheeked Geese of the Central Flyway	126
	The Flyway Concept, the Life-form Concept, and Their Significance as Related to the Migration Routes of the Small White-cheeked Geese of the Central Flyway	140
	Migration Movements of the Small White-cheeked Geese in the Central United States.	145
	Population Status of the Small White-cheeked Geese in the Central United States.	146
VII.	MANAGEMENT IMPLICATIONS	148
	SUMMARY	152
	LITERATURE CITED	157
	APPENDIX	168

LIST OF TABLES

Table		Page
1.	Summary of Goose Trapping Success in Oklahoma . . .	16
2.	Summary of Types of Markers and Colors Used During the Study	20
3.	Shrinkage in Canada Goose Specimens	25
4.	Percentage of Non-overlap of Partially Overlapping Curves Associated With Stated Values of the Coefficient of Difference (C. D.)	30
5.	Comparative Measurements of the Type Specimens of *B. c. hutchinsii*, *B. c. leucopareia*, and *B. c. parvipes* . . .	41
6.	Frequency of Variation Numbers of Small Canada Geese From Three Locations	
7.	Number of Returns by Year From Geese Banded at Stations in the Tall-grass Prairie	51
8.	Distribution of 1,206 Band Returns From Small Canada Geese Banded at Sand Lake National Wildlife Refuge 1951-1959	56
	Distribution of 115 Band Returns From Small Canada Geese Banded at Salt Plains National Wildlife Refuge, 1957-1960	57
10.	Number of Returns by Year From Small Canada Geese Banded at Stations in the Short-grass Prairie	73
11.	Distribution of 1,363 Band Returns From Small Canada Geese Banded at Two Buttes Reservoir, Colorado, 1951-1959	75
12.	Distribution of 114 Band Returns From Small Canada Geese Banded at the Waggoner Ranch, Vernon, Texas, 1955-1959	76
13.	A Comparison of Culmen Lengths of Adult Small Canada Geese in Samples From Stations in the Tall-grass Prairie and the Short-grass Prairie . .	86

Table		Page
14.	Approximate First Arrival Dates of Canada Geese at U. S. National Wildlife Refuges in the Central United States	106
15.	Approximate Date of Population Peak For Canada Geese at U. S. National Wildlife Refuges During the Fall Migration	106
16.	Period of Greatest Influx of Canada Geese at U. S. National Wildlife Refuges During the Fall Migration	107
17.	Adult: Immature Age Ratio Data From Small Canada Geese in the Tall-grass Prairie Gathered by Various Methods, 1957-1960 . .	121
18.	Summary of Male Female Sex Ratios of Small Canada Geese of the Tall-grass Prairie, 1957-1960	122
19.	Some Comparative Diagnostic Criteria of the Subspecies B. c. leucopareia and the Proposed Subspecies B. C. taverneri	137

LIST OF FIGURES

Figure		Page
1.	The Central United States, Showing the Location of the Study Area, Stations Visited, and the Administrative Boundaries of the Central Flyway. .	5
2.	Coefficients of Difference Between Tarsus Length Measurements (upper right) and Coefficients of Difference Between Wing Chord Measurements (lower left) for Eight Subspecies of Canada Geese	32
3.	Coefficients of Difference Between Culmen Length Measurements (upper right) and Coefficients of Difference Between Middle Toe Measurements (lower left) for Eight Subspecies of Canada Geese	33
4.	Characters Indicating Subspecific Distinctness Between Eight Subspecies of Canada Geese . . .	35
5.	Culmen Length of Branta canadensis Complex . .	37
6.	Mean Values of Maxilla Height and Culmen Length of Canada Geese	38
	Culmen Length of the Branta canadensis Complex From Geographic and Ecologic Areas Across the Arctic (Excluding B. c. minima)	43
8.	Distribution of the Small Canada Geese of the Tall-grass Prairie and the Short-grass Prairie . .	49
	Maxilla Height: Culmen Length Measurements From Samples of Small Canada Geese Handled At Salt Plains, Waggoner Ranch and Two Buttes . .	85
10.	Peak Populations of Canada Geese by Years From Selected Refuges	92
11.	Band Return Distribution in Oklahoma in 1952 and 1953 by County	97

LIST OF FIGURES--Continued

Figure		Page
12.	Band Return Distribution in Oklahoma in 1956 and 1957 by County	98
13.	Band Return Distribution in Oklahoma in 1958 and 1959 by County	99
14.	Total Numbers of Canada Geese Censused by Weekly Periods, 1953-1956, at Salt Plains, Tishomingo, Hagerman, Aransas, and Laguna Atascosa	109
15.	Total Numbers of Canada Geese Censused by Weekly Periods, 1957-1959, at Salt Plains, Tishomingo, Hagerman, Aransas, and Laguna Atascosa	111
16.	Population Numbers of Canada Geese in Weekly Census Periods as Reported by Five Refuges in the Southern Tall-grass Prairie, 1956.	114
	Population Numbers of Canada Geese in Weekly Census Periods as Reported by Five Refuges in the Southern Tall-grass Prairie, 1958.	115
18.	Graphic Representation of the Systematics of the White-cheeked Goose Complex by Four Authors . . .	127

LIST OF CHARTS

Chart		Page
1.	Counties Contributing Major Proportions of Band Returns From Small Canada Geese in North Dakota	62
2.	Counties Contributing Major Proportions of Band Returns From Small Canada Geese in South Dakota	64
3.	Counties Contributing Major Proportions of Band Returns From Small Canada Geese in Nebraska	65
4.	Counties Contributing Major Proportions of Band Returns From Small Canada Geese in Kansas . . .	66
5.	Counties Contributing Major Proportions of Band Returns From Small Canada Geese in Missouri	68
6.	Counties Contributing Major Proportions of Band Returns From Small Canada Geese in Oklahoma	69
7.	Counties Contributing Major Proportions of Band Returns From Small Canada Geese in Texas	70

CHAPTER I

INTRODUCTION

Successful management of a species must be based upon a thorough knowledge of the life processes of that species, physiological, genetic and environmental alike. So seldom is this general requisite met in the every-day practice of wildlife management that the significance of the truism often is not seen. Acquisition of the knowledge by which management is implemented is the realm of the researcher, regardless of title, and it is the step by step, piece by piece accumulation of basic data by these individuals which is eventually synthesized and projected into a management program commensurate with the needs of a given species.

The present study was initiated in 1957 as a result of the concern by the United States Fish and Wildlife Service and certain state conservation agencies for an apparent decline in population numbers of small Canada geese censused during the fall migration at two important wildlife refuges in the Central Flyway. By 1956, the numbers of Canada geese observed at these two formerly important stopping-over places had dropped to such a low level that it was feared that a segment of the *Branta canadensis* complex was in danger of near extinction.

The purpose of this study was: to determine the present status and trend of the migrating and wintering population of small white-cheeked geese in the south central United States; to determine the major routes traveled in migration; and to investigate the kinds and extent of attrition among the small white-cheeked geese during their residence in the south central United States. Inexorably, another, even more basic, subject became a necessary and significant part of the investigation. This was clarification of the specie's description and it's relationship to the variation in the species complex observed in the study area.

Field study was conducted primarily in Oklahoma and Texas during the periods of migration and wintering for Canada geese from the fall of 1957 through the spring of 1960. During the intervals between the migration and wintering periods, visits were made to other areas in the Central Flyway having a history of use by Canada geese, and to museums having collections of Canada geese.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

It is axiomatic that a study must have a point of focus. In this study the focus is on that segment of the Branta canadensis complex referred to as the small white-cheeked (Canada) geese. It follows logically that a field study involving these geese must be conducted in an area which they use, that is, small white-cheeked goose habitat. Thus the boundries of this study area are not based on a random or arbitrary decision by the author, but rather are a consequence of the observed natural distribution of this particular group of geese in the south central United States. This distribution is correlated with the land areas characterized by the growth of perennial grasses, i.e., the grasslands or mid-continent prairies.

General Description

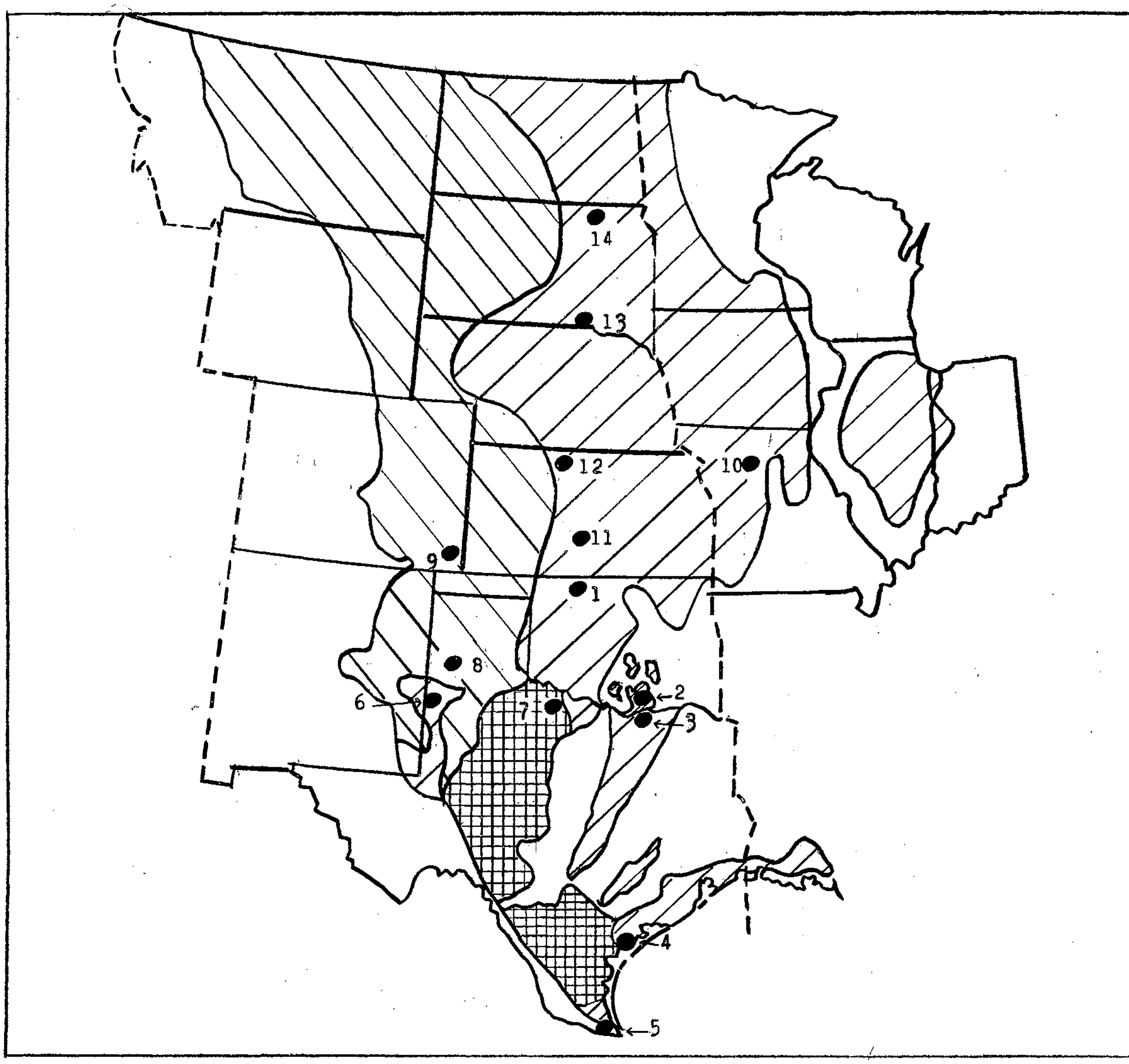
The study area is framed within the political boundaries of Oklahoma and Texas in the south-central United States. The majority of the research was conducted at the Salt Plains National Wildlife Refuge, Jet, Alfalfa County, Oklahoma; Tishomingo National Wildlife Refuge, Tishomingo, Johnston County, Oklahoma; Hagerman National Wildlife Refuge, Denison, Grayson County, Texas; Aransas National Wildlife Refuge, Austwell, Aransas County, Texas; Laguna Atascosa National Wildlife Refuge, San Benito, Cameron County, Texas; Muleshoe National Wildlife Refuge, Muleshoe, Bailey County, Texas; and the Waggoner Ranch, Vernon, Wilbarger County, Texas. In addition, visits were made to the Buffalo Lake

National Wildlife Refuge, Umbarger, Randall County, Texas; the Two Buttes Reservoir, Springfield, Baca County, Colorado; Swan Lake National Wildlife Refuge, Sumner, Chariton County, Missouri; Quivera National Wildlife Refuge, Stafford, Stafford County, Kansas; Kirwin National Wildlife Refuge, Kirwin, Phillips County, Kansas; Lake Andes National Wildlife Refuge, Lake Andes, Charles Mix County, South Dakota; and Sand Lake National Wildlife Refuge, Columbia, Brown County, South Dakota, (Fig. 1). With the exception of Missouri, these states are all within the natural boundaries of the Central Flyway as proposed by Lincoln (1935, 1950) and the administrative boundaries established therefrom by the U. S. Fish and Wildlife Service (Fig. 1).

Physiography

As used here physiography includes topography, in the geologic sense of non-biological features of land relief, in addition to the relatively stable biological features which, combined with topography, provide the total aspect of an area.

The land relief of the study area has a rather regular, southeasterly oriented decrease in elevation from nearly 5,000 feet in the Panhandle of Oklahoma and Texas to sea level along the Texas coast (Marschner, 1936). The rate of this southeasterly slope in Texas is about five to six feet per mile (Bonnen, 1960), and would appear to be approximately the same in Oklahoma. Drainage of the major tributaries in the two states is approximately in this same southeasterly direction (Marschner, 1936, and Bonnen, 1960). The physiography of the study area varies from the flat "high plains" or "Llano Estacado" in the far western and northwestern Texas Panhandle (Carter, 1931)



Legend:

Station

1. Salt Plains National Wildlife Refuge
2. Tishomingo National Wildlife Refuge
3. Hagerman National Wildlife Refuge
4. Aransas National Wildlife Refuge
5. Laguna Atascosa National Wildlife Refuge
6. Muleshoe National Wildlife Refuge
7. Waggoner Ranch
8. Buffalo Lake National Wildlife Refuge
9. Two Buttes Reservoir
10. Swan Lake National Wildlife Refuge
11. Quivera National Wildlife Refuge
12. Kirwin National Wildlife Refuge
13. Lake Andes National Wildlife Refuge
14. Sand Lake National Wildlife Refuge

- - - - Administrative boundries of the Central Flyway.

Tall grass.

Short grass.

Mesquite and desert grass savanna.

Figure 1. The central United States, showing the location of the study area, stations visited, and the administrative boundaries of the Central Flyway. Distribution of the major grassland associations is according to Shantz and Zon (1924).

and extending into the Oklahoma Panhandle (Gray and Galloway, 1959), (=short grass-high plains of Duck and Fletcher, ca. 1944), through the nearly flat to undulating "rolling plains" of northwestern Texas (Carter, 1931) and "rolling red plains" and "reddish prairies" of western Oklahoma (Gray and Galloway, 1959) to the sometimes high, broken, and dissected "grand prairies" of south-central Oklahoma and north-central Texas (Carter, 1931; and Gray and Galloway, 1959), the open, rolling "black prairie" of southeastern Texas (Carter, 1931 and Tharp, 1952) to the flat or slightly undulating "gulf coast prairie", Carter, (1931). The prairies are separated by broken and hilly areas supporting a blackjack and post-oak woodland or "cross timbers" (Carter 1931, Gray and Galloway 1959, Duck and Fletcher ca. 1944).

Climate

Oklahoma and Texas lie within the temperate zone and the climate is essentially one of moderate temperatures and precipitation. Nonetheless, average summer temperatures (June-August) vary from 75° to 80°F. over Oklahoma and the Panhandle and western third of Texas to 80°F. to 90°F. over the remainder of Texas to the coast (Kincer, 1928). During the summer daily maximum may exceed 100°F. The average winter temperature (December-February) varies from 30° to 35°F. in the Panhandle of Oklahoma, 35° to 40°F. through the northern two-thirds of Oklahoma and the Panhandle of Texas, 40° to 45°F. through the southern one-third of Oklahoma and northern one-fourth to one-third of Texas, 45° to 50°F. east to west through the central portion of Texas, 50° to 55°F. in a belt extending about 200 miles inland from the Texas coast and westward to the Rio Grande River, and 55° to 60°F. from Galveston Bay south to the Lower Rio Grande Valley and west to the Rio Grande River (Kincer, 1928). Winter temperatures in the Lower Rio Grande Valley average 60° to 65°F. (Kincer, 1928). Daily minimum temperatures may range from -10° to +20°F. in the northern and northwestern part of the study area to +20°F. along the southern Texas coast. The average daily range in temperature is least along the Texas coast, being 12° to 15°F. in the summer and about 21°F. in the winter and is greatest in the northwestern part of the study area, being 27° to 30°F. in the summer and 27° to 33°F. in the winter (Kincer, 1928). In October the average monthly temperature is about 20°F. greater in each of the areas given in the winter period above and in November the average monthly temperature is about 10°F. greater (Kincer, 1928).

Precipitation varies from an annual average of fifteen to twenty inches in the far western and northwestern portion of the study area to about fifty inches on the upper coast of Texas. The isohyets of annual average rainfall lie in approximately north-south oriented belts with a slight southeast tendency south of central Texas (Kincer, 1922). Within the study area, the average fall precipitation (September-November) varies from about two inches in the far northwest to about fourteen inches along the upper Texas coast. Normally, September and October provide over eighty per cent of the precipitation in this period. The average winter precipitation (December-February) varies from one inch in the far west and northwest to about twelve inches on the upper Texas coast (Kincer, 1922). In the winter, snowfall is common and will average ten to twenty inches in the northern part of the study area, but is rare and will average less than one inch from central Texas south and along the coast (Kincer, 1922).

Vegetation

The dominant vegetation of the study area is formed of the perennial grasses which characterize the immense interior land area lying between the eastern and western forests and extending from Canada to Mexico (Shantz and Zon, 1924). Attempts to provide a descriptive nomen for this vast area have resulted in many different designations, depending upon the natural phenomena emphasized by the author. Perhaps the most familiar are "Grassland Vegetation", Shantz and Zon (1924), the "Grassland Climax" (Weaver and Clements, 1938), "Grassland Formation" (Weaver and Clements, 1938), "Stipa-Antilocapra Biotic Formation (Biome)" (Clements and Shelford, 1939), "Grassland Biome" (Carpenter, 1940), and "Grassland Biotic-Community" (Pitelka, 1941). In the present study this area, characterized by perennial grasses, will be referred to as the grassland biome, emphasizing the dominant biological features and at the same time recognizing the influencing role of the integrated biotic community.

The portion of the study area in the grassland biome is subdivided into areas of tall-grass, short-grass, and mesquite and desert grass savanna as illustrated by Shantz and Zon (1924). These subdivisions will be referred to as associations, namely, the regional climax communities as discussed by Weaver and Clements (1938). Further subdivision classifications (Blair and Hubbell, 1938), (Dice, 1943), (Bruner, 1931), (Duck and Fletcher, ca. 1944), (Tharp, 1952) add little to the recognition of major associations and, except for Duck and Fletcher, (ca. 1944), and Tharp, (1952) nothing to the understanding of small Canada goose distribution in the south central United States.

The majority of the grasslands of the central United States have long been converted to agricultural uses (Shantz and Zon, 1924; Bonnen, 1960). At the present, therefore, the distribution of small white-cheeked geese is more properly related to present land use than to the natural vegetation. In Oklahoma and northern and western Texas, it is the land area devoted to grain sorghum, winter wheat, and to a lesser extent grazed pasture that provides habitat for the Canada geese. On the Texas coast, goose habitat is provided by grain sorghum, rice and coastal pasture land, often Bermuda grass.

CHAPTER III

SPECIES DESCRIPTION

Systematics (AOU, 1931, 1945, 1947, 1949)

Branta canadensis (Linnaeus)

Branta canadensis canadensis (Linnaeus) 1758

Branta canadensis hutchinsii (Richardson) 1831

Branta canadensis leucopareia (Brandt) 1836

Branta canadensis parvipes (Cassin) 1852

Branta canadensis occidentalis (Baird) 1858

Branta canadensis minima (Ridgeway) 1885

Branta canadensis interior Todd 1953

Branta canadensis moffitti Aldrich 1956

General Characteristics

So familiar to North Americans is the Canada goose and so often has this species been described that another involved listing of characteristics does not seem warranted. In general, a representative of the species Branta canadensis is characterized by a relatively long, black neck, a black head with white cheek patches, a gray to brown body, white tail coverts, black rump, blackish-brown flight and tail feathers, and black bill, legs, and feet. Those desiring a modern and complete description of the species may refer to the recent treatment by Delacour (1954).

Less generally well-known is the remarkable variation in color, size, and proportions found among representatives of this species. Included within the general description are taxa ranging in color from pale gray to nearly chocolate brown and in weight from less than three pounds to more than nineteen pounds. Delacour (1954) has pointed out that found within this species are both the largest and the smallest of all geese. There are minor plumage variations such as a white collar at the base of the black neck, white feathering on the forehead, and black band separating the white cheek patches, which are of unknown importance in the present classification, but do show regional differences in frequency (Delacour, 1954; Marquardt, 1961 a.).

Distribution (Delacour, 1954)

"Canada Geese occupy the Nearctic Region, breeding from the Arctic tundra south to the northern parts of eastern California, Nevada, Utah, Colorado, South Dakota, Nebraska, Indiana, east to the Gulf of St. Lawrence and Newfoundland. They trespass into Asia on the Commander [though probably not breeding (Johansen, 1961)] and Kurile [known breeding in 1896 on Ushishir and Ekarma (Stenjneger, 1899)] Islands, and also occasionally nest in western Greenland. Their breeding range no doubt extended farther south formerly, before settlement destroyed the local populations, probably to New Mexico, northern Kansas, northwestern Arkansas, western Tennessee and North Carolina, a vast zone in which pairs may still exceptionally be found nesting; but it is difficult now to ascertain whether they are genuinely wild or re-introduced birds. They winter from British Columbia, Wyoming, South Dakota, southern Wisconsin, Ohio, southern Ontario, Maine and Nova Scotia, south to Mexico [south to Vera Cruz (AOU, 1957)], the Gulf Coast States and

Florida. [..... in winter to Honshu, northern Baja California, ... (AOU, 1957)]. Accidental elsewhere (Hawaii, Bermuda, Jamaica, etc)." [.... the Bahama Islands (Andros and New Providence). (AOU, 1957)].

The systematics of a species is not always simple of description and in the case of the Canada geese the extensive range, variability in size and plumage color, and numerous ecologic situations wherein segments of the species population are found during the seasons of the annual cycle presently precludes a classification acceptable to all authorities. Use of the classification proposed by the American Ornithologists' Union (1931, 1945, 1947, 1949) does not mean that it is without error or that it cannot be improved. Its use does mean that it is believed to contain fewer faults than other existing classifications, including the new revision (A.O.U., 1957) and that its system can be more successfully defended.

CHAPTER IV

METHODS AND TECHNIQUES

As the study in any particular field progresses, so must the techniques by which it is implemented. In some instances the advances may be in the form of innovations; in others they may represent only refinements of well-established techniques which increase efficiency under the conditions encountered. For the most part, methods and techniques discussed in this study are included in the latter category.

Trapping

The methods of trapping geese are extremely varied and, depending upon the season of the year, range from drive traps for flightless young and adults (Cooch, 1953, 1955) (Scott and Fisher, 1954) to walk-in or decoy traps (Hanson, 1949) (Ryder, 1955) and most recently, to projectile or rocket-net traps (Dill and Thornsberry, 1950), (Scott and Fisher, 1954) (Miller, 1957). A general discussion of the most common methods and equipment used is provided in the U. S. Fish and Wildlife Service manual, Guide to Waterfowl Banding (Patuxent Research Refuge, 1956).

At the present time, the projectile-net is the most popular type of goose trapping equipment used in the Central Flyway. It has the advantage of portability, relatively low maintenance costs, and, in the Central Flyway, appears to be more efficient than walk-in type traps. During the first year of this study, a walk-in trap was tried at

Tishomingo National Wildlife Refuge, but geese could not be induced to enter the trap. At the same time little success was experienced with the Dill-type projectile-net equipment then available to the study. The difficulties experienced were traceable, in part, to the black powder propellant used, the weight of the treated cotton nets, and the dete-ioration of the cannon bores as a result of incomplete removal of the black powder residue following combustion in previous years of use.

Accordingly, prior to the second season of field work a Dill-type cannon modified for the use of smokeless powder was constructed. In addition a modification of the Miller projectile assembly (originally designed for smokeless powder) was also constructed. Lightweight nets were fabricated from discarded 2½ in. mesh nylon gill-netting (No. 6 cord) which reduced both weight and air resistance (Marquardt 1960, 1961 b.). These units, proved superior to the equipment used during the 1957-1958 season. No less important is the matter of enticing geese into a position where they can be trapped. Experience in this study indicates that geese can be conditioned to a food symbol and thereby directed into areas most convenient for the trapping operation. During the first two seasons of study it became obvious that the placing of the bait in an area suitable for trapping and then waiting for birds to find and become accustomed to the bait often resulted in long periods of frustrating idleness. During the last study season, a system of bait site conditioning was undertaken prior to and during the active trapping program. This was achieved by placing grain in limited amounts in the fields which geese regularly used, but which fields were too close to human activities to be suitable for a trapping program. Here the grain was placed in two strips approximately eighteen inches wide, one inch deep, and 60 to 80 feet long. When geese began using these grain strips regularly, usually within two or three days from first baiting, the strips were shifted from area to area within a field and from field to field. This baiting was usually done in the late evenings so that grain was present only for a short period of time in the early mornings. In time it appeared that some flocks of geese actively searched for the identifying strips of grain bait. Ultimately the baited strips were moved into the field where active trapping was planned and geese immediately began using the field. During the succeeding month, more than 500 were trapped at approximately one week intervals in this field. Baiting was continued throughout the intervals between actual trapping and geese were still visiting the trap site when trapping was suspended. All captures were made during the early morning hours which provided adequate time for banding and color-marking and in addition gave the birds time to dress their plumage and re-establish flock contact. A summary of trapping activities in Oklahoma during this study is presented in Table 1. In addition, in 1957-1958, 54 geese were banded under the direction of Claude F. Lard, refuge manager, Aransas National Wildlife Refuge, and the author assisted Donald Kriebe, Milton Boone, and Charles Boynton in trapping 161 geese at the Waggoner Ranch, Vernon, Texas. In the 1958-1959 season, the author again assisted in trapping 726 geese at the Waggoner Ranch. In the 1959-1960 season the author helped Jack Grieb, Micheal Sheldon and others trap approximately 400 geese at Two Buttes Reservoir, Colorado.

Table 1. Summary of Goose Trapping Activities in Oklahoma.

Year	Area	Canada Geese Trapped and Banded	
		Large Geese	Small Geese
1957-1958	Salt Plains	1	26
	Tishomingo	15	0
1958-1959	Salt Plains	0	136
	Tishomingo	35	40
1959-1960	Salt Plains	3	545
	Tishomingo	0	2 (trap site innundated)
Total		54	749

Banding and Color-marking

The method of handling the geese following a capture differs among operators depending on the characteristics of the trap site, size of the banding crew, data desired, facilities available, and discretion of the operator in charge. Because of the infinite variations encountered in the time and place of goose captures, no rigid set of standards can be proposed for the correct handling of captured geese. However, two points do seem important enough to merit special consideration. In discussing the handling of captured pink-footed geese, Anser brachyrhynchus Baillon, in Scotland, Scott and Fisher (1954) emphasized the importance of maintaining the family and flock unity. This is important not only from the standpoint of the increased vulnerability of broken families (Hanson and Smith, 1950), but also because of the possible effect on the discreteness of established gene pools. The other point is that every effort should be made to insure that the individual bird, upon release, has a reasonable chance of survival. To maintain flock and family unity, Scott and Fisher (1954) removed the geese from the net to compartmentalized "keeping-cages" to be held until all individuals could be processed and released at the same time. At Salt Plains National Wildlife Refuge birds from each capture were released together on the margin of the Salt Plains Reservoir. During the course of trapping in the third year at Salt Plains, the birds were released on a fenced display pond. The enclosed pond offered protection from most predators and here the geese injured in the trapping operation or suffering from gunshot wounds could recuperate until such time as they were able to take wing.

The small geese trapped were banded with No. 7b aluminum leg bands and the large geese with No. 8 aluminum leg bands. All bands were furnished by the U. S. Fish and Wildlife Service and records of date of capture, number banded, sex and age of the individual and whether the individual was color-marked were sent to the Bird Banding Office, Patuxent Research Center.

The color-mark used during this study varied as experience indicated necessary changes. During the 1957-1958 season a "necktie" fabricated from either 3/8 in. or 1/2 in. plasticized polyvinyl chloride tape was placed about the neck of the goose and secured with a "Jesse" of falconer's knot. The area of banding was identified by whether the band had a single or double tail and sexes were identified by separate colors. Banding stations were identified by a code punched into the pendant tail of the tie. This material and marker was first used and described by Craighead and Stockstead (1956 a). During the succeeding two years of field work, this marker was modified by adding a lace-through collar of heavy plastic upholstery material. Three basic colors were used, orange, red, and green for both ties and collars. Use of the collars allowed for nine combinations or codes to identify individual banding stations. Table 2 provides a summary of the types of markers and colors used and the numbers marked during the study. A form to provide for the uniform reporting of color-marked geese was designed, printed, and distributed to the Regional Office, refuges, and game management agents in Region 2 of the U. S. Fish and Wildlife Service. The Region 3 office and refuges were also notified of the color-marking program and reports on observations requested. Reports obtained from observers of color-marked birds ranged from satisfactory to unusable. When combinations of colors were used, reports would often include only one color, usually that of the tie. The number of tails on the tie were seldom reported. There was occasionally failure to distinguish between orange and red, particularly in the field, but also when the bird was in the hand. Not all problems encountered in the color-marking program, however, were reducible to observer reliability. Some color combinations were not easily distinguished unless the observer was wholly congnizant of the colors used. The collars used during the latter two years of field work were more susceptible to tearing and loss than were the ties, consequently the distinguishing code was sometimes lost. Occasionally, the impact of a lead shot through the tail of a tie would cause the material to shatter and thereby create a situation in which the code would be misidentified.

On the whole, the color-marking tended to add little to the migration data obtained from band returns. However, in the case of this short-term study the quantity of reference data was more than tripled. The color-markers appeared to have no observable effect, either physically or psychologically, on the geese after the first day or two following banding. Several geese which have carried these neck markers for periods ranging from one week to slightly more than one year have been examined and no damage to the skin or feathers of the neck has been observed.

One report was received from the vicinity of Salt Plains in which a hunter shot a color-marked goose on which a large (reported 3 1/2 in.) ball of ice had formed on a tie end. From the Waggoner Ranch came a report of three geese found strangled by large packs of grass lodged in the esophagus above the collar and tie. However, it could not be ascertained whether this was attributable to the tie or the result of compaction, not a common phenomenon in the Central Flyway, but reported as an occasional cause of death among Canada geese of the Mississippi Flyway by Hanson and Smith (1950). Hunters in the vicinity of Salt Plains indicated that they often observed the color-markers on geese decoying to their blinds and endeavored to shoot them for the novelty of bagging a banded and color-marked goose. In view of this, it was felt that the color-marking of geese might increase their mortality as a result of selective gunning pressure. In an attempt to establish this point, samples of 100 geese color-marked and released on November 9, 1959, 42 geese color-marked and released on November 18, 1959, and 135 geese released without color-marks on November 18, 1959 were selected for testing. The percentage of return for color-marked and non-color-marked was 10.6 per cent and 9.6 per cent respectively. The Chi^2 based on a 2x2 contingency test (Bailey, 1959) indicates there is no significant difference between percentage of returns for the two groups. This finding tends to substantiate the observations of Helm (1955) and Craighead and Stockstead (1956 b). Although Aldrich and Steenis (1955) have pointed out that the novelty of this system of identification can cause public relation problems, only a few instances of unfavorable comment came to the attention of this investigator during the course of this study. In each instance an effort was made to contact the individual concerned and discuss the program and it's objectives. In only one case did this method fail to bring an understanding and a cessation of criticism.

Table 2. Summary of Types of Markers and Colors Used During the Study.

Banding Station	Year	Tie	Tie/Collar	1 Tail	2 Tail
Salt Plains	1957	Red- ♂ Green- ♀		X	
Salt Plains	1958		Orange/Orange		X
Salt Plains	1959		Red/Green		X
Tishomingo	1958		Green/Green		X
Waggoner Ranch	1957	Red- ♂ Green- ♀			X X
Waggoner Ranch	1958		Red/Orange		X
Aransas	1957	Red- ♂ Green- ♀			X X

Sex and Age Determination

Hochbaum (1942) has described the general method of sex and age determination of waterfowl by cloacal examination. Refinements of this method, dealing specifically with Canada geese, have been offered by Elder (1946) and Hanson (1949). Because of the size and strength of geese the method requires considerable effort. Turner (1953) has offered a rapid method of sexing Canada geese by maxilla characteristics which appeared reasonably accurate for the large Canada geese of the Atlantic coast. However, it appears that Turner was dealing with a rather homogeneous population of geese while in contrast, the geese handled in this study were heterogeneous in the extreme. The same situation precluded attempts to divide the geese examined into more than two age classes as did Elder (1946) and Hanson (1949). Perhaps the simplest method of distinguishing immature Canada geese from those two years of age and older is the characteristic notch in the tip of the immature tail feather, Schiøler (1924, 1925, 1926) and Kortright, (1942). The brownish cast on the remiges and rectrices mentioned by Brooks (1914) as a distinguishing characteristic of juvenile geese was readily observed in the juveniles handled in this study. Another characteristic distinguishing age classes and mentioned briefly by Elder (1946) is the size and shape of the breast feathers. The breast feather of the immature Canada goose is perhaps only half as wide as that of an adult and tends to have a rounded tip. More important it displays a strongly pigmented rachis which contrasts with the usually lightly pigmented vanes and lacks the prominent light terminal bar of the adult vanes. As a consequence of these differences the breast plumage of an adult Canada goose presents an irregular pattern of alternate light and dark barring. The breast plumage of the immature Canada goose lacks this barring, is generally lighter than the adult in any given race, and grossly presents a diffuse unpatterned effect. It was also observed that the adult Canada geese show a regular barring over the back and on the flanks which is lacking in the immature birds. In the handling of captured birds these plumage differences were easily observed at distances of thirty or more feet. Later it was found that the differences between adult and immature plumage in Canada geese could be recognized in field flocks (Marquardt, 1962). Reliability of the method has not been tested on field flocks but, based on observation of its efficiency in correctly aging captured birds, it is believed to provide a method for obtaining age ratio samples unbiased by differential susceptibility to capture and gunning. Marquardt (1962) pointed out that because of the progression of the molt the method lost its accuracy during late winter and that for captured geese it should not replace the tail-feather method of aging.

Hunter Contacts

Throughout the gunning season hunters were contacted to obtain estimates of hunting pressure, hunter success, age and sex ratios of birds taken by hunting and as a means of obtaining mensurational data from shot geese to supplement the data taken from birds captured. The majority of hunter contacts were made in the vicinity of the Salt Plains National Wildlife Refuge. Salt Plains lent itself well to this phase of study because of the congregation of hunters on a relatively small number of hunting areas.

Refuge Records

The majority of the data on population numbers comes from the several National Wildlife Refuges that were centers of study in this project. At least once a week during the waterfowl season each of these refuges conducts a census which provides an estimate of the species' numbers using the area at the given time. The records also contain a summary of weather conditions prevailing during the period and the condition of water, cover, and crops in the local area. The reliability of these records, as might be expected, varied from refuge to refuge.

Museum Collections

During the course of this study, 297 specimens of the *Branta canadensis* complex were examined at the U. S. National Museum, Washington, D. C., 55 at the Chicago Museum of Natural History, Chicago, Illinois, 65 at the Denver Museum of Natural History, Denver, Colorado, and three at the Welder Foundation Museum, Sinton, Texas. In addition, five specimens from the University of Alaska collection were examined while in Washington, D. C., and the type specimen of *B.c. parvipes* was obtained for examination through loan from the Academy of Natural Sciences of Philadelphia.

The measurements of the specimens examined were taken carefully and recorded. In addition, notes on plumage color and characteristics were recorded as well as instances where there appeared to be an error in the identification or aging of an individual specimen.

The technique of measurement followed closely that prescribed by Baldwin, Oberholster, and Worley (1931). A dial caliper, calibrated to 1/10 mm. was used for all measurements except total length and wing chord. For the larger measurements, a mechanics quick-set caliper was used to obtain the length and the interval was then read to the nearest millimeter from a meter scale. These same instruments were also used for all field measurements on both live and dead geese.

A word of caution concerning the use of museum specimens of Canada geese is appropriate. It is not uncommon to review papers listing the measurements and often the plumage colors and shading of a series of museum specimens. These papers often imply that the characteristics offered are representative of the living individuals of the particular taxa under discussion. Based on the examination of museum specimens of Canada geese in this study, in addition to a small sample of personal material, there is reason to suspect that this implication of reprentativeness may be in error. Discounting obvious errors such as aging the specimens, there is apparently a more insidious source of errors resulting from shrinkage and foxing or possibly, fading. Miller (1955) takes particular care to caution taxonomists concerning color changes which occur in stored avian specimens. In stored specimens of Canada geese, the plumage becomes noticeably browner in color. This occurs either as a fading through loss of black melanins and the consequent dominance of the remaining brown melanins or through foxing, oxidation of the black melanins, which decreases the saturation and results in a reddish-brown shade in the plumage. Once this change in the plumage has occurred there is no valid means of estimating what the original color might have been. It may be assumed that an investigator will recognize this paling phenomenon at some point in its later stages, but since it is a gradual process it seems likely that subtle changes will occur long before they are recognized. It seems proper to ask what effect this potential source of error has had on the naming and description of races based on museum series of specimens. The matter of shrinkage in prepared specimens is perhaps of most importance when the measurements of museum specimens are compared with those of living or freshly killed individuals. When a series of specimens are compared among themselves or with another series the relative proportions of structural measurements are probably quite constant. However, as is indicated in Table 3, in a comparison between prepared specimens and a living population the measurements and porportions may be in considerable variance. The rate at which shrinkage took place in these specimens is not known. However, in the case of a large Canada goose (specimen No. 62), which had been dead an estimated three or four days before the head and feet were measured and prepared in 1957, the per cent of shrinkage in the parts when remeasured in 1961 were: Culmen, .6, Maxilla height, .4, Maxilla length, .2, Tarsus, 1.3, and Middle Toe, .0. From this it seems possible that the rate of shrinkage is very rapid in the first few days after death. Error, involved in the taking of measurements may be responsible for some of the variation shown in Table 3. Repeated tests, however, have indicated the variation between measurements usually fall between .25 and .5 per cent. Of particular interest, from the standpoint of ratios, is the

Table 3. Shrinkage in Canada Goose Specimens[1]

Specimen No.	Age	Character	1957[2]	1961[3]	Diff.	% Diff.	
36	Ad.	Culmen	38.6	37.5	1.1	2.8	
39	Im.	Culmen	34.4	33.0	1.4	4.1	
51	Im.	Culmen	30.2	29.4	.8	2.6	
52	Im.	Culmen	31.4	30.7	.7	2.2	
53	Im.	Culmen	36.8	35.4	1.4	3.8	Ave. % diff. = 3.1
36	Ad.	Max. Height	20.7	19.7	1.0	4.8	
39	Im.	Max. Height	19.3	18.8	.5	2.6	
51	Im.	Max. Height	18.7	17.1	1.6	8.6	
52	Im.	Max. Height	18.7	17.5	1.2	6.4	
53	Im.	Max. Height	19.6	18.5	1.1	5.6	Ave. % diff. = 5.6
36	Ad.	Max. Length[4]	39.4	39.2	.2	.5	
39	Im.	Max. Length	34.2	34.0	.2	.6	
51	Im.	Max. Length	32.3	32.1	.2	.6	
52	Im.	Max. Length	33.7	33.5	.2	.6	
53	Im.	Max. Length	36.8	36.6	.2	.5	Ave. % diff. = .56
51	Im.	Tarsus	66.5	64.1	2.4	3.6	
52	Im.	Tarsus	67.5	66.1	1.4	2.1	
51	Im.	Mid. Toe	50.5	49.3	1.2	2.4	
52	Im.	Mid. Toe	54.5	52.0	2.5	4.6	

1. All specimens were measured and prepared during the day they were killed.

2. Fall hunting season, 1957.

3. Spring of 1961.

4. Actually Tomium length (chord).

matter of differential shrinkage between parts. As can be seen in Table 3 the change in ratio between culmen length and maxilla height, or more particularly, maxilla length (tomium) would be considerable. The importance of shrinkage in prepared specimens will depend upon the emphasis given measurements in defining a species' population or segment thereof.

CHAPTER V

RESULTS

Systematics of *Branta canadensis* in the Central Flyway

The differences in views among various authorities concerning subspeciation in the *Branta canadensis* complex is primarily one dealing with numbers of subspecies and consequently, there is a considerable lack of agreement concerning distribution of a given form. Rand and Traylor (1950) have pointed out that some differences are to be expected since subspecies are essentially subjective or arbitrary units, though they are based on natural phenomena. Thus, the discreteness of the units named by various workers will vary with the fineness of distinctions used in categorizing them. These same authors assert that there is a tendency at present toward finer subdividing of species into subspecies or geographic races and this trend is quite apparent in the systematics of the white-cheeked geese. Carried to the extreme this procedure leads to the naming of every population unit which can be shown to differ genetically. Thus, a local population unit or even an individual may become a taxon. Obviously, the question of what should be considered a subspecies hinges on the recognition of degrees of difference between natural populations. The problem is then one of defining the limits of acceptable degrees of difference. Mayr, *et. al.* (1953) define subspecies as ...." a geographically defined aggregate of local populations which differ taxonomically from other such subdivisions of the species." The definition contains three important limits of subspecies, namely: the unit must be all allopatric, superior or more general in variability than a local population, and have taxonomic distinctness. A taxonomic difference, as pointed out by Mayr, et al. (1953) is not necessarily synonymous with genetic or statistical difference. Nearly every moderately isolated local population can be demonstrated to have a significant difference, at least in the statistical sense, from neighboring populations and the naming of each of these minor units would only encumber the biologist studying geographical variation. The concept of subspecies is used to bring together these geographical variants into a single group which on the average has one or more characters distinguishing it from similar and adjacent groups. This means that some of the individuals in the subspecies may not demonstrate the diagnostic character and therefore will not be identifiable. This is to be expected in closely related populations where some intergrading may be involved.

In dealing with subspecies it is necessary that we treat population averages rather than the individual. The level at which the biologist sets his average for subspecific identity will vary inversely with the degree of division desired; a low average creates splitting, a high average tends to lump. Mayr, et al. (1953) suggest as "... a standard of subspecific separation that 75 per cent of population A be different from 97 per cent of population B. Then about 90 per cent of the individuals of A are different from about 90 per cent of the individuals of B." This would generally agree with Rand and Traylor (1950) who suggest 80 to 90 per cent of one be recognizable from 80 to 90 per cent of the other.

Accepting an average for distinctness, a statistical method can be formulated to facilitate the handling of data. To test the degree of distinctness between two populations Mayr, et al. (1953) offer a formula in which the difference between the means of two populations are divided by the sum of their standard deviations. The factor obtained is designated as the coefficient of difference. As the authors point out, the method obtains an approximation of the point of intersect of the curves between the means of two populations and because it is based on a normal curve, requires that the larger standard deviation not greatly exceed one and a half times the smaller. The calculated coefficient of difference for two natural populations having 90 per cent joint non-overlap is 1.28; this coefficient then represents the level of subspecific distinctness. Table 4 is reproduced from Mayr, et al. (1953) to provide a handy reference of the percentages of symmetrical non-overlap associated with various values of the coefficient of difference.

In the following tables all data are derived from measurements of adult specimens of white-cheeked geese contained in the bird collections at the U. S. National Museum, the Chicago Museum of Natural History, and the Denver Museum of Natural History. The measurements are standards prescribed by Baldwin, Oberholster, and Worley (1931). Dr. John W. Aldrich assisted with the identification of races at the U. S. National Museum. Unless otherwise noted, all statistical analysis is of standard design suggested by Arkin and Colton (1956), Snedecor (1957), or Bailey (1959).

In the analysis, B. c. leucopareia includes specimens of the proposed races B. c. asiatica and B. c. taverneri, B. c. moffitti includes specimens of the proposed race B. c. maxima, and B. c. occidentalis includes individuals of the proposed race B. c. fulva. Also included in B. c. leucopareia are the specimens collected by Hanson in the vicinity

Table 4. Percentage of non-overlap of partially overlapping curves associated with stated values of the coefficient of difference (C. D.). Reproduced from Mayr, et al. (1953).

Values	C. D.	Joint non-overlap per cent
	0.675	75
Below	0.84	80
the	0.915	82
level of	0.995	84
conventional	1.04	85
subspecific	1.08	86
distinctness	1.13	87
	1.175	88
	1.23	89
Conventional level of subspecific difference	1.28	90
Above	1.34	91
the	1.405	92
level of	1.48	93
conventional	1.555	94
subspecific	1.645	95
difference	1.75	96

of Perry River, N.W.T. No significant difference between measurements of adult males and females could be determined for B. c. leucopareia, the only sample large enough to provide an adequate test. Accordingly, measurements from males and females of each considered subspecies are pooled to increase sample size. Hanson (1951) was able to show a significant difference in measurements between adult males and adult females of B. c. interior handled at Horseshoe Lake, Illinois. However, Hanson and Smith (1950) indicate that only a part of the race B. c. interior migrate through or stop over at Horseshoe Lake, and further, that the race can be divided into four distinct populations. Thus, the analysis may not be valid for the entire race, but rather for the infra-race segment migrating through Horseshoe Lake. Analysis of a given attribute, such as size, in a local population would be expected to bring to light intra-sex differences whereas analysis of the same attribute in a race with clinal variation through a large geographic area might fail to show any such difference because of the overlap between small males and large females. This phenomenon may explain, in part, the difference in results of the analysis of intra-sex size found by Hanson (1951) and those obtained in the present study.

The comparative data contained in Figures 2 and 3, are an analysis of taxonomic distinctness of presently considered subspecies of white-cheeked geese. It is emphasized that the method is an approximation, there is no assurance that the samples are randomly drawn, the sample numbers are small, and the subspecies identification may, in some cases, be questionable.

In the following Figures (2 and 3) those coefficients below 1.28 are marked with an asterisk (*). The number in parentheses over each subspecies is the number of specimens in that sample. Where the

	(11) hutchinsii	(80) leucopareia	(12) parvipes	(10) interior	(19) canadensis	(13) moffitti	(15) occidentalis	(18) minima
(10) hutchinsii		* .963	1.301	2.814	2.622	2.402 **	3.320	* .029
(76) leucopareia	* .718		* .545	1.627	1.729	1.781 **	2.244	* 1.106
(12) parvipes	1.584	* .713		* .604 **	* .885	* 1.146	* 1.162	1.440 **
(10) interior	2.337	1.473	* .869		* .574 **	* 1.014 **	* .932	3.253
(19) canadensis	2.790	1.805	* 1.165	* .199		* .531 **	* .174	2.920
(13) moffitti	2.103 **	1.503 **	* 1.079 **	* .436 **	* .320 **		* .471 **	2.586 **
(15) occidentalis	2.411	1.531	* .924	* .039	* .155	* .458 **		3.769
(17) minima	* .781	1.516	2.533	3.267 **	3.882	2.703 **	3.361 **	

Figure 2: Coefficients of difference between tarsus length measurements (upper right) and coefficients of difference between wing chord measurements (lower left) for eight subspecies of Canada geese. Coefficients of less than 1.28 (marked *) indicate less than subspecific distinctness. Coefficients marked ** indicate ratio of difference between standard deviations exceeds 1.75. Number in parentheses indicates number in sample.

	(12) hutchinsii	(84) leucopareia	(29) parvipes	(13) interior	(19) canadensis	(17) moffitti	(17) occidentalis	(21) minima
12) hutchinsii		* .692	1.904	3.763	4.044	3.573 **	3.354	1.461
88) leucopareia	* .807		* 1.258	3.019	3.364	2.998 **	2.607	2.236
29) parvipes	1.45	* .779		1.499	1.941	1.783	* 1.104	3.436 **
13) interior	2.650	1.771	* 1.004		* .597	* .605	* .448	5.760 **
19) canadensis	3.053	2.485	1.466	* .508		* .078	* 1.015	5.853 **
17) moffitti	3.373	2.888	1.918	* 1.050	* .638		* .969	5.024 **
17) occidentalis	3.017	2.434	1.404	* .428	* .097	* .737		5.328 **
21) minima	* .519 **	1.860 **	2.704 **	4.141 **	5.485 **	5.687 **	5.488 **	

Figure 3: Coefficients of difference between culmen length measurements (upper right) and coefficients of difference between middle toe measurements (lower left) for eight subspecies of Canada geese. Coefficients of less than 1.28 (marked *) indicate less than subspecific distinctness. Coefficients marked ** indicate ratio of difference between standard deviations exceeds 1.75. Number in parentheses indicates sample size.

ratio of difference between standard deviations of two compared subspecies exceeds 1.75 the coefficient is marked with a double asterisk (**). In the specimens examined the use of tail length measurements has proved to be of little or no value in differentiating between closely allied races and therefore is omitted.

Figures 2 and 3 are dual tables giving the calculated coefficients of difference of two different measurements for the indicated samples. With the exception of B. c. minima which proved distinguishable from all other races, the races are arranged in the order of increasing size, which emphasizes the amount of overlap. By use of the tables a rapid comparison between any two of the included races for a given character can be made. In the Figures, there is a surprising regularity with which difference or lack of difference is indicated among the various considered subspecies. With the occasional exception, usually occurring in the comparison with B. c. parvipes, two populations which cannot be distinguished by the character measured in one portion of a Figure will also fail to have distinctive differences in the other parts of the Figures. On the basis of the samples at hand it would appear that of the four standard characters analyzed, culmen length, and middle toe length, as individual measurements, are of most value in differentiating subspecies of white-cheeked geese. This is shown more clearly in Figure 4, where the characters considered in the preceding tables are entered as symbols in the appropriate square where they can be tentatively accepted as capable of separating the subspecies of the intersecting columns. A double asterisk (**) follows those comparisons which cannot be catagorically accepted because the ratio of difference between their standard deviations exceeds 1.75. The majority of these instances occur in comparisons with B. c. moffitti or B. c. minima.

	hutchinsii	leucopareia	parvipes	interior	canadensis	moffitti	occidentalis	minima
hutchinsii			Cul. M.T. Tr. W.C.	Cul. M.T. Tr. W.C.	Cul. M.T. Tr. W.C.	Cul. ** M.T. Tr. ** W.C. **	Cul. M.T. Tr. W.C.	Cul.
leucopareia			Cul. 1.	Cul. M.T. Tr. W.C.	Cul. M.T. Tr. W.C.	Cul. ** M.T. Tr. ** W.C. **	Cul. M.T. Tr. W.C.	Cul. M.T. ** W.C.
parvipes				Cul.	Cul. M.T.	Cul. M.T.	M.T.	Cul. ** M.T. ** Tr. ** W.C.
interior								Cul. ** M.T. ** Tr. W.C. **
canadensis								Cul. ** M.T. ** Tr. W.C.
moffitti								Cul. ** M.T. ** Tr. ** W.C. **
occidentalis								Cul. ** M.T. ** Tr. W.C. **
minima								

Legend

Cul. -- Culmen length
M.T. -- Middle toe length
Tr. -- Tarsus length
W.C. -- Wing chord length

1. Approximately 89.5 per cent joint non-overlap.

Figure 4: Characters indicating subspecific distinctness between eight subspecies of Canada geese. Characters marked ** indicate ratio of difference between standard deviations exceeds 1.75.

The sample of B. c. moffitti is small and includes specimens with extreme variability and consequently, has a large standard deviation. On the other hand B. c. minima, though having an equally small sample, is extremely uniform in series and has a very small standard deviation.

Of interest in this analysis is the apparent break between large Canada geese, (B. c. canadensis, moffitti, interior, and occidentalis) and small Canada geese, (B. c. minima, hutchinsii, leucopareia, and parvipes). This break, represented by differences in culmen length between large and small Canadas is not complete, as is shown graphically in Figure 5. The technique used in Figure 5 is modified from Hubbs and Hubbs (1953) to compare differences at a level of 90 per cent joint non-overlap. Although the measurements alone will not separate the subspecies being considered, a knowledge of geographic range and evaluation of plumage color differences would serve to catagorize individuals where an overlap in measurements occur. Perhaps a better method of showing the break between large and small Canada geese is the comparison of the ratios of maxilla height, at the base, to culmen length (Fig. 6). The mean ratios plotted in Figure 6 are from the same specimens analyzed in Figures 2, 3, and 5. The oblique line which divides the group represents a culmen length: maxilla height ratio of 2:1, and is an arbitrary value fitted by eye. This method has served well to distinguish between large and small Canadas examined in this study with the exception of a group encountered in the short-grass prairie route of the Central Flyway. This group appears to be intermediate between the large and small Canada geese not only in measurements, but in proportions as well. In fact it is the inclusion of a large number of these birds from the collection at the Denver Museum of Natural History in the sample of B. c. parvipes that is responsible

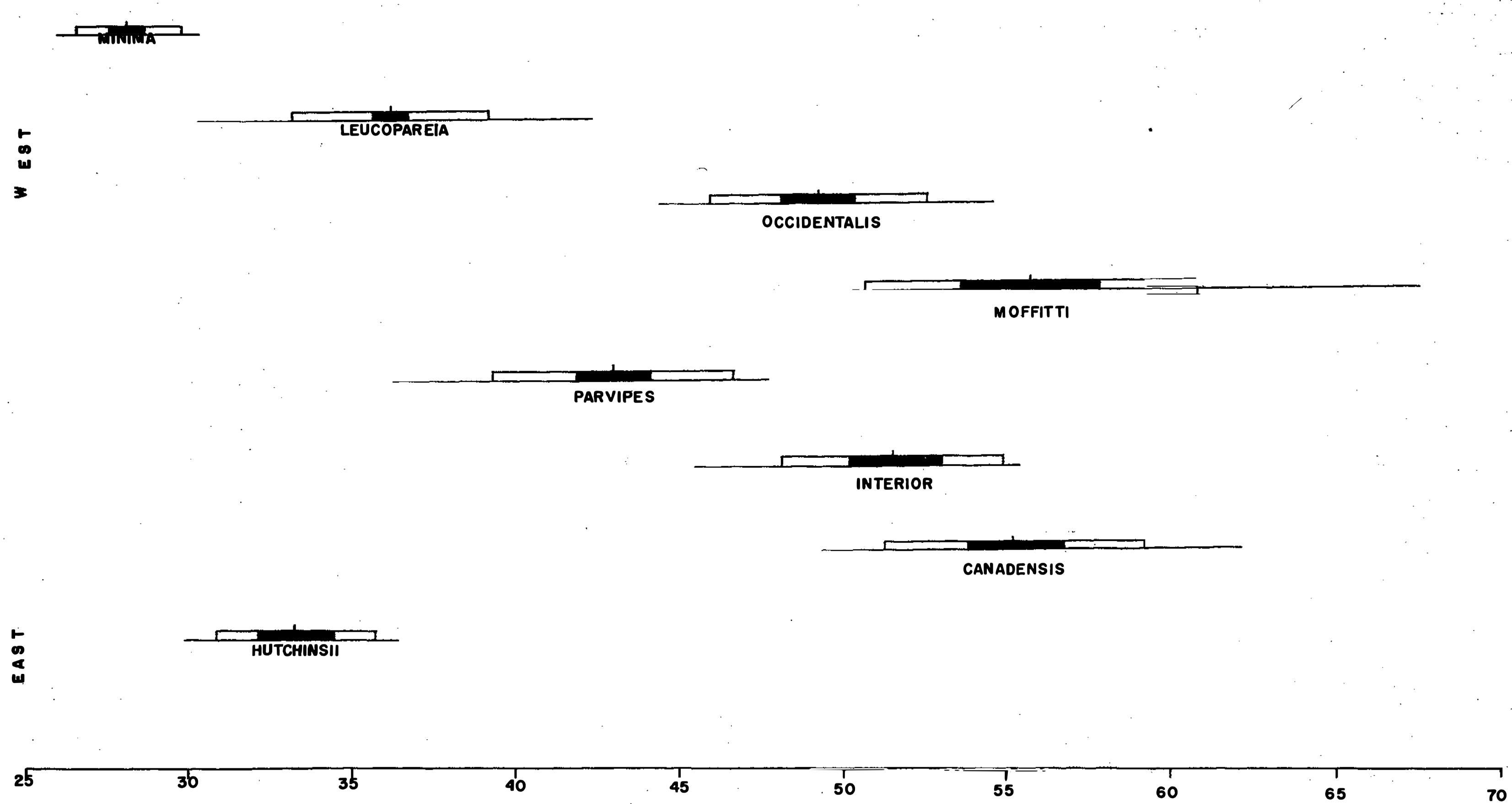


Figure 5. Culmen Length of the *Branta canadensis* complex. Data are from specimens in the U. S. National Museum, Chicago Museum of Natural History, and the Denver Museum of Natural History. Graphic representation of the data is a modification of Hubbs and Hubbs (1953).

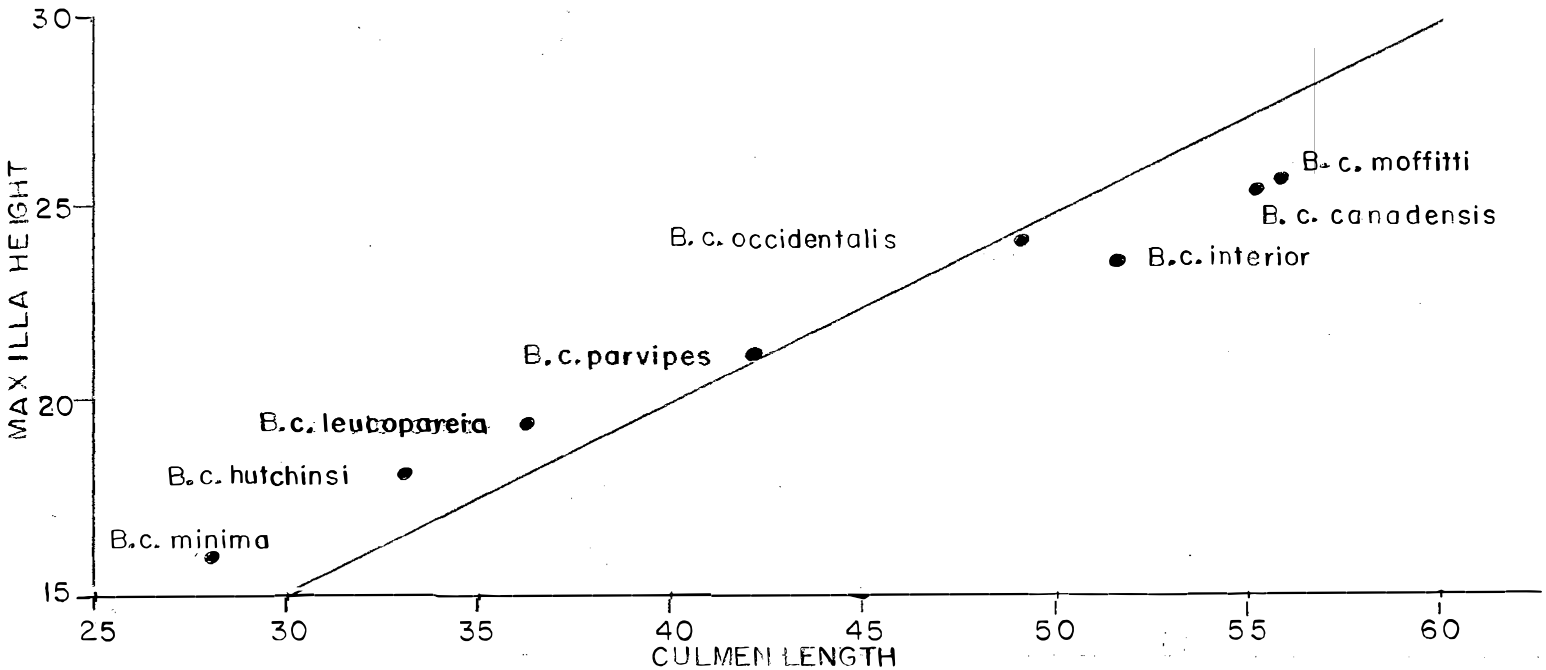


Figure 6. Mean values of maxilla height and culmen length measurements for eight recognized subspecies of Canada geese.

for the overlaps occurring between B. c. parvipes and B. c. occidentalis and B. c. interior in the previous tables and figures. The large specimens of B. c. parvipes from the MacKenzie River, Athabaska River and Athabaska Lake included by Aldrich (1946) in B. c. parvipes and also discussed by Irving (1960) are representatives of this same group. MacKenzie (1927), pointed out that individuals from the Athabaska River and Athabaska Lake were much superior in size to those observed in the MacKenzie River Delta. In size and color these large B. c. parvipes appear somewhat similar to the large B. c. leucopareia (= parvipes (?)) recorded for Southampton Island by Sutton (1932). It may be that this short-grass prairie group represents an intergrade between B. c. moffitti and B. c. parvipes, or perhaps, B. c. leucopareia; or it may represent a more southern and western terminal of a clinal increase in size in B. c. parvipes, or even a more northern terminal of clinal decrease in size in B. c. moffitti. Whatever will be ultimately decided regarding the true position of this short-grass prairie group in the Branta canadensis complex it must be admitted that they bear little resemblance to the typical B. c. parvipes as represented by the type specimen. Hereinafter, these birds of the short-grass prairie will be referred to as B. c. parvipes-beta. With the exception of this one group, the use of the culmen length: maxilla height ratio will serve to separate the large Canada geese and the small Canada geese.

The small Canada geese of the Central Flyway include representatives of three recognized races, namely: B. c. hutchinsii, B. c. leucopareia, and B. c. parvipes. Representatives of these three races are found in both the short-grass prairie route and the tall-grass prairie route, but the proportionate numbers of each race differ considerably in the two routes. The B. c. hutchinsii type is dominant in the tall-grass prairie and is followed by *B. c. parvipes* and *B. c. leucopareia,* in that order. In a sample of 36 geese from the short-grass prairie at Two Buttes, Colorado *B. c. parvipes-beta* was dominant followed by *B. c. leucopareia,* and a few representatives of near typical *B. c. parvipes.* In a sample of 33 birds at the Waggoner Ranch, Vernon, Texas *B. c. leucopareia* was dominant, followed by *B. c. parvipes* and *B. c. parvipes-beta.*

As has been shown, measurements alone are not particularly helpful in differentiating between these three races. Indeed, the measurements of the type specimens are quite similar to each other, Table 5. The measurements of the type specimen of *B. c. leucopareia* appear to be somewhat larger than average, while those of *B. c. parvipes* appear to be somewhat smaller than average. However, in the latter case it should be remembered that the sample of *B. c. parvipes* given in this report does include some very large individuals from the short-grass prairie route whose identity may be questioned. The type specimen of *B. c. parvipes* appears to fit very well with a sample of twenty specimens collected by MacPherson and Manning (1959) on the Adelaide Peninsula. Inasmuch as the type of *B. c. parvipes* was taken in the southern portion of the tall-grass prairie route and there is little evidence that the birds of the short-grass prairie route penetrate this Gulf of Mexico coast area, it seems likely that the type of *B. c. parvipes* is a representative of the breeding birds of the northern Hudson Bay coast and the Arctic coast west to perhaps Queen Maud Gulf. Unless a connection between these birds and *B. c. parvipes-beta* of the short-grass prairie route can be shown, there is even more question concerning the validity of including the two groups in the same race. Disregarding the question of size between *leucopareia* and *parvipes,* these

Table 5. Comparative measurements of the type specimens of B. c. hutchinsii, B. c. leucopareia, and B. c. parvipes.

	B. c. hutchinsii[1]	B. c. leucopareia	B. c. parvipes
Culmen	43.4 (33.66)*	38.1	39.2
Middle Toe	48.7	69.85	59.7
Tarsus	63.5	83.6	71.8
Wing Chord	355.6	400.05	381.0
Tail	139.7	150.28	134.0

[1]Measurements for B. c. hutchinsii are from Richardson (1831); for B. c. leucopareia from Brandt (1836). Both have been converted from the English inch and lines to millimeters. The measurements for B. c. parvipes are by the author.

* Considering the other measurements given by Richardson for the type specimen a culmen length of 43.4 mm. seems disportionate. In the measurements Richardson also offers length of the bill to the rictus (length of tomium) as one inch, five lines /36 mm.). From the specimens of B. c. hutchinsii in the U. S. National Museum it was determined that tomium length averaged 1.0694 culmen length. The calculated culmen length of 33.66 mm. is more in keeping with the remainder of the measurements given for this specimen.

two races can usually be separated on the basis of plumage color. B. c. leucopareia is predominantly a brown goose while B. c. parvipes is predominantly a gray goose. In size B. c. leucopareia varies considerably in different geographic or ecologic locations (Figure 7). However, the brownish-colored plumage, especially that of the breast, remains a uniform characteristic regardless of the area from which a specimen is taken. Both B. c. hutchinsii and B. c. parvipes are essentially gray geese, particularly over the breast. As will be discussed later, it is possible this may range from a rather dark gray to nearly white in either of the subspecies. If the birds recorded by MacPherson and Manning (1959) from the Adelaide Peninsula are B. c. parvipes, and the type specimen conforms to this group, and if the geese recorded by Sutton (1932) from Southampton Island are B. c. hutchinsii and they appear to fit well with the means given for the race on Baffin Island by Soper (1946), then there is a question as to the validity of a distinction between these two races of which both are gray in color and which overlap to a marked degree in size. It would appear possible that the same type of cline observed in size of B. c. leucopareia from west to east may occur in B. c. hutchinsii in a generally north to south or southwest direction. If such a cline exists, B. c. parvipes becomes a synonym of B. c. hutchinsii, being no more than a southern variant of the latter race.

In the handling of small Canada geese in the Central Flyway during this study it was observed that although the variation in size and color was great, there appeared to be foci of variation within which large numbers of geese could be catagorized. In the small Canada geese of the Central Flyway, a total of eight such catagories was recognized. Each catagory was assigned a variation number without in anyway implying nomenclatural taxonomic status. For the most part the catagories are

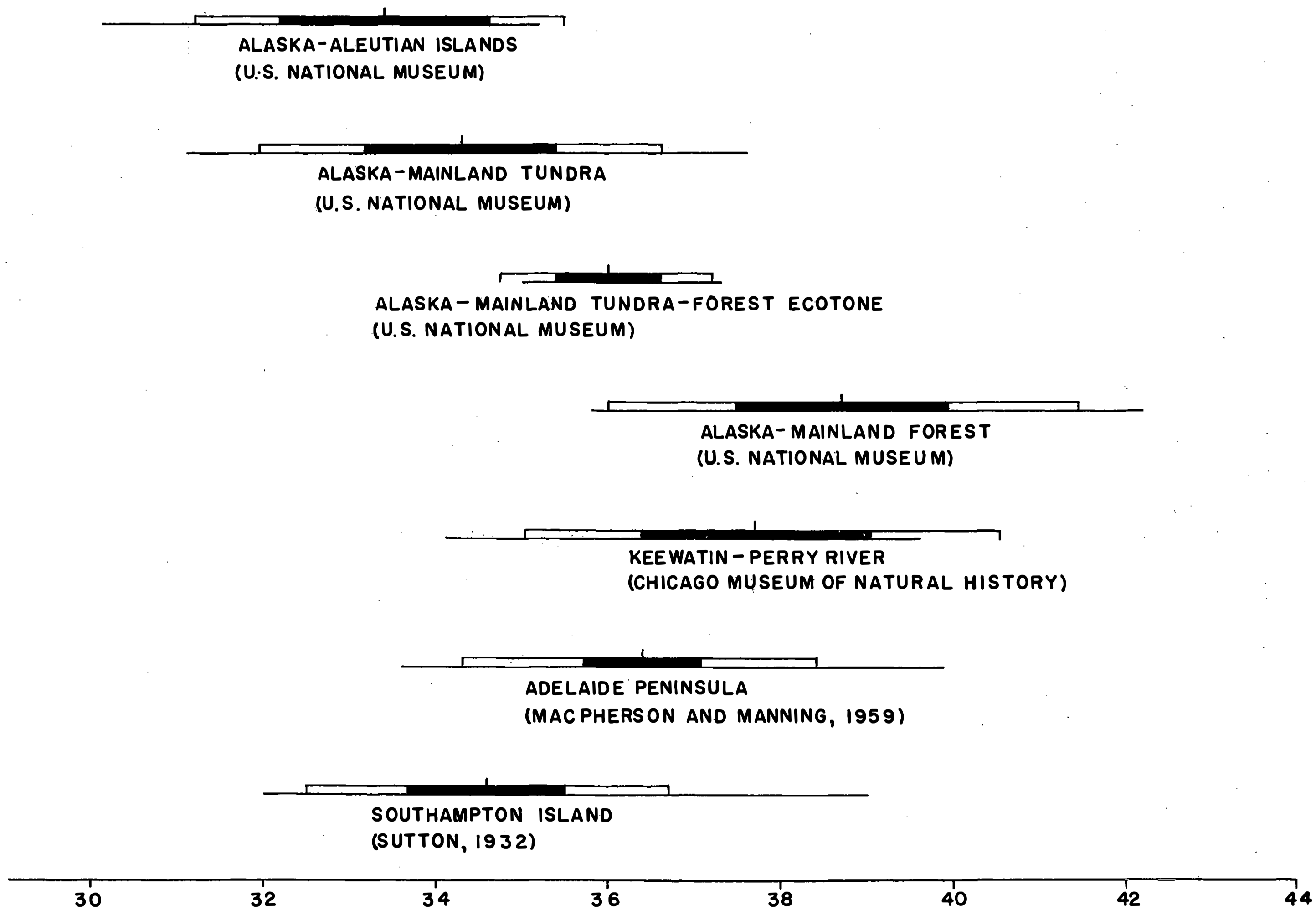


Figure 7. Culmen length of the *Branta canadensis* complex from geographic and ecologic areas across the Arctic (excluding *B. c. minima*). Graphic representation modified from Hubbs and Hubbs (1953).

defined on the basis of size, as indicated in culmen length, plumage color, and forehead profile. The significance of the latter character is not understood. It does not appear to be age or sex dependent, but its relationship to a race or infra-race population cannot be demonstrated clearly. In the field the difference between an abrupt and a sloping forehead is easily recognized; in museum specimens, it is often difficult to perceive.

The foci of variation presently recognized are described below. These variations will include about 80 to 85 per cent of the small Canada geese handled in the Central Flyway.

Variation No. 1. This is the smallest of the white-cheeked geese found in migration in the south central United States, with the possible exception of an occasional *B. c. minima.* It is light breasted, being nearly white on the belly and upper chest. The back is light gray to grayish brown. The culmen length probably seldom exceeds 35 mm. and the weight of an adult in good condition probably does not exceed four pounds. The forehead profile is abrupt.

Variation No. 2. This bird is approximately the same size as Variation No. 1, but differs from it primarily in being darker gray on the belly and upper chest. The back is usually a uniform gray with little tendency toward the brown shades. The forehead profile is abrupt.

Variation No. 3. This bird has a definite brownish cast which is especially apparent on the plumage of the belly and upper chest. A white neck ring is not always present, but when it is, there is a definite contrast between the ring and the brown upper chest. The back is relatively dark and brown. The culmen length of tall-grass prairie specimens may be as long as 40 mm., the weight seldom exceeds six pounds. In the short-grass prairie, examples of this variation have a culmen length up to perhaps 44 mm. In some birds there is a tendency toward grayness, but the brown upper chest is unmistakable. The forehead profile is usually sloping.

Variation No. 4. This bird has a very pale gray or white belly and upper chest. The back is light to medium gray and usually has a slight brownish cast. Altogether, this bird is similar to No. 1 in color, but is larger in size and has the sloping forehead profile. The culmen length of a large specimen will rarely exceed 42 mm. and the maximum weight is about six pounds. Occasionally small examples of this variation overlap No.1 in measurements, but the sloping profile is distinctive.

Variation No. 5. This bird is approximately the same size as No. 4, but with a definite gray belly grading to a lighter gray or white upper chest. The back shows a predominant gray cast. The forehead profile is usually abrupt.

Variation No. 6. The plumage color of this bird is very similar to Variation No. 4, but it is somewhat larger with weights of adults in good condition slightly exceeding seven pounds. The culmen length probably does not exceed 49 mm., but the ratio of maxilla height to culmen length will regularly exceed 1:2.0. In all other variations of small white-cheeked geese this ratio is usually about 1:1.8. The forehead profile is sloping.

Variation No. 7. Typically this bird is about the size of Variation No. 3, but is rather uniform medium gray both above and below, a little lighter on the upper chest, and has an abrupt forehead profile. In size and color it is overlapped by Variations No. 2 and No. 5, though it is paler than No. 2 and generally does not appear as pale gray on the upper chest as No. 5. Occasionally the plumage of this variation will show a faint brownish cast, but lacks the definite brown upper chest of No. 3.

Variation No. 8. This is a very brown bird with a high-bridged, narrow maxilla very similar to some of *B. c. leucopareia* specimens from the Aleutian Islands. It is approximately the size of Variation No. 1 and No. 2 and in the few specimens examined had a very broad white ring at the base of the neck and a relatively sloping forehead profile. It is neither as dark in color nor as small as *B. c. minima.*

The catagorizing of Canada geese by variation number was not attempted until late in the present study. Consequently, the number of specimens involved in comparative samples is small. However, it is of interest to consider the distribution of these variation numbers from three different trapping stations (Table 6).

No examples of Variation No. 8 were examined in these particular samples, though it is known to occur in the tall-grass prairie route and probably occurs in the short-grass prairie route as well. The samples from the short-grass prairie stations are so small that lack of any given variation numbers in the table can hardly be considered significant. However, the non-occurrence of Variation No. 6 in the tall-grass prairie route is considered significant. No examples of this variation have been examined for the tall-grass prairie route during the course of this study.

In a very general way, the variations may be catagorized into groups corresponding to recognized races. Thus, Variation 1 and 2 are referable to *B. c. hutchinsii,* Variation 3 and 8 are referable to *B. c. leucopareia,* and Variations 4 and 5 are referable to *B. c. parvipes.* Variation 7 should probably be considered a part of the *B. c. hutchinsii* group though some individuals approach Variation 3 in color and others are similar to Variation 5. Variation 6 can be considered a part of the *B. c. parvipes* group, but numerous reservations, already stated, make its position in this group tentative.

Table 6. Frequency of Variation Numbers of Small Canada Geese From Three Locations. Number in Parentheses is Size of Samples.

Variation Number	Waggoner Ranch Texas February, 1959 (33)		Two Buttes, Colo. January, 1960 (36)		Salt Plains (N.W.R.) Oklahoma November, 1959 (355)	
	No.	%	No.	%	No.	%
1	2	6			9	2.5
2					85	24
3	12	36	11	30.5	27	7.5
4	11	33			9	2.5
5			5	14	41	12
6	8	24	16	44		
7			4	11	184	52

Migration Routes and Wintering Areas

In recent years, various authors have used the term "migration" in describing not only the movement between breeding and wintering areas, but for local movements and random wandering as well. Hochbaum (1955) has taken issue with such non-critical use of the term migration and has suggested that the type of movement be categorized as presented by Wilkinson (1952). Including a rather detailed description of word derivation, Wilkinson (1952) has classified the movements of birds to and from the breeding area as anastrophic migration and all other movements as diasporic migration. These two categories include all the major movements of waterfowl and avoid any confusion that might exist as to the proper classification of a particular spatial displacement.

In a discussion of migration routes, therefore, anastrophic migration is being considered. In the central United States, the small Canada geese migrate southward to the wintering areas in two relatively distinct routes through the grassland biome (Fig. 8). Because of the close correlation between these routes and the natural vegetative associations in the biome, these routes, for convenience, can be called the tall-grass prairie route and the short-grass prairie route. It should be understood that the route names imply no correlation between goose use and dominant vegetation of the association. The comparison is proposed strictly on the basis of areal boundaries of the migration routes and the vegetative association. Knowledge of the boundaries of these routes has been derived primarily from band returns from hunter kills, and trapping reports on Canada geese. A smaller amount of supplemental information has come from reports on color-marked geese.

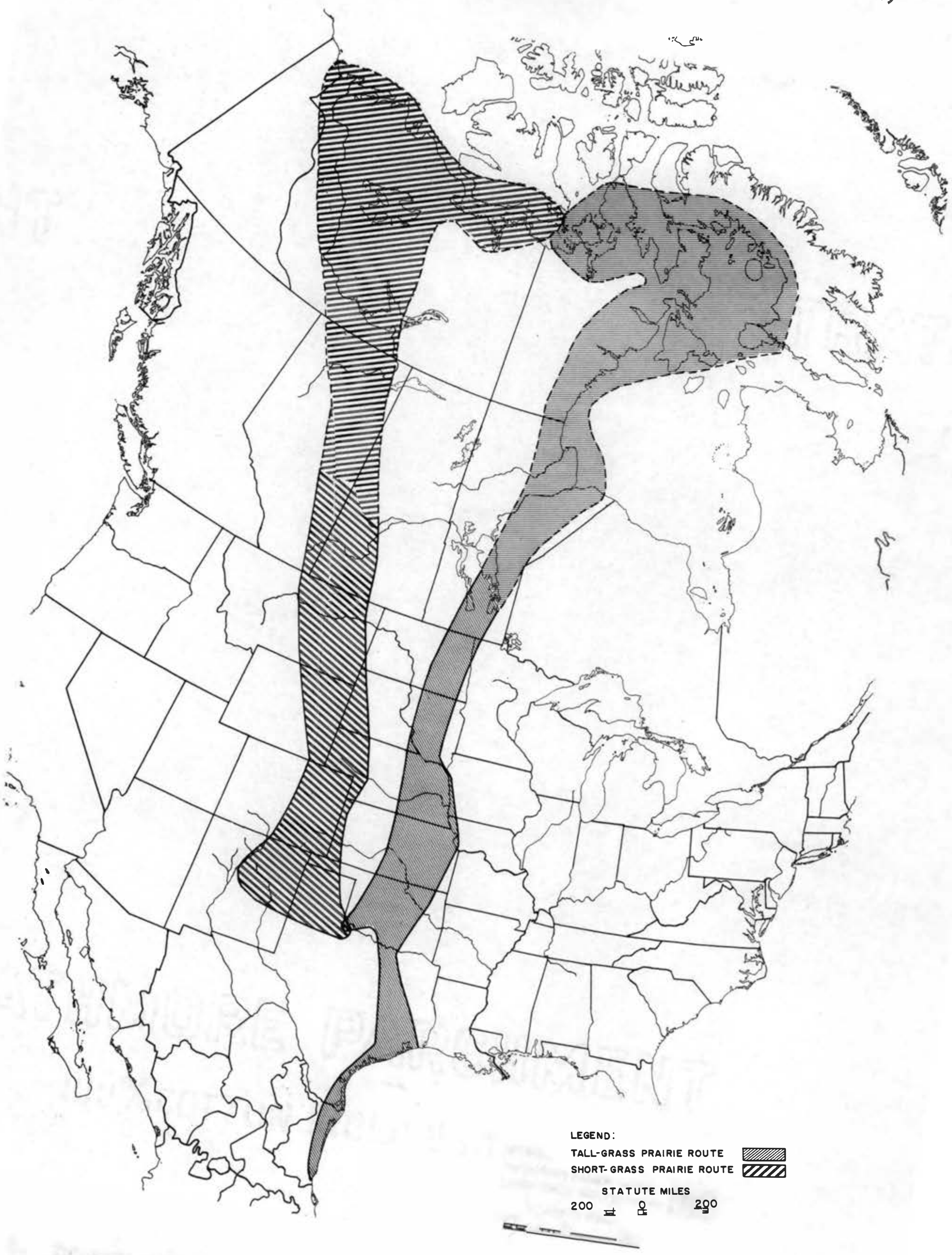


Figure 8. Distribution of the small Canada geese of the tall-grass prairie and the short-grass prairie. Distribution is based primarily on band return data.

<u>The Tall-grass Prairie Route.</u> The boundaries of the tall-grass prairie route are postulated primarily on the basis of 1,334 band returns covering a period from 1952 through 1960 (Appendix I, 1-2). A majority of the band returns are from geese banded at the Sand Lake National Wildlife Refuge, Columbia, South Dakota. The remaining returns are from geese banded in connection with this study (Table 7). In Table 7 the year of recovery is considered to be from June 1 to May 31. The band returns from Sand Lake are not complete, yet they are believed to be adequate for the purposes of migration route delineation.

Also helpful in delineating the route are the approximately sixty individual sightings of color-marked geese. This does not include nearly 300 observations of color-marked geese at the station of banding or what was judged to be repeated observations of color-marked geese in other locations.

Additional data has come from geese killed in this area, but banded at Eskimo Point, Keewatin, N.W.T.; Wheeler Bottoms, Fort Randall reservoir, South Dakota; Swan Lake National Wildlife Refuge, Sunner, Missouri; and Squaw Creek National Wildlife Refuge, Mound City, Missouri.

The tall-grass prairie route varies in breadth from about three degrees Longitude in southern Manitoba to about five degrees Longitude through Nebraska, Kansas, and Missouri, to about one to two degrees Longitude along the wintering areas of the Gulf Coast of Texas and Mexico. For the most part the route lies between 95 and 100 degrees West Longitude. Data from band returns indicate that few of the small Canada geese of the tall-grass prairie route wander west of the 100th meridian; and in a general way the 100th meridian coincides with the boundary between the tall and short-grass associations, (Shantz and

Table 7. Number of Returns by Year From Geese Banded at Stations in the Tall-grass Prairie.

Year Recovered	Sand Lake N.W.R.	Salt Plains N.W.R.	Tishomingo N.W.R.	Aransas N.W.R.	Total
1952	49				49
1953	31				31
1954	35				35
1955	43				43
1956	261				261
1957	315				315
1958	226	13		5	244
1959	246	69	2	2	319
1960		33	2	2	37
Total	1206	115	4	9	1334

Zon, 1924).

The eastern boundary of the route extends from the southern end of Lake Winnipeg in Manitoba southwestward to the eastern boundaries of North Dakota and South Dakota, then along the Missouri River into northwestern Missouri. From northwestern Missouri the route appears to swing southwestward coinciding with the eastern boundary of the tall-grass prairie across southeastern Kansas and northeastern Oklahoma to the vicinity of Lake Texoma on the Red River. South of Lake Texoma there are numerous returns from the tall-grass prairie region south to Waco, Texas. From this vicinity there is essentially a blank in the route picture, so far as band returns are concerned, to the Eagle Lake-Lissie Prairie region between the Brazos and Colorado Rivers. This is the beginning of the tall-grass prairie segment of the Texas Gulf Coast. Band returns and communication with refuge managers at the Sabine, Laccasine, and Delta National Wildlife Refuges indicate that few of the small Canada geese move eastward along the Gulf Coast beyond the Sabine River. Band returns from small Canada geese banded in the tall-grass prairie distributed narrowly along the Gulf Coast from Galveston, Texas to Tampico, Vera Cruz. Loetscher (1955), in quoting correspondence from G. B. Saunders, indicates small Canada geese occur as far south as the Papaloapan basin fifty miles south of the city of Vera Cruz. A total of thirteen band returns, or about one per cent of the total returns of Sand Lake bands, have come from the Coast of Mexico.

It is this southern portion, from Galveston, Texas southwardly, that serves as the major wintering area for small Canada geese of the tall-grass prairie route. In smaller numbers, and depending on weather conditions, small Canada geese do winter as far north as Salt Plains National Wildlife Refuge, Oklahoma. Periods of severe winter weather here will push most of the flocks south of the Red River for a part of the winter season. Given moderate winter weather, a few small geese probably winter as far north as southern Nebraska, and some have been recorded for most of the winter period in northern South Dakota.

During the hunting season, most of the geese are congregated on the state and federal refuges or on private ranches which offer complete or partial protection from human molestation. Examples of such ranches on the Texas Coast are the King and O'Connor ranches. These large, private landholdings function as refuges for large numbers of geese through much of the winter hunting period.

Following the close of the hunting season, geese disperse from the refuges over much of the farm land in winter grain crops, pasture, or the standing or cut grain fields of the previous harvest season. The extensive use of agricultural lands by Canada geese throughout both the migration and wintering period is a notable feature of their habitat use. At Salt Plains, the first flights of small Canada geese generally use the large, open fields of winter grain crops or grazed pastures which offer a high degree of visibility. As the season progresses, the small Canadas will eventually feed in smaller pastures and standing grain crops and graze close to the wooded edges of large fields. This phenomenon is in marked contrast to the habits of the large Canada geese which show little hesitation in using small fields and pastures with wooded margins which offer limited visibility. This same contrast in habits is noted in the different water areas used by the two groups at Salt Plains. For both resting and roosting, the small Canadas use the broad, shallow flats of Sand Creek Bay which offers high visibility. The large Canadas seem to prefer the brush and tree - margined waters of interior ponds such as Wilson Pond and Mink Run. Thus, in both feeding and resting or roosting situations a high degree of visibility appears to be a prerequisite to site use by small Canada geese. The size of the water area or feed field appears to be significant only as it relates to visibility. At Aransas and Laguna Atascosa small Canada geese commonly use small ponds of one to twenty acres for watering and loafing during the day, but in each instance these ponds are so situated as to offer a high degree of visibility. At Tishomingo, small Canada geese used the waterholes left in depressions in the field after a rain. Often the use of these small pools was so intense that the vegetation at the margins would be completely eradicated by the combination of "puddling" and grazing. It was noted also that when these water sources were available geese would often omit the mid-morning and mid-afternoon flights to the lake. However, small Canadas normally returned to the large reservoirs or coastal bays for roosting.

Observations of small Canada geese throughout the fall, winter, and spring from Oklahoma south to the Texas-Mexico border indicate a strong preference for grazing on winter grains and grazed pastures. These observations agree well with the findings of Glazener (1946) relative to food habits of geese on the Gulf Coast of Texas. Winter wheat is an important food source throughout the migration and wintering areas to the north of the Texas coast. On the Texas coast, rice fields replace winter wheat as a primary source of grazing. In the grazing areas it is the short, (approximately four inches), succulent vegetation that is preferred. This preference is well demonstrated in feed fields at Salt Plains and Tishomingo where large congregations of the small Canada geese are often present. The field interiors are grazed continuously until almost devoid of vegetation, while the wooded field margins receive slight to moderate use.

Eventually the vegetation in these margins becomes quite tall and rank and it is only when the onset of cold weather slows the growth of vegetation in the open interiors that geese use the peripheral areas for grazing. On the Gulf Coast, Bermuda grass pastures are regularly used by goose flocks if the pastures are receiving moderate to heavy grazing by cattle. Goose flocks were not observed in those pastures which were idle or only slightly grazed. In these situations it is probable that a combination of poor visibility and lack of succulent vegetation make the areas unsuitable for use by small Canada geese.

The distribution of small Canada geese in the migration route and wintering area is not uniform. Indeed, band return data point to an interesting lack of uniformity, area for area, in the distribution of small Canada geese in the tall-grass prairie, (Tables 8 and 9). Thus, a relatively few states and provinces contribute the major proportion of band returns on small geese in the tall-grass prairie. One province, Manitoba, and six states, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas yield 93 per cent of the returns on small Canada geese banded at Sand Lake and nearly 94 per cent of the returns on the same geese banded at Salt Plains. This distribution is not unexpected, since it is derived from data procured through hunting and perhaps may be more correctly considered to be a picture of the huntable or accessible populations of small Canada geese. It should not be assumed however, that the distribution is purely artificial, brought about by the coincidence of hunter and goose. The distribution of small Canada geese is directly correlated with the distribution of habitat within the broad scope of the tall-grass prairie. During the hunting season, the total area of habitat is reduced by the activities of hunters to a point where the refuges offer the only quiet or attractive habitat within

Table 8. Distribution of 1,206 Band Returns From Small Canada Geese Banded at Sand Lake National Wildlife Refuge 1951-1959.*

	No. of Returns	Per Cent
Canada	66	5.4
Saskatchewan	4	.3
Manitoba	34	2.8
Ontario	13	1.1
Keewatin	11	.9
Franklin	4	.3
United States	1127	93.5
North Dakota	82	6.8
Minnesota	6	.5
South Dakota	528	43.8
Nebraska	45	3.7
Iowa	7	.6
Colorado	2	.2
Kansas	48	4.0
Missouri	17	1.4
Oklahoma	81	6.7
Arkansas	1	.1
Texas	307	25.5
Louisiana	1	.1
Mississippi	1	.1
Mexico	13	1.1
Tamaulipas	12	1.0
Vera Cruz	1	.1
Total	1206	100.0

* Primarily Fall Banding

Table 9. Distribution of 115 Band Returns From Small Canada Geese Banded at Salt Plains National Wildlife Refuge, 1957-1960.*

	No. of Returns	Per Cent
Canada	6	5.2
Alberta	1	.87
Keewatin	1	.87
Ontario	1	.87
Manitoba	2	1.72
Franklin	1	.87
United States	108	93.9
North Dakota	8	6.95
South Dakota	12	10.43
Wisconsin	1	.87
Nebraska	3	2.60
Kansas	6	5.21
Missouri	1	.87
Oklahoma	60	52.2
Texas	16	13.9
Colorado	1	.87
Mexico	1	.9
Tamaulipas	1	.9
Total	115	100.0

* Primarily Fall Banding

the flyway. Prior to the hunting season at Salt Plains, flocks of geese are a common sight on winter wheat fields, harvested grain fields, and pastures bordering the refuge. With the opening of the hunting season constant gunning pressure removes these areas from the goose habitat though flocks may vainly endeavor to use them. In some hunting areas, such as the Flying Goose Ranch, operated by Mr. Adam Diel, shooting is allowed on mornings only, six days a week. Thus, for one full day and six afternoons of each week the fields of the Flying Goose Ranch provide habitat for small Canada geese. During the forenoons of six days of each week these same fields are totally inaccessible to flocks of geese, and lacking usability, are removed from the habitat. During the hunting season geese are congregated on the refuges and the food component of the habitat is rapidly depleted. Within pre-hunting season habitat, the food component is abundant, but constant molestation prevents use of this component. Thus, it is the seasonal invasion and usurpation of habitat by hunters that provides the band return data and subsequent picture of goose population distribution.

The lack of uniformity in distribution is even more pronounced when band returns from the individual provinces and states are considered. Hanson and Smith (1955) concluded that the kill of geese by the natives of Hudson Bay and James Bay region was no more than ten per cent of the geese reaching the breeding grounds in the spring. The small number of band returns from the Northwest Territories would suggest this same factor of low native kill may be operative in the small Canada geese as well. It is also probable that the return rate on bands is somewhat less than the recovery rate on geese. The coastal distribution of band returns is probably a phenomenon related to the distribution of hunting efforts in the northern regions rather than a reflection of goose distribution. E. B. Chamberlain, U. S. Fish and Wildlife Service biologist (personal communication, 1960) referring to a 1959 report on a waterfowl survey conducted by Chamberlain and Robert H. Smith between 63° 30' North and 65° 00' North Latitude and 92° 00' West to 110° West Longitude pointed out that the majority of geese were seen within 200 miles of the coast. A number of earlier aerial surveys by Smith, Sutton, and Solman (1951), Wellein, Colls, and Harris (1952), Wellein and Newcomb (1953), and Smith and Sutton (1953) indicated that considerable numbers of Canada geese are present inland along the Perry, Ellice, and Kugaruk Rivers and especially throughout much of the lower Thelon River drainage from Eyeberry Lake to the coast. Clarke (1940) stated geese were abundant east of the Thelon Game Sanctuary to Baker Lake and were reported to be abundant on the Back River. Geese were also reported to be present on the Kazan River and Dubawnt Lake. Clarke indicated that P. A. Taverner identified Canada geese from the vicinity of Grassy Island on the Thelon River as being B. c. leucopareia. Wellein and Newcomb (1953) suggested that the Canada geese they were seeing in their northern survey were "probably the Lesser". Disregarding the question of subspecies identification it would appear the majority of these birds were small Canada geese and probably segments of the population migrating through the tall-grass prairie route. From the Keewatin and Franklin Districts in the Northwest Territories there are a total of seventeen reported band recoveries scattered primarily along the coastal regions from Eskimo Point north to Pelly Bay, east to Cape Dorset on Baffin Island, and west to Gjoa Haven on King William Island and Sherman Inlet. There is a single return from Yathkyed Lake which represents the most interior Arctic return. The exact location on two of three returns from the Back River are not given, but it is believed they probably came from near the coast, the other was reported from near Lake Macdougall. Breckenridge (1955) tentatively identified the Canada geese observed on the lower Back River as being B. c. parvipes.

In Manitoba, band returns are received primarily from two locations, York Factory on the Hudson Bay Coast and an area north of Winnipeg lying approximately between the south end of Lake Winnipeg and Lake Manitoba. Combined, these two areas contribute more than 83 per cent of the Sand Lake and Salt Plains band returns received from Manitoba. The distribution of returns does not confirm a migration along the Churchill and Nelson Rivers, but it seems reasonable to assume these watercourses may function as migration route stimuli.

Band returns from Ontario present a picture of scattered distribution. Most Ontario returns from Sand Lake and Salt Plains bandings come from the coastal areas of James Bay and Hudson Bay, from the Attawapiskat River north to Fort Severn. Inland through Ontario it appears the migration may follow the Severn River in a southwesterly direction to the south end of Lake Winnipeg in Manitoba or possibly somewhat more southerly to the Lake of the Woods on the Manitoba-Ontario-Minnesota border. Hochbaum (1955) noted that in the spring "Richardson's geese" migrate north or north-northeast from the vicinity of the Delta Research Station. An alternate route may branch south from Big Trout Lake to Lake Nipigon and Lake Superior, but the number of returns are too few to provide more than a suggestion.

In Manitoba and Ontario, as well as south through North and South Dakota there is a striking similarity in the distribution of band returns from Sand Lake banded geese and the distribution of Swan Lake banded geese, as presented by Lynch (1956). This is interesting because the Swan Lake returns are presumably from large Canada geese while the Sand Lake returns are from small Canada geese.

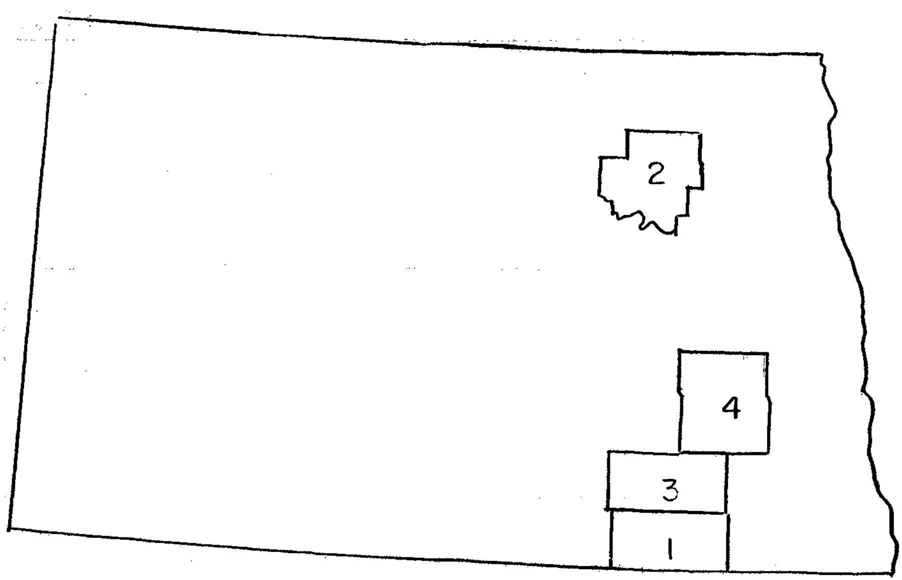
The band returns in Alberta and Saskatchewan from small Canada geese banded at Sand Lake and Salt Plains are of interest. Of the five geese on which returns were received from these provinces, two were in their third year, one in the fifth year, one in the seventh year, and one in the eighth year of life. Sub-adult wandering, therefore, is ruled out as an explanation of this western occurrence of tall-grass prairie geese. Three of the Saskatchewan returns came from the Quill Lakes region north of Regina and represent the only small Canada goose band returns from that part of the province. These three returns most nearly fit a rather restricted distribution of large Canada goose returns to the north. One of the returns in Saskatchewan and the single return from Alberta fall into the major area of band returns from the short-grass prairie route bandings for the two respective provinces and will be discussed in a later section.

In the following discussion of band return distribution in the United States, the data are derived from bandings at Sand Lake National Wildlife Refuge, unless otherwise stated.

In North Dakota, band returns from small Canada geese have been received from sixteen counties, but nearly 77 per cent of the state returns are from only four counties, (Chart 1). Dickey County lies north of the Sand Lake National Wildlife Refuge on the North Dakota-South Dakota border. The returns in Ramsey County are concentrated in the Devils Lake region, an area of numerous large lakes. The majority of returns from the state come from the area between these two regions.

Chart 1. Counties contributing major proportions of band returns from Small Canada geese in North Dakota. (From Sand Lake banding data, 1951 - 1959).

County	No. of returns	Per cent of Total No. Dakota Returns
1. Dickey	28	34.1
2. Ramsey	20	24.4
3. La Moure	9	11.0
4. Barnes	6	7.3
Total	63	76.8
Total returns in No. Dakota	82	100.0



Band returns in South Dakota are distributed over 24 counties, but more than 94 per cent of the returns came from only seven counties and Brown County alone contributed over 84 per cent of the total state returns, (Chart 2). Large reservoirs such as Houghton Reservoir, Fort Randall Reservoir, Lewis and Clark Lake, and the series of lakes in the vicinity of Lake Preston apparently attract and hold large numbers of geese, many of which are subsequently taken by hunters. The disproportionate number of returns from the vicinity of the Sand Lake refuge in Brown County is a noticeable feature of fall migration banding and may be, in part, the result of breaking up of family units, debilitation of the birds because of trapping and an increased reporting rate as a result of the activities of employees of conservation agencies (Atwood and Geis, 1960 and Gies and Atwood, 1961), or the interest of hunters in an area where large numbers of banded and color-marked birds exist.

In Nebraska the returns are distributed over 25 counties. Nine of these counties yield about 64 per cent of the state total, (Chart 3). For the most part, the distribution of returns in the state closely conforms to the Missouri River and the eastern portion of the Platte River with a scattering of records in other southeastern counties.

Band returns in Kansas are scattered over thirty counties, and only two counties have contributed more than two returns each, (Chart 4). The returns in Harper County are probably the result of the influence of Salt Plains National Wildlife Refuge which lies about fifteen miles south of the Kansas-Oklahoma border. The three returns from Kiowa County are somewhat misleading, since all are 1957 returns, and are the only returns ever received from this county. In general, 1957 band returns show a more westerly distribution throughout the Canadian provinces and the several states of the tall-grass prairie

Chart 2. Counties contributing major proportions of band returns from Small Canada geese in South Dakota. (From Sand Lake banding data, 1951 - 1959).

County	No. of returns	Per cent of Total So. Dakota Returns
1. Brown	447	84.7
2. Kingsbury	10	1.9
3. Charles Mix	10	1.9
4. Yankton	9	1.7
5. Clark	9	1.7
6. Spink	7	1.3
7. Union	7	1.3
Total	499	94.5
Total returns in So. Dakota	528	100.0

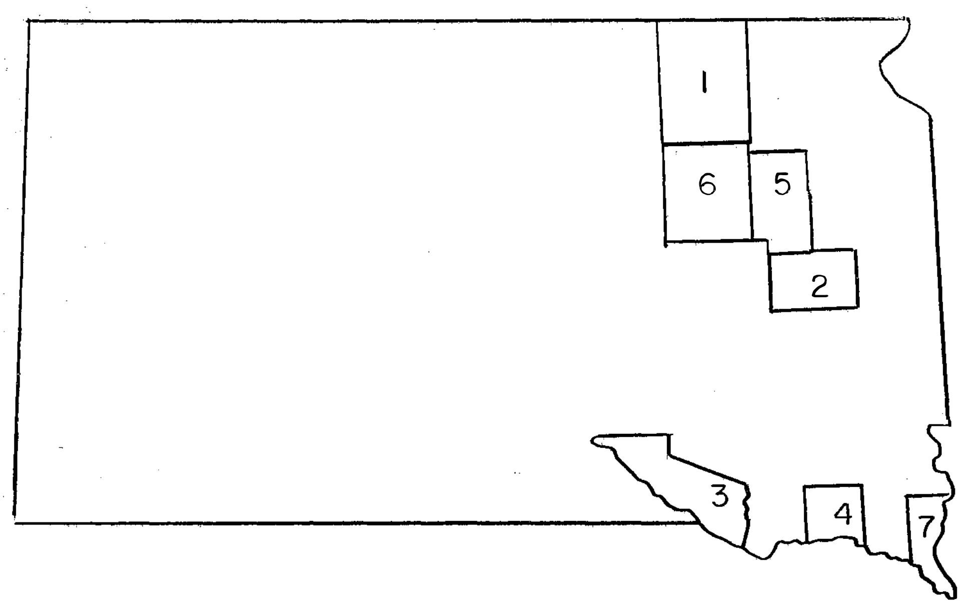


Chart 3. Counties contributing major proportions of band returns from Small Canada geese in Nebraska. (From Sand Lake banding data, 1951 - 1959).

County	No. of returns	Per cent of Total Nebraska Returns
1. Dixon	6	13.3
2. Knox	5	11.1
3. Burt	5	11.1
4. Nemaha	3	6.7
5. Pierce	2	4.4
6. Platte	2	4.4
7. Colfax	2	4.4
8. Otee	2	4.4
9. Webster	2	4.4
Total	29	64.4
Total returns in Nebraska	45	100.0

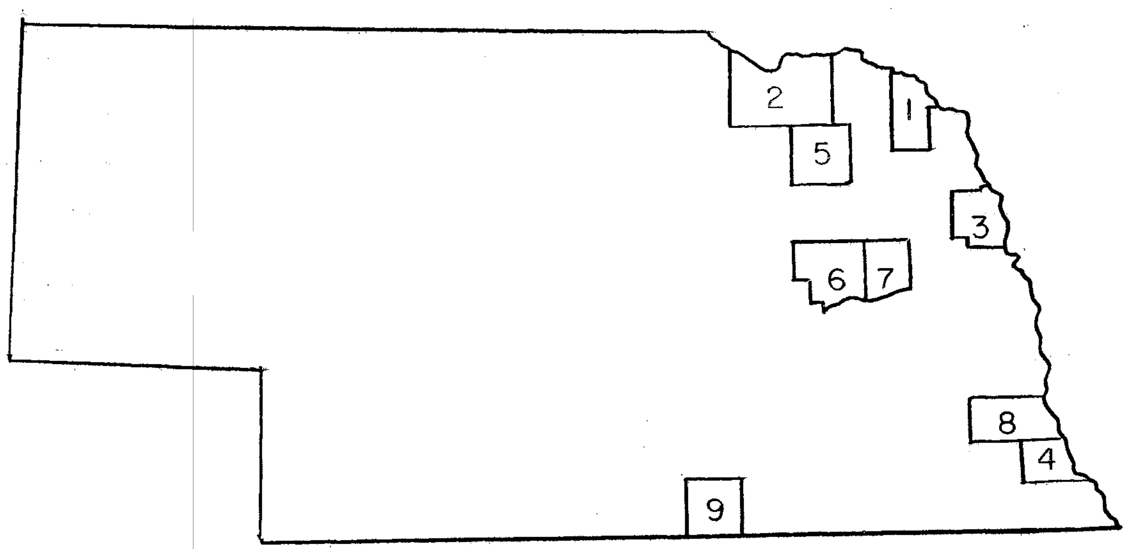
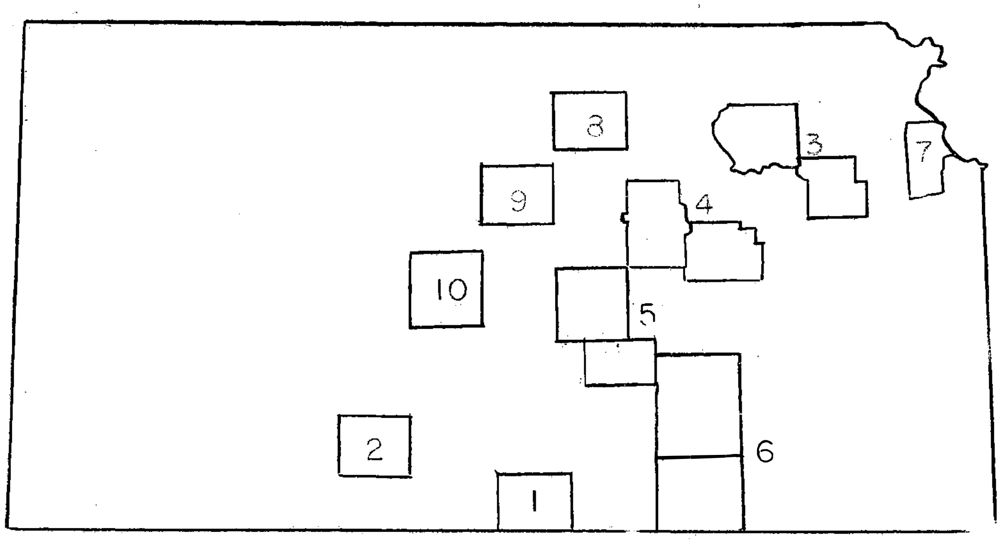


Chart 4. Counties contributing major proportion of band returns from Small Canada geese in Kansas. (From Sand Lake banding data, 1951 - 1959).

County	No. of returns	Per cent of Total Kansas Returns
1. Harper	5	10.4
2. Kiowa	3	6.3
3. Pottawatomie-Shawnee	4	8.3
4. Dickinson-Morris	4	8.3
5. McPherson-Harvey	4	8.3
6. Butler-Cowley	4	8.3
7. Leavenworth	2	4.2
8. Cloud	2	4.2
9. Lincoln	2	4.2
10. Barton	2	4.2
Total	32	66.7
Total returns in Kansas	48	100.0



route. The overall pattern of band recovery distribution in the state is from the northeast to the south-central area.

Band returns from small Canada geese in Missouri are distributed over seven counties, but two counties provide over 70 per cent of the state total, (Chart 5). Holt County, in which the Squaw Creek National Wildlife Refuge is located, and Chariton County, in which the Swan Lake National Wildlife Refuge is located, both border the Missouri River and are areas of goose congregation in the fall. It is of interest that eight returns, 47.1 per cent of the state total, are from 1956. This is correlated with a general eastern distribution of tall-grass prairie returns in 1956 from South Dakota to the Red River at the border of Oklahoma and Texas.

Band returns from Sand Lake bandings are distributed over eighteen counties in Oklahoma. Four of these counties contribute more than 76 per cent of the state total and one, Alfalfa County, alone yields nearly 57 per cent of the state total, (Chart 6). The band recovery distribution suggests two major migration pathways within the tall-grass prairie route across Oklahoma. To the west one pathway enters the state in the vicinity of Alfalfa County, then divides south of Alfalfa County with one branch directed southwest to the Waggoner Ranch in Wilbarger County, Texas and the other branch directed southeast to the Tishomingo National Wildlife Refuge, Johnston County, Oklahoma, or the Hagerman National Wildlife Refuge, Grayson County, Texas. To the east, another pathway enters the state in the vicinity of Osage County and is directed nearly due south to the Tishomingo or Hagerman refuges. Band returns and color-mark reports from geese trapped at the Salt Plains refuge from 1957 to 1959 lend support to the hypothesized path-

Chart 5. Counties contributing major proportions of band returns from Small Canada geese in Missouri. (From Sand Lake banding data returns, 1951 - 1959).

County	No. of returns	Per cent of Total Missouri Returns
1. Holt	7	41.2
2. Chariton	5	29.4
Total	12	70.6
Total returns from Missouri	17	100.0

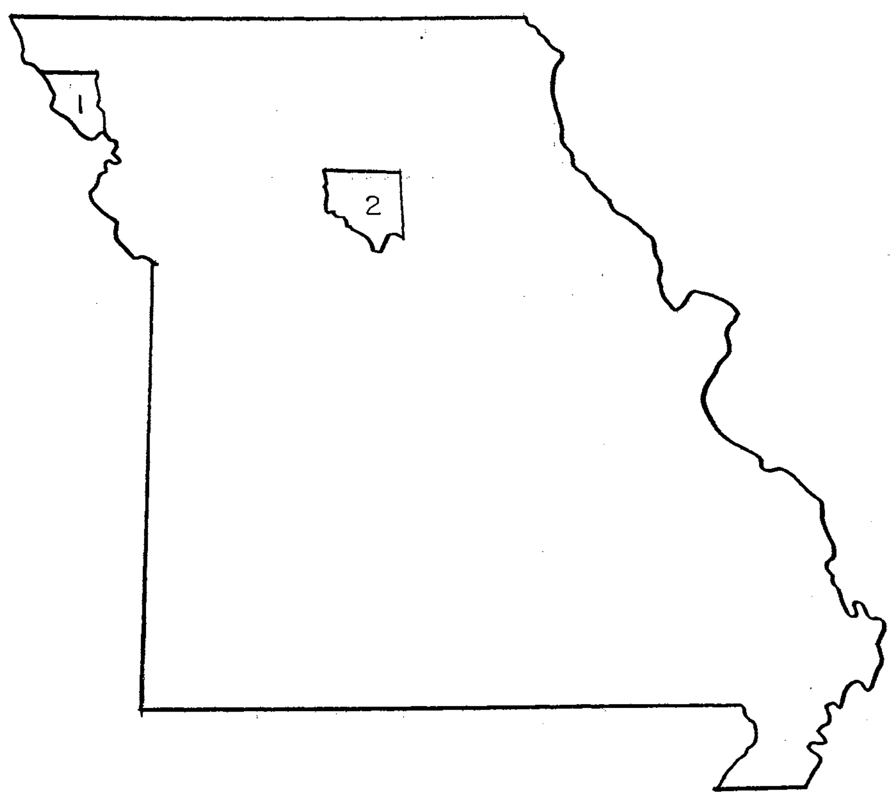


Chart 6. Counties contributing major proportions of band returns from Small Canada geese in Oklahoma. (From Sand Lake banding data, 1951 - 1959).

County	No. of returns	Per cent of Total Oklahoma Returns
1. Alfalfa	46	56.8
2. Johnston	6	7.4
3. Blaine	5	6.2
4. Osage	5	6.2
Total	62	76.5
Total returns in Oklahoma	81	100.0

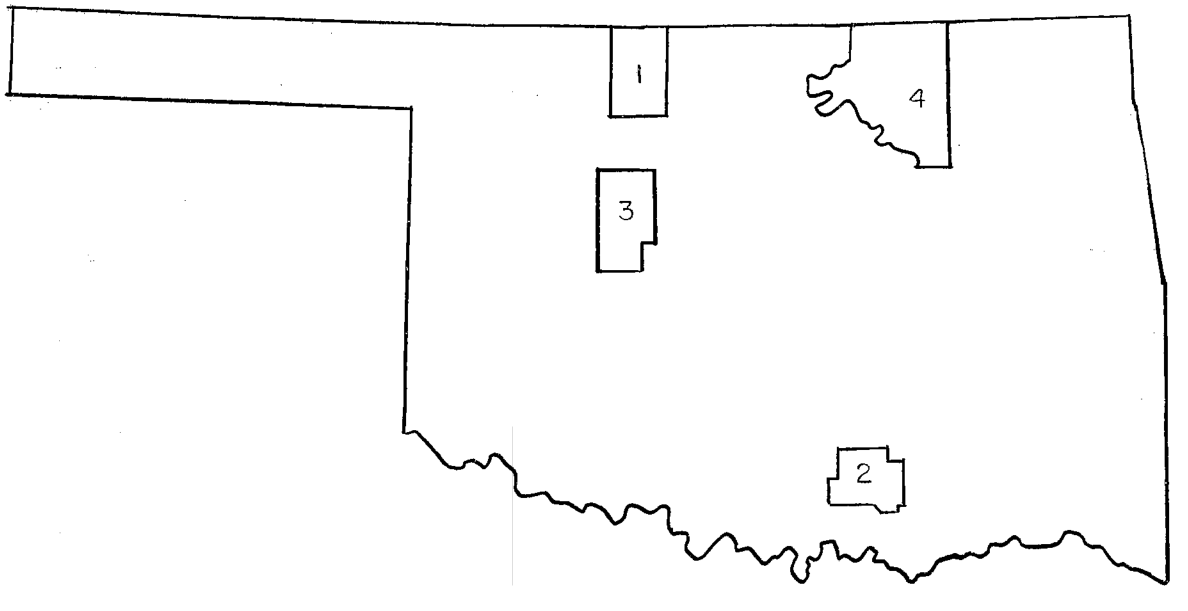
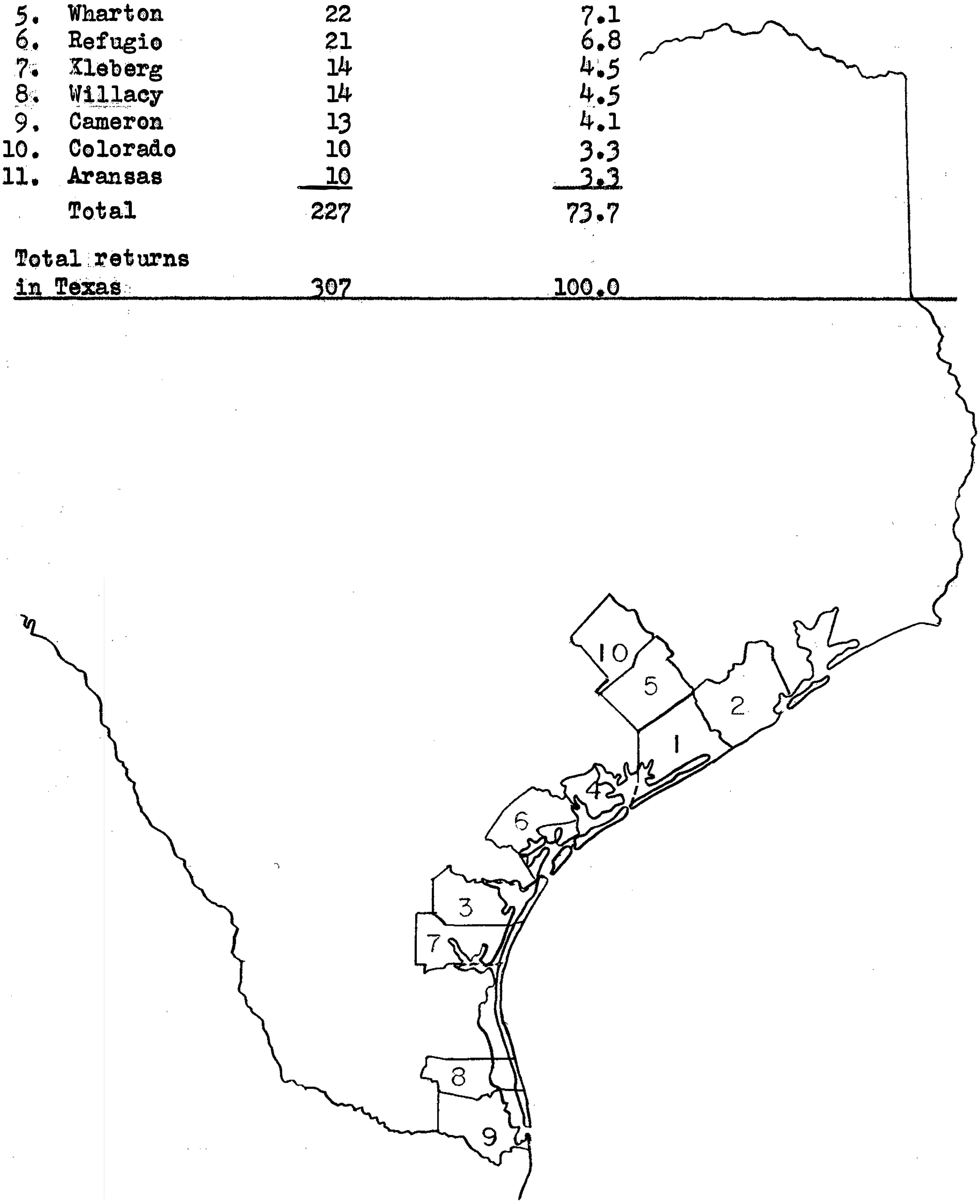


Chart 7. Counties contributing major proportions of band returns from Small Canada geese in Texas. (From Sand Lake banding data, 1951 - 1959).

County	No. of returns	Per cent of Total Texas Returns
1. Matagorda	36	11.7
2. Brazoria	31	10.1
3. Nueces	30	9.8
4. Calhoun	26	8.5
5. Wharton	22	7.1
6. Refugio	21	6.8
7. Kleberg	14	4.5
8. Willacy	14	4.5
9. Cameron	13	4.1
10. Colorado	10	3.3
11. Aransas	10	3.3
Total	227	73.7
Total returns in Texas	307	100.0



ways with no returns reported from either northeastern Oklahoma or southeastern Kansas. However, 93 per cent of the returns from Salt Plains bandings in Oklahoma come from the county of banding, Alfalfa, and the only return which is not from this or adjoining counties is a single return from Comanche County which lies in the southwest branch of the western pathway. The Kansas returns from Salt Plains banding come from Barber and Barton Counties, due north of Salt Plains. The only Oklahoma return from geese banded at Tishomingo is from Alfalfa County and the single return from Kansas is from Harvey County, nearly due north of Tishomingo. This does not imply that geese migrating through northeastern Kansas are restricted to the eastern pathway in Oklahoma, for geese banded at both Swan Lake and Squaw Creek in Missouri have been reported from Alfalfa County. Also, there are noticeable differences in the year to year distribution of band returns from geese banded at the Sand Lake refuge and recovered south of that point. It would appear that the cycles of wet and dry years in the tall-grass prairies may influence the distribution of returns year to year. This will be discussed more fully in a later section.

In Texas, band returns are distributed over 44 counties, but eleven counties yield over 73 per cent of the state total, (Chart 7). These eleven counties are included in the Coastal Prairie (Tharp, 1952) and only two, Colorado and Wharton Counties, do not border the Gulf of Mexico. This is the primary wintering area of the small Canada geese of the tall-grass prairie migration route. The route from the Red River to the coast appears to be directed nearly due south to the Brazos River south of Waco then southeastward to the Colorado River in the vicinity of Eagle Lake, and from there to and along the coast.

Residents of Cameron state that large flocks pass over and to the east in the fall and occasionally stop on or near the river. Along most of the Texas Coast, excepting Colorado and Wharton Counties, during the wintering season, the geese appear to be confined to a narrow belt extending about thirty miles inland and the majority of returns are from a coastal strip of slightly more than half this width. Following the close of the hunting season, the majority of small Canada geese were still found in this coastal belt, but the flocks were smaller and more evenly distributed. The amount of precipitation appears to have considerable influence on the dispersion of geese along the coast; the geese being widely scattered in wet years and closely congregated in dry years.

Of the thirteen returns from Mexico, twelve are from Tamaulipas and one from the vicinity of Tampico, Vera Cruz. Eleven of the returns in Tamaulipas are distributed along the coast within about sixty miles of Matamoros. The exception was taken on the Soto la Marina, 125 miles south of Matamoros. It is of interest that five of the returns (38.5 per cent) are from 1956, including the most southerly returns from Vera Cruz and the Soto la Marina.

<u>The Short-Grass Prairie Route.</u> The boundaries of the short-grass prairie route are postulated on the basis of 1,480 band returns covering a period from 1951 to 1960 (Appendix I, 3-4). The majority of these returns are from Canada geese banded at Two Buttes Reservoir, Baca County, Colorado by the Colorado Game and Fish Department, Table 10. In addition to the band returns there are about ten reported sightings of Canada geese color-marked at the Waggoner Ranch in the springs of 1958 and 1959.

Table 10. Number of Returns by Year From Small Canada Geese Banded at Stations in the Short-grass Prairie.

Year Recovered	Two Buttes Reservoir	Waggoner Ranch	Muleshoe N. W. R.	Total
1951	81			81
1952	180			180
1953	243			243
1954	167			167
1955	137	3		140
1956	145	16		161
1957	116	25		141
1958	144	32		176
1959	151	33	2	186
1960		5		5
Total	1364	114	2	1480

The distribution of band returns from Canada geese banded in the short-grass prairie route does not present a picture of so sharply a defined route as that observed in the tall-grass prairie. Grieb, (1960 and 1961) has depicted the major route of the Arkansas Valley Canada Goose flock as extending south from a "staging area", in Alberta and Saskatchewan, through north-central to southeastern Montana, eastern Wyoming, southwestern South Dakota, western Nebraska east to about North Platte, eastern Colorado, the western edge of Kansas north-eastern and east-central New Mexico, the Panhandle of Oklahoma, and the Panhandle of Texas south to about Muleshoe and east to the Waggoner Ranch. The "staging area", of Grieb, (1961) is an area where geese migrating from breeding grounds in the north gather in the fall prior to the major migration southward. In the short-grass prairie route this area is situated approximately between the North and South Saskatchewan Rivers west of a line from North Battleford to Swift Current, Saskatchewan and east of a line from Edmonton to Medicene Hat, Alberta. The wintering area of the Arkansas Valley Canada goose flock is depicted by Grieb (1961) as being that portion of the migration route situated in southeastern Colorado, the entirety of the route in New Mexico and Texas and a small area along the North Platte River in Nebraska.

The distribution of band returns by states and provinces from small Canada geese banded at the Two Buttes Reservoir and the Waggoner Ranch are presented in Tables 11 and 12. The data in Table 11 differ from that presented by Grieb (1961) primarily in that it provides a breakdown of returns from the Northwest Territories. In the short-grass prairie route the clumping in the distribution of band returns

Table 11. Distribution of 1,363 Band Returns From Small Canada Geese Banded at Two Buttes Reservoir, Colorado, 1951-1959.*

	No. of Returns	Per Cent
Canada	716	52.5
MacKenzie	32	2.3
Franklin	4	.3
Alberta	461	33.8
Saskatchewan	216	15.8
Manitoba	2	.2
British Columbia	1	.1
United States	646	47.4
Montana	8	.6
North Dakota	1	.1
South Dakota	11	.8
Idaho	6	.5
Wyoming	7	.5
Kansas	5	.3
Oklahoma	9	.6
Utah	1	.1
Nebraska	75	5.5
Colorado	399	29.3
Nevada	5	.3
New Mexico	17	1.2
Texas	88	6.5
Arizona	2	.2
Washington	1	.1
Oregon	3	.2
California	7	.5
Iowa	1	.1
Mexico	1	.1
Sonora	1	.1
Total	1363	100.

* Spring Banding

Table 12. Distribution of 114 Band Returns From Small Canada Geese Banded at the Waggoner Ranch, Vernon, Texas, 1955-1959.*

	No. of Returns	Per Cent
Canada	80	70.2
Keewatin	1	.9
Franklin	8	7.0
MacKenzie	1	.9
Ontario	1	.9
Alberta	26	22.8
Saskatchewan	43	37.7
United States	34	29.8
Montana	1	.9
North Dakota	1	.9
South Dakota	2	1.8
Nebraska	4	3.5
Kansas	5	4.4
Oklahoma	2	1.7
Colorado	6	5.3
Texas	13	11.4
Total	114	100.

* Spring Banding

from a relatively few areas is perhaps even more noticeable than the same phenomenon in the tall-grass prairie route. Two provinces and three states, Alberta, Saskatchewan, Colorado, Nebraska, and Texas yield nearly 91 per cent of the band returns from Canada geese banded at the Two Buttes Reservoir. The first three of these areas alone contribute nearly 79 per cent of the band returns from this station. The distribution of band returns from small Canada geese banded at the Waggoner Ranch is somewhat similar with Alberta, Saskatchewan, and Texas contributing nearly 72 per cent of the returns from this latter banding station and Franklin, Colorado, and Kansas contributing an additional 16.7 per cent for a total return of over 88 per cent from three states and three provinces.

As proposed by Grieb (1961), the short-grass prairie route has a breadth of about three degrees longitude in Alberta and Saskatchewan, then narrows slightly southeastward across the northern United States to Nebraska, then broadens to about five degrees longitude through Nebraska and Colorado, and to about seven degrees longitude in northern Texas and northeastern New Mexico. Except for the southern terminus at the Waggoner Ranch, Vernon, Texas, this route lies essentially west of the 100th meridian. A scattering of returns along the major watercourses east of the 100th meridian represents the limited invasion of the tall-grass prairie route by birds from the west.

There are a considerable number of returns west of the Rocky Mountains from geese banded at the Two Buttes Reservoir. There is no simple explanation for this far western distribution. The returns are widely scattered, but relatively uniform in number from year to year, which would appear to rule out annual weather phenomena. In part, the distribution resembles that presented by Kozlik, et al. (1959) for lesser snow geese and Ross' geese banded near Tulelake, California. Of interest are the three returns from geese banded in 1926 on the Old Crow River, Yukon and reported by Lincoln (1927). These returns are all in the year of banding and are from Clairmont, Alberta; Rupert, Idaho; and Washoe Lake, Nevada. That these are probably small Canada geese is suggested by the measurements provided by Irving (1960), from geese taken in the Old Crow region. A number of the Two Buttes returns come from areas in which large Canada geese are normally taken and it may be that some small Canada geese, crippled in the staging area, linger on until forced south by inclement weather, then join the flocks of large Canada geese which are migrating at that time. It is also possible that some of these birds are large Canada geese which wandered south in the short-grass prairie route during a previous year and were mistakenly banded as small Canada geese. There is perhaps no other area in the United States where an error in identification of large and small Canada geese can be as easily made as in the short-grass prairie route of the Central Flyway.

Grieb (1961) discussed all of the small Canada geese of the short-grass prairie route as members of a single flock, the Arkansas Valley Canada goose flock. Without wishing to seem pedantic, this use of the term "flock" to describe the several variants of small Canada geese wintering from western Nebraska to northern Texas seems somewhat inappropriate. That there is some shifting about by the wintering geese from the Waggoner Ranch to Two Buttes and even to Nebraska is probable. On the basis of band return distribution, it also appears probable that many of the small Canada geese banded at Two Buttes and the Waggoner

Ranch use a common migration route during the southward migration to the wintering grounds. However, the distribution of band returns from geese banded at the two stations would suggest that there are also many of these wintering geese which do not share this common route.

In the Northwest Territories, the returns from geese banded at the Waggoner Ranch are distributed east from Cambridge Bay on Victoria Island and Kent Peninsula on the mainland to the southeastern coastal area of Victoria Island and Queen Maud Gulf. Relatively few of the returns in the Northwest Territories from geese banded at Two Buttes come from the coastal regions or Arctic Islands and these few are distributed from Cambridge Bay westward to the MacKenzie River delta. The majority of far northern returns from geese banded at Two Buttes are distributed along the MacKenzie River from Little Chicago south to Fort Norman. From data provided by Smith and Safranek (1950), Smith, Sutton, and Solman (1951), Smith and Sutton (1952) (1954), Lincoln (1927), and Irving (1960), it would appear that the migration of small Canada geese of the short-grass prairie route begins north of the Canadian provinces as far east as Queen Maud Gulf, and as far west as MacKenzie Bay and the Old Crow Flats. The main route then probably lies in the MacKenzie River Valley and is supplemented by a pathway from the coast in the vicinity of Great Bear Lake. From this area the migration south may be over a rather broad front including the MacKenzie River Valley and most of the lakes and watercourses between Great Bear Lake and Great Slave Lake. South of Great Slave Lake to the "staging area" there is essentially a blank in the distribution of band returns from small Canada geese banded in the short-grass prairie. It seems probable that the migration is southward along the Slave River to Lake Athabaska, then south along the Athabaska River, through the numerous lakes and watercourses to the "staging area" in Saskatchewan and Alberta.

In the "staging area", the east and west inclination in the distribution of band returns from geese banded at the Waggoner Ranch and Two Buttes, respectively, is even more apparent than in the Arctic (Tables 11 and 12). Considering the returns on small Canada geese in Alberta and Saskatchewan alone it is found that 68.1 per cent of the 677 returns from Two Buttes bandings come from Alberta. On the other hand, of 69 returns in these two provinces from geese banded at the Waggoner Ranch, 62.3 per cent came from Saskatchewan.

Grieb (1961) suggested that the migration south from the staging area is accomplished essentially in one non-stop flight to the wintering area in western Nebraska, southeastern Colorado, and northwestern Texas. The distribution of band returns from geese banded at both the Waggoner Ranch and at Two Buttes would tend to substantiate this proposal so far as the major migration is concerned. However, a scattering of returns of Two Buttes bands along the Missouri River in Montana, North Dakota, and South Dakota suggests that some short-grass prairie birds migrate east and south along this major watercourse to the western edge of the tall-grass prairie route, but that relatively few penetrate the more eastern route. Band return data suggest these birds drift south to the Platte River, the Arkansas River, or possibly enter the western pathway of the tall-grass prairie route through Oklahoma and from these points feed back into the short-grass prairie route. Conversely, there are returns from geese banded at the Waggoner Ranch which fall well within the tall-grass prairie route. Moreover, the distribution of these returns is the same as the distribution of returns from geese banded in the tall-grass prairie. This suggests that the occurrence of these Waggoner Ranch bands is not the result of a penetration from the west, but that they are a component of the tall-grass prairie migration. This will be discussed in the section on areas of intermingling.

The physical features correlated with the distribution of band returns in the short-grass prairie are essentially the same as those observed in the tall-grass prairie. Large reservoirs and major water-courses, together with state and federal refuges and a few private land-holdings, offer the only areas in which the geese can be relatively free from molestation during the hunting season. Thus, during the hunting season these areas become islands of goose habitat and annually support large congregations. The fields observed to be frequented by flocks of small Canada geese in the wintering areas of the short-grass prairie were primarily green winter wheat and harvested wheat or grain sorghum. In all cases these fields offered a high degree of visibility to feeding or resting flocks. In general the physiognomy of these areas of actual use appear little different from situations in which small Canada geese are found in the tall-grass prairie.

Perhaps the best example of a nearly complete refuge for Canada geese in the short-grass prairie route is the half-million acre Waggoner Ranch, near Vernon, Texas. During some years as many as 55,000 Canada geese may spend a major portion of the winter on this ranch (Grieb, 1961). Only a limited amount of hunting, primarily to guests, is permitted and judging from the number of band returns from the ranch the take is relatively small. Thousands of acres of winter wheat in open fields provide abundant pasturage and numerous small ponds, as well as Santa Rosa Lake, provide roosting and resting areas. The large congregations of wintering Canada geese on the Waggoner Ranch create some problems, the most serious being competition with cattle for winter pasture. Moderate methods of harrassment such as attempted herding with ground vehicles and aircraft in an effort to move the geese off the ranch have been relatively unsuccessful. The extent of the ranch is so great that the general effect of this harrassment has been only to move the geese from field to field, but seldom beyond the ranch boundaries.

Areas of Co-mingling. Throughout the length of the migration routes small Canada geese of the tall-grass prairie and the short-grass prairie show little tendency to mingle. This same phenomenon is a characteristic of the geese on wintering areas as well. The majority of the tall-grass prairie geese winter far to the east and south of the short-grass prairie birds. Geese using the wintering areas on the Waggoner Ranch, however, appear to provide an exception to this general picture. The number of returns from geese banded in the tall-grass prairie and recovered on the Waggoner Ranch is small, though this might be expected because of the slight amount of hunting permitted on the ranch. Also, the only known record of a color-mark originating in the tall-grass prairie and observed on the Waggoner Ranch was a black and white collar originating from the Sand Lake Refuge in the fall of 1957 and found lying on the shore of Santa Rosa Lake in mid-February, 1958. This lack of color-mark sightings is also to be expected for this flock receives little intensive observation during the wintering period.

Perhaps the best evidence establishing the mixed character of the flock wintering on the Waggoner Ranch is the number and distribution of band returns of geese banded on the ranch and recovered in the tall-grass prairie. Of the 114 band returns available for analysis, seventeen or about fifteen per cent are located in the tall-grass prairie route. Not only are the returns in the more eastern route, but they are distributed over the same areas from which returns are received from small Canada geese banded in the tall-grass prairie. In addition to the band returns from the tall-grass prairie there are also three observations of the Waggoner Ranch color-codes in this same route. A goose bearing the color code used on Waggoner Ranch geese in the spring of 1958 was observed and subsequently shot by a hunter in the fall of 1958 at Salt Plains, Oklahoma. On March 18, 1959, Mr. R. L. Means, Refuge Manager, Kirwin National Wildlife Management Area, Phillipsburg, Kansas, observed a Waggoner Ranch color-code which was used on geese banded in February, 1959. On March 19, 1959 the author observed a color-mark from the same banding at the Salt Plains Refuge. Also, in the latter instance, three other geese in the flock of approximately 100 were observed to be leg-banded. Though it may be stretching the point, the presence of a color-marked bird plus three leg-banded birds suggests that this entire flock may have been composed of Waggoner Ranch birds on their northward migration.

Another phenomenon which suggests mingling on the Waggoner Ranch of small Canada geese from the tall-and short-grass prairie routes is the intermediate position in size and proportions of Waggoner Ranch birds compared to the geese from the tall-grass prairie, as represented by a sample from Salt Plains, Oklahoma, and the short-grass prairie, as represented by a sample from Two Buttes, Colorado, Figure 9. It is recognized that these samples are small and therefore the possibility of spurious comparisons is an inherent danger. In addition the sample from Salt Plains is from a migrating population while the other two samples are from wintering populations. Also, the sample from the Waggoner Ranch is not strictly comparable to the other two in that it is obtained from the previous migration period. However, a sample from Salt Plains geese during the fall of 1958 is not appreciably different than the 1959 sample (Table 13) and thus, the comparison is not necessarily invalid. Critical measurements of the geese trapped and banded at Two Buttes for the years prior to 1960 are not available. The data in Figure 9 is merely suggestive. It is believed the data presented do provide a general approximation of the relationships between the populations of geese included, but much larger samples are needed for a critical analysis of these populations. The data in Figure 9 indicate that there is a considerable difference in size and proportions between geese handled at Two Buttes and at Salt Plains. This has been discussed, in part, in the earlier section concerning systematics. In the samples presented there is slightly less than 32 per cent overlap in the given measurements of geese from the two aforementioned stations. The measurements of the Waggoner Ranch sample lie essentially mid-way between the other two samples with a 66 per cent overlap in the Waggoner Ranch-Salt Plains populations and slightly less than 73 per cent overlap in the Waggoner Ranch-Two Buttes populations. There is a noticeable break in the series of culmen length measurements at slightly under 40 mm. In this particular

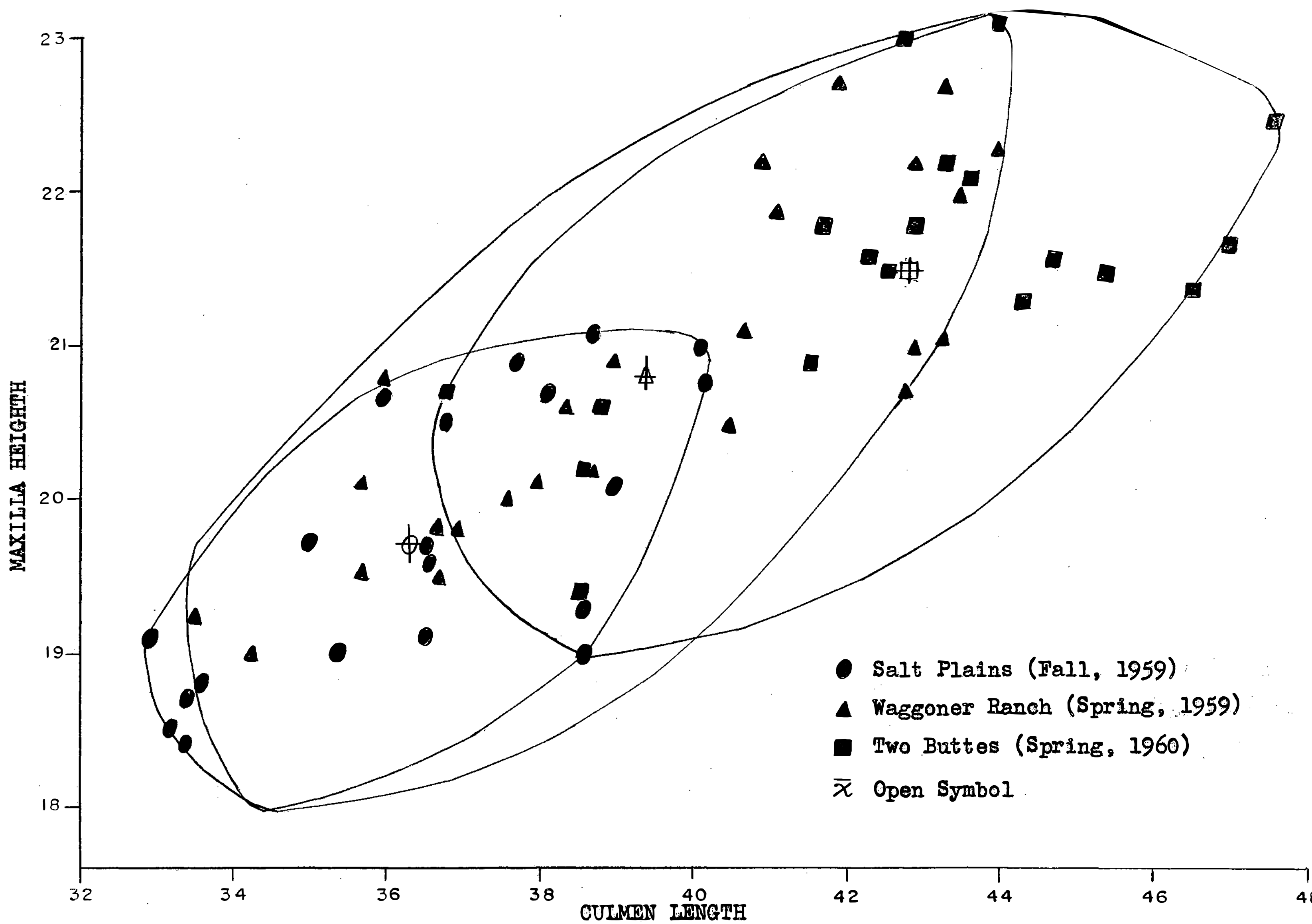


Figure 9. Maxilla Height: Culmen Length measurements from samples of small Canada geese handled at Salt Plains, Waggoner Ranch, and Two Buttes.

Table 13. A Comparison of Culmen Lengths of Adult Small Canada Geese in Samples From Stations in the Tall-grass Prairie and the Short-grass Prairie.

Station	Number in Sample	Average Culmen Length	Culmen Less than 40 mm.		Culmen Greater than 40 mm.	
			Number	Per Cent	Number	Per Cent
Salt Plains (Fall, 1957)	22	38.2	17	77	5	23
Salt Plains (Fall, 1958)	13	36.2	11	85	2	15
Salt Plains (Fall, 1959)	22	36.3	20	91	2	9
Tishomingo (Fall, 1958)	35	36.9	32	91	3	9
Waggoner Ranch (Spring, 1959)	25	39.4	13	52	12	48
Two Buttes (Spring, 1960)	19	42.8	4	21	15	79

case it is perhaps apparent because of the small samples. However, examination of small Canada geese in the tall-grass prairie during 1957, 1958, and 1959 indicates that the majority of individuals have a culmen length of less than 40 mm. The one sample of wintering geese from Two Buttes, in the short-grass prairie, indicates the majority of these individuals have a culmen length greater than 40 mm. Table 13 provides a comparison between relative numbers of small Canada geese having a culmen length greater than or less than 40 mm. from stations in the tall- and short-grass prairies. Again, the measurements of individuals from the Waggoner Ranch are distributed in a nearly equal number above and below 40 mm. However, this is not intended to imply that the wintering flock on the Waggoner Ranch is composed of equal numbers of tall- and short-grass prairie birds.

The number of tall-grass prairie geese involved in the mingling on the Waggoner Ranch can be estimated, but the number of variables and biasses included in such an estimate make it a very gross type of approximation. Crissey (1955) has pointed out that banding of wintering flocks can provide for a "rough measure of volume of movement". From the observations of the author, the wintering flock on the Waggoner Ranch has varied in number from an estimated 25,000 in 1957 upward to about 40,000 in 1959 and was reported as 55,000 in 1960 (Grieb, 1961). As pointed out, of the total returns from Waggoner Ranch-banded geese about fifteen per cent are believed to represent returns from the tall-grass prairie segment. If this average percentage is reasonably valid, then the average number of tall-grass prairie geese wintering on the Waggoner Ranch from the spring of 1957 through the spring of 1960 has been about 5,600 per year and varied from about

3,000 to over 8,000. This estimate would be valid only if the recovery rate on geese and return rate on bands were the same in both routes, if the proportion of tall-grass prairie geese varied directly with variation in numbers of the total wintering flock, and if the banded sample represented a true cross-section of the segments of the wintering population.

Some data are available to provide an estimate of differential recovery rate between geese banded at Sand Lake, South Dakota and Two Buttes, Colorado. The data from Sand Lake are known to be incomplete and may contain some inaccuracies and Grieb (1961) has pointed out that the Two Buttes data are neither complete nor accurate. For a critical evaluation of mortality and the assembling of life tables these sources of potential error would be important. However, they are probably too small to affect materially the estimates given here. Based on five individual years' data, Sand Lake has an average first year recovery rate of about seventeen per cent as opposed to an average first year recovery rate based on seven individual years of about ten per cent from geese banded at Two Buttes. On the other hand, the gross accumulated recovery at Sand Lake for seven consecutive years is 23.8 per cent while for Two Buttes the gross accumulated recovery based on nine consecutive years presented by Grieb (1961) is 28.8 per cent. These estimates are not weighted for differential return rate between the two routes. It is believed the somewhat higher average first year recovery rate for geese banded at Sand Lake is possibly the result of trapping during the fall migration. The high first-year recovery rate of geese banded at Sand Lake is apparently offset by an average recovery rate thereafter which is somewhat lower than that from geese banded at Two Buttes, so that the accumulated recovery over a period of time is quite similar at both stations.

Considering the general phenotypic differences between small Canada geese of the tall-grass prairie route and the short-grass prairie route and the essentially discrete ranges, which include differences in climatic and edaphic factors, it seems reasonable to assume that the variation in numbers of geese in the two routes is an independent phenomenon. Thus, the number of tall-grass prairie geese wintering on the Waggoner Ranch would tend to vary independently of variation in the total numbers wintering on the Ranch. Therefore, the use of an average recovery rate is not clearly justified.

The wintering population on the Waggoner Ranch is often divided into two or three, or more, flocks. It is therefore possible, in fact, probable that in some years the geese banded represent only a sample from one of these flocks and may not be truly representative of the entire wintering population. What effect this bias in sampling might have on the present recovery data is not known.

Effects of Weather on Distribution

The previous sections have described the broad outlines of the two major migration routes of small Canada geese in the Central Flyway. It should not be assumed that each year small Canada geese migrate south in a broad front including all of the area between the boundaries of a route. In a general way the routes illustrated indicate only that the migration of geese will be somewhere within these boundaries. Hochbaum (1955) proposed that although Canada geese show a strong attachment to specific breeding areas they are quite elastic in their use of migration routes and wintering areas. The use by waterfowl of watercourses as migration pathways is often pronounced (Bellrose, 1951), and in the tall-grass prairie some of the small Canada geese show a definite tendency to follow the Missouri River for that part of the southward migration extending from southeastern South Dakota to northeastern Kansas and northwestern Missouri. Also, Lincoln (1950) and Bellrose (1951) have pointed out that waterfowl do not hesitate to leave watercourses and migrate overland. This overland migration is perhaps the most common phenomenon of small Canada goose movement in the tall-grass prairie, for here the major drainage is essentially at right angles to the migration route. The migration pattern along rivers is restricted in scope as a result of the continuous physiognomic feature to which the birds are oriented. Thus, year after year, though it may vary in magnitude, the migration has a constant pattern in space. On the other hand, in overland migration birds are probably offered only discontinuous orientation stimuli so that the migration takes place over a broader space and is directed in a general way by traditional landmarks. In a lengthy migration system some of these landmarks may also function as areas of congregation. Hochbaum (1955) has proposed that relatively few landmarks are necessary as "cues" to orient migrating waterfowl over long distances of travel. Kramer (1952) and Matthews (1955) have demonstrated that some birds are apparently capable of using the sun to orient their relative position in migration. Thus, even overland the migration route of a population segment will have, when mapped, somewhat restricted boundaries appearing, superficially, as a broad river. Insofar as the landmarks function as areas of congregation, hence habitat, their value can be expected to vary from year to year or period to period.

Of all the factors influencing the value of habitat for a given species, the foremost probably is weather. Inasmuch as weather can affect the componental value of a species habitat it is axiomatic that it can also affect the distribution of a species. On a river-oriented migration route weather effects, as related to distribution, probably have only a moderate influence. In an overland route, especially through the southern Great Plains, many of the landmarks, particularly those related to food and water, lack the permanency of character observed in a major watercourse and, therefore, weather influences are often marked.

The year 1956 climaxed a five-year drought period in the central and southern Great Plains (Weather Bureau, 1957). Severely affected by the drought were portions of Nebraska, eastern Colorado, western Kansas, western Oklahoma, western Texas, and New Mexico. In Oklahoma the cumulative effect of four years of sub-normal precipitation was intensified by a final drought year (1956) in which precipitation in the north-central and west-central portions of the state averaged less than fifty per cent of the long-term mean (Weather Bureau, 1956 a). The result was loss of crops, pasture, and water reserves over most of western Oklahoma.

Paralleling the drought period in Oklahoma, and covering approximately the same length of time, was a steady decrease in peak population numbers of Canada geese congregating during the fall migration at the Salt Plains National Wildlife Refuge, Oklahoma (Figure 10). From a high of slightly over 26,000 in the fall of 1951 the peak numbers dwindled to about 6,000 in the fall of 1956. A similar decrease in numbers during the same general period was observed at the Sand Lake

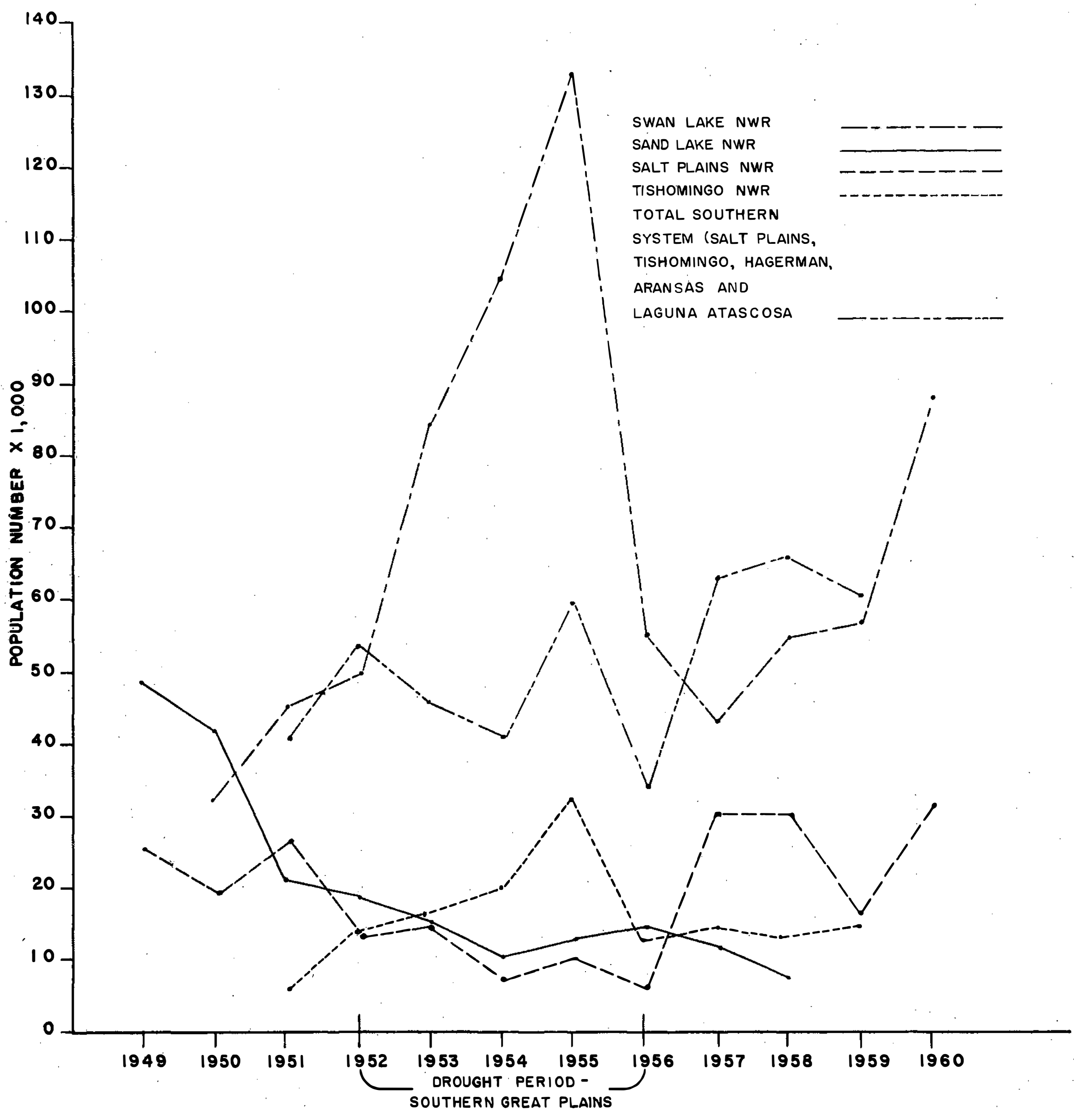


Figure 10. Peak populations of Canada geese by years from selected refuges.

National Wildlife Refuge, South Dakota. The magnitude of the decrease at Sand Lake was perhaps more dramatic than at Salt Plains because of the numbers involved. From a high of about 48,000 birds at Sand Lake in the fall of 1949, the peak population decreased to a low of about 10,000 birds in 1954 and thereafter rose only to about 14,000 in 1956. In January of 1955, Herbert H. Dill, then refuge manager at Sand Lake, submitted a memorandum to the director, Region 3, Bureau of Sport Fisheries and Wildlife, expressing concern for the welfare of the small Canada geese migrating through the Sand Lake area. In data presented in the memorandum, Dill illustrated that small Canada geese accounted for more than eighty per cent of the total Canada goose peak populations on the Sand Lake Refuge. A survey of the Sand Lake Refuge narrative reports for the same period indicates the small Canada geese accounted for something over ninety per cent of the kill of all Canada geese. On April 18, 1955, in reply to a request from the director, Region 2, Bureau of Sport Fisheries and Wildlife for hunter kill information on Canada geese at Salt Plains, John B. Van den Akker, then refuge manager, estimated that 275 of 870, or about 32 per cent of the Canada geese killed in the vicinity of Salt Plains in 1954 were small Canada geese. Though no estimate of the numbers of small Canada geese at Salt Plains was given, Van den Akker pointed out in the September-December refuge narrative report for 1954 that small Canadas made up a smaller proportion of the refuge flock than in previous years. The reasons offered for the decrease in population numbers of small Canada geese at Salt Plains and Sand Lake were many, but most emphasis was on two factors, hunting and weather.

In 1957 the drought in the central and southern Great Plains ended. In the vicinity of the Salt Plains Refuge the end of the drought brought improved pasture conditions, excellent grain crops, a full reservoir, and as evidenced in Figure 10, a dramatic increase in the peak population of Canada geese congregating on the refuge during the fall migration. This increase at Salt Plains is reflected in the increased total for the system of five refuges, Salt Plains, Tishomingo, Hagerman, Aransas, and Laguna Atascosa (Figure 10). It should be emphasized that this total is an average index figure of all Canada geese of all races censused on the above refuges during a given one week period, not the total populations of Canada geese wintering in the tall-grass prairie. In some years it is probable that as many geese winter off the refuges as on them. This rapid increase in Canada goose numbers present at Salt Plains and in the total system of southern tall-grass prairie refuges following the end of the drought would suggest that the observed decline at Salt Plains was the result of a weather-influenced distribution change rather than an actual loss in population numbers.

The Northern Great Plains, which includes Sand Lake, in 1955 experienced the beginning of a drought period which, with short periods of temporary relief, extends to the present time. Thus, the continuing low numbers of Canada geese congregating at Sand Lake may also be the result of weather-influenced distribution changes. Data available for analysis are not adequate to provide a definitive statement on the reason for the decline in Sand Lake population from 1949 to 1955. A suggested heavy and disportionate kill on small Canada geese at Sand Lake does not seem consistent with observations of Canada goose flocks at refuges in Oklahoma and Texas where, since 1957, numbers of all Canada geese are higher than at any time in the past and, since 1954, the proportion of small Canada has apparently increased. In the

September-December 1954 Tishomingo refuge narrative, Earl W. Craven stated, "We noted a definite increase in the number of smaller Canada geese in the peak concentration this year. Mr. Van den Akker at Salt Plains advised us that their concentration at this time was predominantly the large birds, but the reverse was true at this station." In 1955 Mr. Craven noted that, ".... approximately seventy per cent of the geese (Canadas) were the smaller Canadas.", and again in 1956 stated that, "And again we noted a great preponderance of the smaller Canada geese in the Refuge concentration, probably ninety per cent of the total." During 1957, 1958, and 1959 the proportions of small Canada in the peak populations were approximately the same as those noted in 1956. At Salt Plains the narrative reports indicate the proportion of small Canada geese in the peak populations between 1953 and 1957 fluctuated from 50 to 75 per cent of all Canada geese. Estimates by the author at Salt Plains in 1957, 1958 and 1959 fixed the proportions of small Canada geese in the peak populations at 90 to 99 per cent. In fact, in actual numbers, observations since 1957 at Salt Plains and Tishomingo would suggest a declining population of large Canada geese. It should be noted, however, that as a result of the present study, beginning in 1957, there has been an emphasis on the critical distinction of small Canada geese and this may have resulted in the apparent proportionate increase of small Canada geese rather than an actual change in the ratios. Whatever the true situation may be concerning proportions of the large and small Canada geese in the past, at present all evidence points to a Canada goose population in the tall-grass prairie that is stable at a relatively high number or slightly increasing and that contains at least ninety per cent small Canada geese. There is no evidence to support the hypothesis that this population, as a whole, has been materially reduced in total number. On the other hand, this should not be construed to mean that individual segments of this population have not been or are not being decimated by various mortality factors. Data of a sufficiently critical nature to analyze the population dynamics of individual segments of the tall-grass prairie population are not available.

If it is valid to assume that there has been no appreciable loss in the population of tall-grass prairie geese then it would seem proper to consider weather-influenced distributional changes as an explanation of the observed decline in small Canada goose numbers in the south-central United States. If the distribution of Canada geese in the migration through the tall-grass prairie changed during the drought period in the southern Great Plains a question is posed as to what changes in distribution were effected.

Band return distribution in Oklahoma by year and county, from geese banded at Sand Lake are illustrated in Figures 11, 12, and 13. Based on band return data received from the Region 3 office, Bureau of Sport Fisheries and Wildlife, no Sand Lake bands were recovered in Oklahoma in 1954 and 1955. As mentioned earlier the band return data received at this station were incomplete and it is possible that the 1954 and 1955 Oklahoma returns had been omitted. If this is not the case, then the absence of returns in Oklahoma has added significance when considered in light of the high numbers of Canada geese censused at Swan Lake, Missouri in 1954 and 1955. In 1955 numbers of Canada geese at Swan Lake reached an all time high of approximately 133,000 birds, the peak of a steady increase beginning in 1953. No breakdown into large and

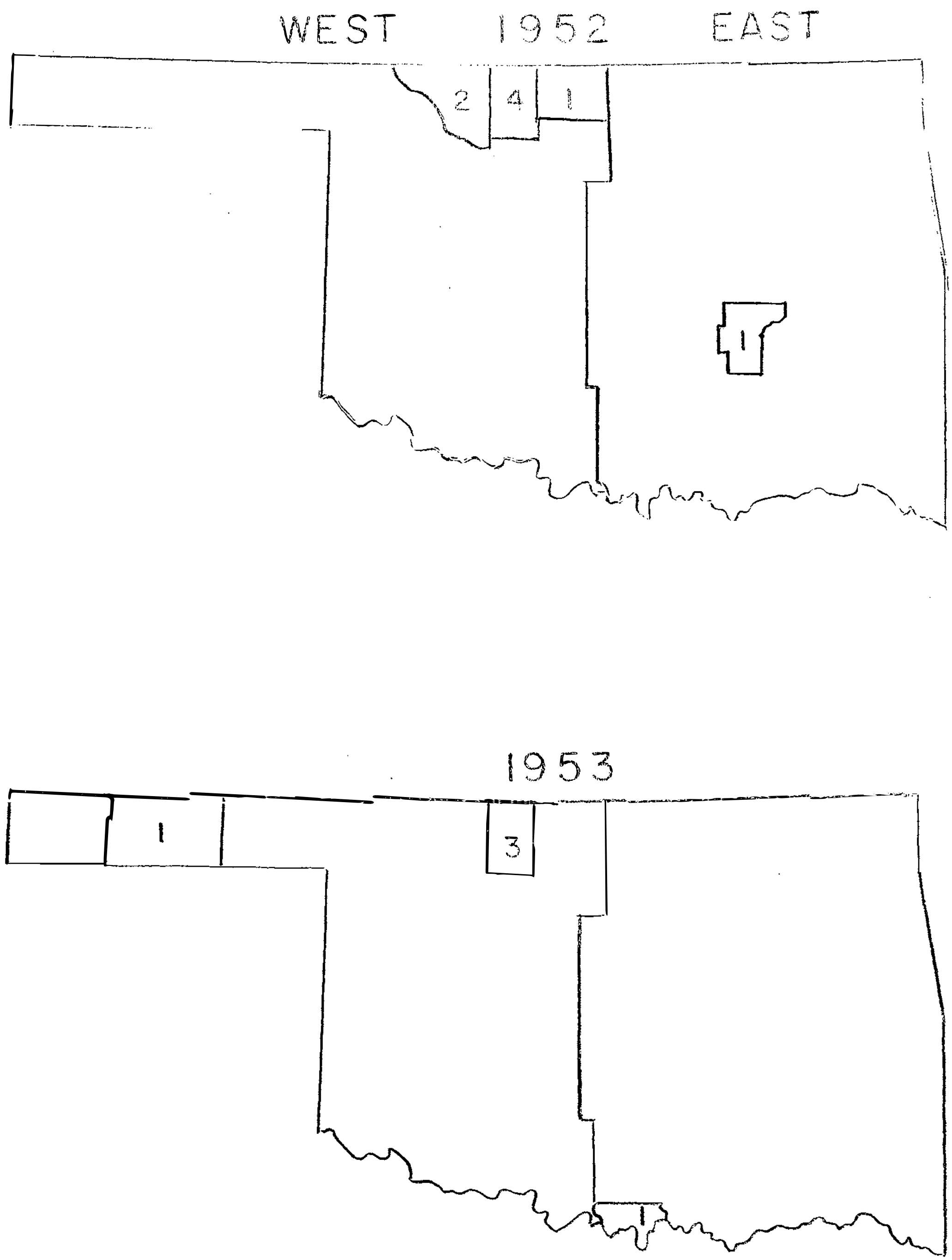


Figure 11. Band return distribution in Oklahoma in 1952 and 1953 by county.

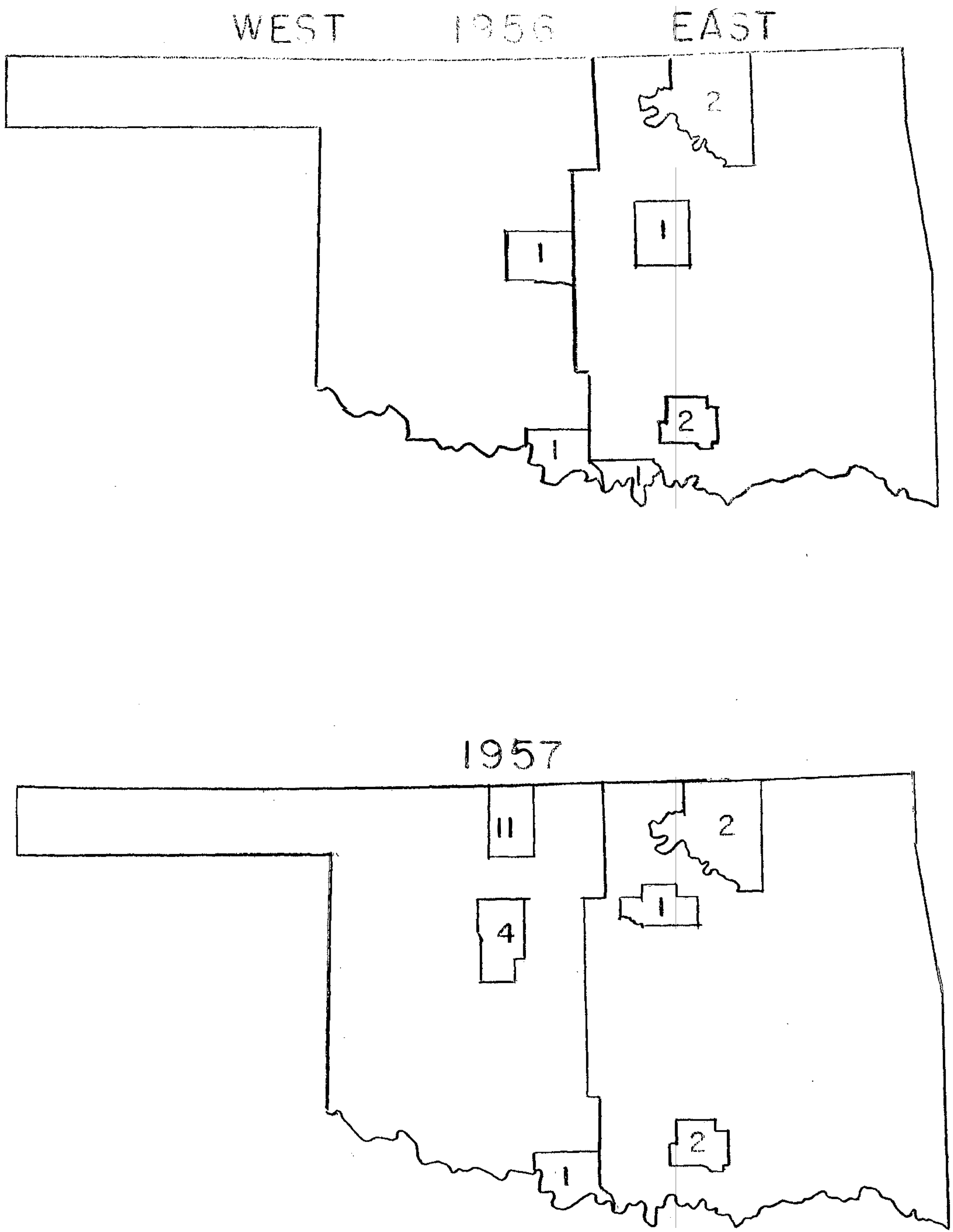
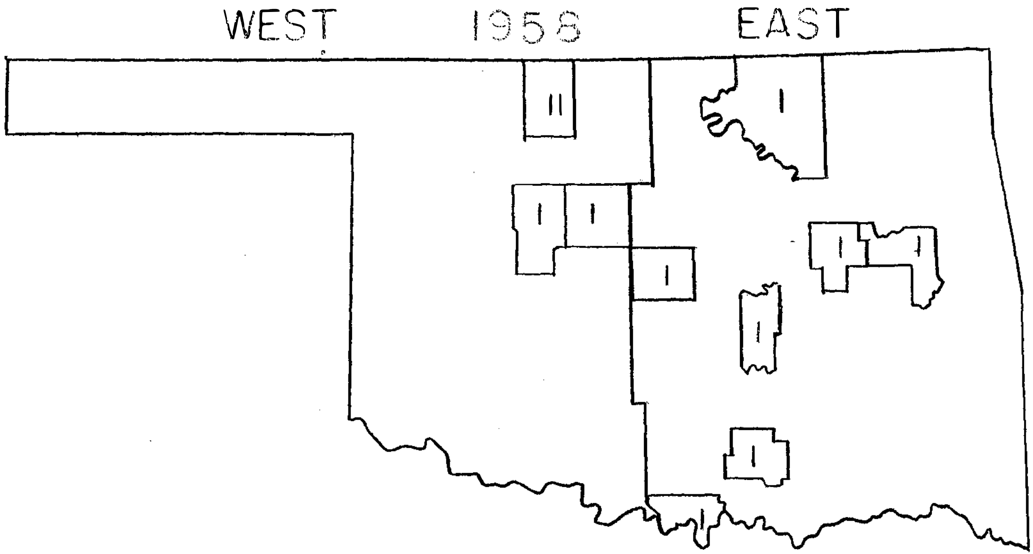


Figure 12. Band return distribution in Oklahoma in 1956 and 1957 by county.



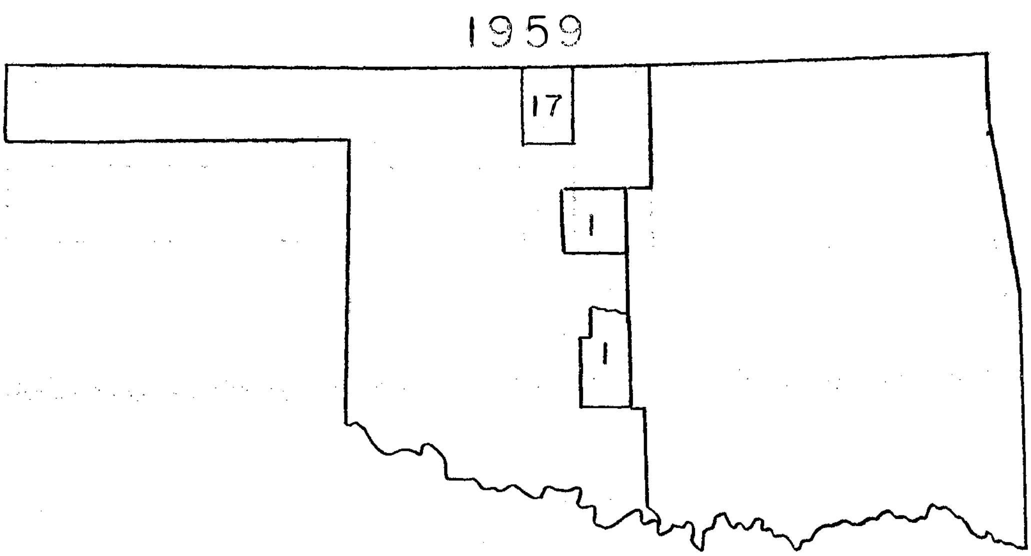


Figure 13. Band return distribution in Oklahoma in 1958 and 1959 by county.

small Canada geese is available, but refuge personnel recall the numbers of small Canada geese were higher than usual. On the other hand, Richard W. Vaught, Biologist, Missouri Conservation Commission has provided a detailed breakdown of large and small Canada geese killed in the vicinity of Swan Lake from 1955 through 1960 and these data indicate that except for 1959 small Canada geese seldom exceeded two per cent of the total kill. In 1955 small Canada geese made up about one per cent of the kill and only during a one-week period at the peak did they approach ten per cent of the kill. Thus, if small Canadas were present in exceptionally large numbers they were not harvested in proportion to their occurrence.

In Oklahoma, the majority of band returns in 1952 and 1953 shown in Figure 11 are decidedly western in distribution, the returns from Hughes and Love counties being the only eastern returns. The band returns in 1956 (Figure 12) are grouped in just the opposite manner with the majority of returns being in the eastern part of the state and only Canadian and Jefferson counties providing returns in the western half of the state. Considering this eastern shift of band distribution in Oklahoma it is of interest that of a total of 17 band returns in Missouri 8 or 47 per cent are 1956 returns. In 1956 the peak number of Canada geese censused at Swan Lake was about 55,000, a decrease of nearly 80,000 from the peak of the previous year. At Tishomingo the steady increase in peak population numbers from 1951 through 1955 (Figure 10) also show an abrupt decrease in 1956 even though the band returns from Sand Lake geese would suggest that larger numbers than usual of small Canada geese were migrating through the eastern half of the state. These discrepancies between large numbers suggested by band returns and low numbers observed in census at Swan Lake and Tishomingo may have been the result of birds moving through the area without stopping at the refuges or by a rapid turnover in refuge congregations which is very difficult to detect and which will contribute to an observed low number of birds in any given census period. In 1956 the area affected by the drought had spread as far as Illinois in the northeast and thus included all of Oklahoma and much of northern and western Missouri (Weather Bureau, 1956 b). The lack of large numbers of geese along the Texas coast is not surprising for there habitat was no more available than farther north. Of interest is the fact that of a total of thirteen returns from Sand Lake bands in Mexico, 5 or 38 per cent were recovered in 1956. This would suggest that larger than usual numbers of small Canada geese penetrated south well into Mexico along the coast. Unfortunately, the United States Fish and Wildlife Service was unable to conduct their regular mid-winter inventory in Mexico in January of 1957 and this suggested explanation of distribution cannot be confirmed.

In 1957 (Figure 12) the end of the drought in the southern Great Plains brought a change in band return distribution in Oklahoma, with the western half of the state again contributing the majority of Sand Lake band recoveries. At Swan Lake the peak population of Canada geese was censused at about 42,000 birds. On the Texas coast, both Aransas and Laguna Atascosa reported increases in their peak populations of Canada geese. Heavy rains and severe flooding damaged feeding fields at Tishomingo and this probably was responsible for the relatively low numbers in the peak population.

In 1958 and 1959 the distribution of returns of Sand Lake bands in Oklahoma (Figure 13) is similar to that observed in 1952 and 1953 (Figure 11). The lack of returns in the eastern half of the state, is particularly interesting. The Hagerman Refuge, 35 miles south of Tishomingo, censused 30,000 Canada geese during the peak in 1959 and it may be that many geese passed over or moved rapidly through Tishomingo and congregated on the more southern refuge. The drop in numbers in the 1959 Salt Plains peak may have been the result of early-season flooding which destroyed some fields of feed, or the result of disturbance coincident with the trapping and banding program which was active from mid-October to late-November of that year. How much effect the activities concerned with trapping geese during the migration might have on population turnover cannot be stated with certainty. It is inconceivable that the apparent confusion and fright of the birds which are trapped, as well as the untrapped members of a flock, would have no effect whatever. It is also note-worthy that in 1960, a year in which no trapping occurred, the population peak was again slightly more than 31,000 Canada geese (Personal communication from Richard J. Hitch, Refuge Manager).

As pointed out before, available data on water and food conditions at Sand Lake do not appear to show a correlation with the initial decline from 1949 through 1954 in Canada goose populations congregating on that refuge. On the other hand, the first major decrease in fall populations at Sand Lake coincides with the first year of major banding activity, 1951. Hunting pressure has been proposed as a factor in the decline at Sand Lake and to the degree that hunting limits the amount of available habitat for the geese it is responsible to that same degree for the by-passing of an area or the rapid turnover of flocks using an area.

Chronology of the Fall Migration

Hanson and Smith (1950), in discussing the fall migration of Canada geese in the Mississippi Flyway, have likened the southerly movement from the breeding grounds to "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."

Considering all of the Canada geese (large and small) of the Central Flyway, the statement above can be accepted as a general statement of fact. From our knowledge of the breeding distribution of the large and small Canada geese, we know that the small Canada geese nest farther north than the large Canada geese. In the fall migration, Sand Lake National Wildlife Refuge records the first arrivals of small geese approximately one week earlier than the first arrivals of large geese. Based on observations during this study, this is approximately the same schedule followed by large and small Canada geese in the southern tall-grass prairies. Refuge records at Sand Lake and Salt Plains indicate that the small geese not only arrive earlier, but pass on south earlier, with the result that wintering flocks at Sand Lake are usually predominantly large Canada geese and at Salt Plains the wintering flocks contain a higher proportion of large Canada geese than do the earlier flocks.

The data presented in Table 14 suggests that flocks arriving at Sand Lake may either delay their southward migration at this point, or at least proceed southward at a leisurely pace. Generally, it is one to two weeks after the first arrivals at Sand Lake that the first arrivals are recorded at Salt Plains, Tishomingo, or Hagerman. South from Oklahoma to Laguna Atascosa on the Texas-Mexico border the first arrivals are generally recorded within a one week period. The use of averages may be somewhat misleading for each year appears to have an individual pattern of chronology, dependent, perhaps, on weather and the habitat values existing on an individual refuge or general area. The data in Table 14 clearly illustrate the sometimes rapid pace of the southward migration within the southern portion of the tall-grass prairie. It is noteworthy that the first arrivals at Salt Plains are often later than the first arrivals recorded at Tishomingo, Hagerman, and occasionally even Aransas. As might be expected from the proximity of the two refuges, first arrivals at Tishomingo and Hagerman are usually reported very close together. It would also appear that the migration along the Texas coast is quite rapid with Aransas and Laguna Atascosa often reporting first arrivals only one or two days apart.

The arrival dates for the Muleshoe refuge are presented for the purpose of illustrating the marked difference between the tall-grass prairie and the short-grass prairie in early migration chronology.

Annual Canada goose population peaks are given in Table 15. In a general way the data illustrate the progressive southward build-ups of migrating geese in the southern tall-grass prairie. At the same time, the data also emphasize the highly erratic chronology of the southward migration from year to year and place to place. In Table 16 are given the one week periods within which the greatest influx of Canada geese occurred at a given refuge from 1953 through 1955. These data show a lack of any consistency of pattern of migration in time and space through the southern tall-grass prairie. As might be expected, no single weather phenomenon can account for the spread of dates in any given year presented in Tables 14, 15, and 16. In this study attempts to correlate migration movements with major weather systems have not proved completely successful. The weather conditions responsible for the massed migration flights arising in the plains of Saskatchewan and Manitoba and passing through the Mississippi Flyway in 1955, 1956, and 1957, (Bellrose, 1957, and Bellrose and Sieh, 1960), with one exception, show little correlation with reported Canada goose migration at individual refuges in the southern tall-grass prairie during these three years. The above authors give the dates of the massed flights as October 31 through November 3, 1955, November 6 through 8, 1956, and October 23 through 25, 1957. In both 1955 and 1957 there is agreement between the dates of the reported mass migration and the period of greatest influx of Canada geese at Salt Plains. Also in 1955, Aransas reported the first large flight of Canada geese in the weekly report period of November 3 through 9. In 1957, the influx of geese at Hagerman in the weekly report period of October 27 through November 2 may also have been correlated with the mass movement of waterfowl in the Mississippi Flyway, though the number of geese involved was rather small (Appendix II-5). On the other hand, in 1955 large numbers of Canada geese were migrating through the southern tall-grass prairie well in advance of the

Table 14. Approximate First Arrival Dates of Canada Geese at National Wildlife Refuges in the Central United States.

	1953	1954	1955	1956	1957	1958	1959	Average
Sand Lake	9/23	9/24	9/25	9/19	9/23	9/27		9/23
Salt Plains	10/5	10/5	10/5	9/28	10/5	10/4	10/6	10/5
Tishomingo	9/29	10/9	9/30	10/4	10/5	10/3	10/4	10/3
Hagerman	9/28	10/12	10/8	10/5	10/3	10/3	9/26	10/3
Aransas	10/7	10/15	10/7	10/9	10/4	10/9	10/4	10/8
Laguna Atascosa	10/10	10/13	10/8	10/13	10/11	10/8	10/8	10/10
Muleshoe	10/28	10/23	11/6	11/10	11/16	11/3		11/4

Table 15. Approximate Date of Population Peak for Canada Geese at U.S. National Wildlife Refuges During the Fall Migration.

	1953	1954	1955	1956	1957	1958	1959
Sand Lake	10/28	10/23	10/8	10/29	10/19	10/11	
Salt Plains	11/27	11/27	12/25	10/30	10/30	11/16	11/14
Tishomingo	11/19	11/11	11/16	11/17	11/16	11/1	11/9
Hagerman	12/30	12/11	11/18	12/18	12/18	12/12	12/12
Aransas	12/7	12/31	12/31	12/18	11/13	12/18	11/13
Laguna Atascosa	12/11	12/31	12/25	11/10	12/31	12/13	11/11
Muleshoe	12/18	12/30	12/30	12/31	12/31	12/28	12/30

Table 16. Period of Greatest Influx of Canada Geese at U. S. National Wildlife Refuges During Fall Migration.

	1953	1954	1955	1956	1957	1958	1959
Salt Plains	10/13-19	10/13-19	10/27-11/2	10/13-19	10/20-26	11/17-23	10/13-19
Tishomingo	11/17-23	11/3-9	10/20-26	11/17-23	11/10-16	10/20-26	11/10-16
Hagerman	11/10-16	11/24-30	10/13-19	10/20-26	10/27-11/2	12/8-14	12/8-14
Aransas	11/24-30	11/3-9	11/3-9	10/27-11/2	11/10-16	10/13-19	11/3-9
Laguna Atascosa	12/8-14	10/20-26	12/1-7	11/10-16	11/17-23	10/20-26	10/27-11/2

weather system which "triggered" the mass migration reported by Bellrose (1957), (Appendix II-3). At Tishomingo an influx of over 22,000 Canada geese occurred between the census on October 21 and October 22, 1955. Sand Lake reported a loss of 5,000 Canada geese for the weekly report period ending October 22, 1955. At the time of the Tishomingo census on October 23, 13,000 Canada geese had apparently moved on south. Neither weather conditions extant in the far north nor locally in Oklahoma and Texas provided an answer to this sudden migration.

In Figures 14 and 15 are given the total weekly censused number of Canada geese by year in the system of five refuges in the southern tall-grass prairie, Salt Plains, Tishomingo, Hagerman, Aransas, and Laguna Atascosa. Figure 14 illustrates a series of years of the most recent drought period in the southern Great Plains and Figure 15 depicts population numbers during the three relatively wet years following the drought. In this overall picture of Canada goose migration into the southern tall-grass prairie there is slightly better evidence of a correlation with the mass migration dates given by Bellrose (1957, and Bellrose and Sieh 1960), especially for the October 23 to 25 movement in 1957 (Fig. 15). In each case, a date shown in Figures 14 and 15 is the mid-point of a weekly report period. Thus, in Figure 15, October 23 is the mid-point of the October 20 to 26 report period. Personal census records for this period indicate that at Salt Plains arrivals were observed on October 20, 23, and 24. There was no observed increase to the end of the report period. All refuges in the system reported increases for the period, but only at Salt Plains could the increase be considered unusual (Appendix II, 1-7). In 1956, the period of mass migration in the Mississippi Flyway occurred during

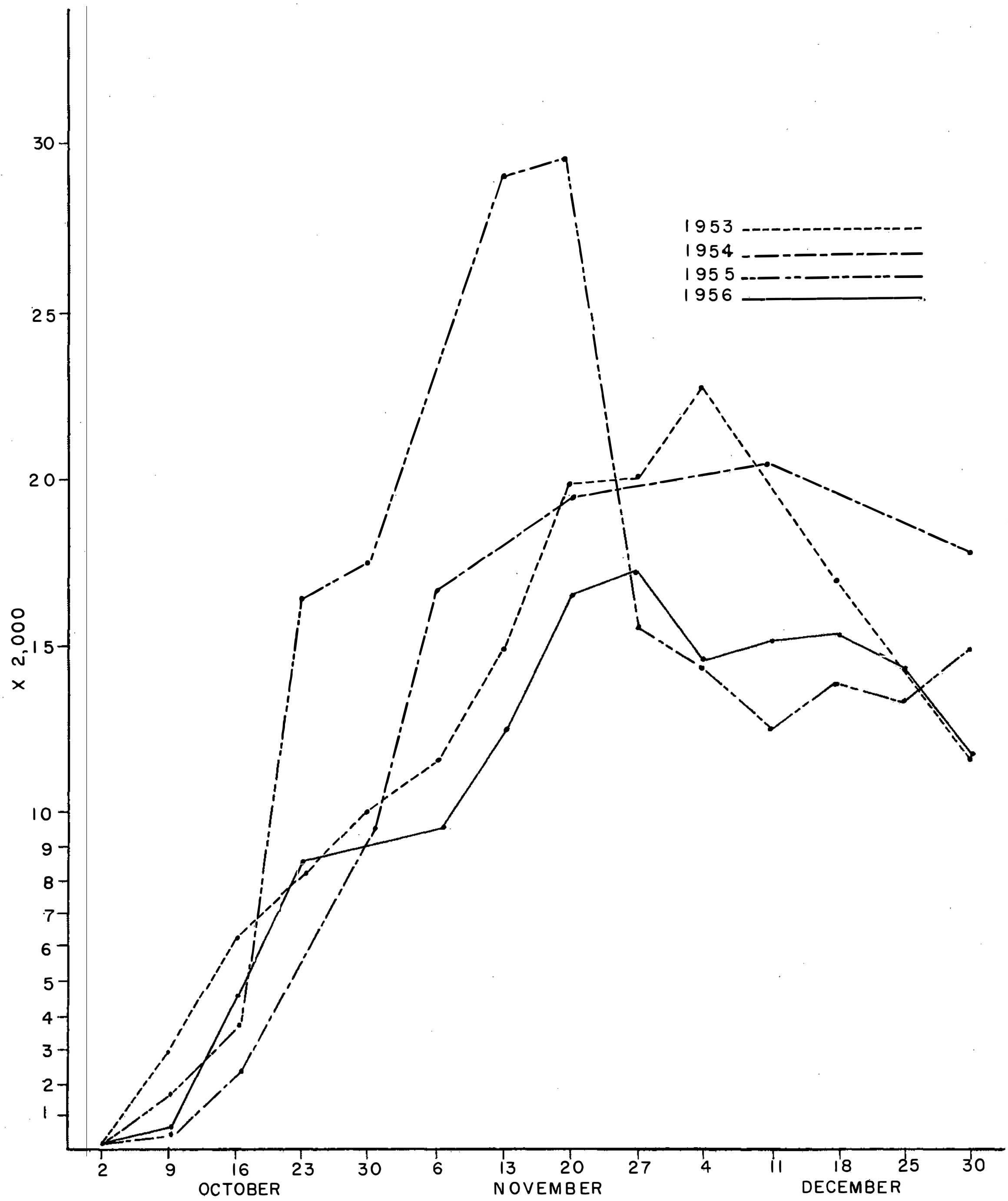


Figure 14. Total numbers of Canada geese censused by weekly periods, 1953-1956, at Salt Plains, Tishomingo, Hagerman, Aransas, and Laguna Atascosa. (Appendix II, 1-4).

a relatively stable period in the south Central Flyway (Fig. 14). This is also the case for the system as a whole in 1955 (Fig. 14), though all refuges except Tishomingo do show small increases for the period October 27-November 2 (Appendix II-3). The nearly 11,000 bird increase at Aransas in the succeeding period, November 3-9, and the reported loss of nearly 6,000 geese from Sand Lake between October 30 and November 5 both appear to be correlated with the mass migration phenomenon.

Apparently distance and the divergent pathways followed by geese migrating through the tall-grass prairie tend to mask the influence of major weather systems on the chronology and magnitude of the migration. In addition, the lack of a uniform reporting system among the refuges for waterfowl census permits only the most gross type of analysis.

Habitat and Chronology. Normally, by the time Canada geese reach Oklahoma much of the migration impetus has apparently diminished. Many of the birds spend the winter at this latitude. These are not necessarily late-arriving geese, for banding data from Salt Plains show that some geese banded in the third week of October and first week of November are still present on the refuge in late December and early January. In the southern latitudes the length of time that geese remain on a given refuge, and the number that will remain, hinges on many factors which include weather, disturbance, food, water, and space. Probably other more subtle habitat components and perhaps, ancestral wintering areas are also involved. Each of these factors has some influence on the apparent chronology and apparent magnitude of the southward migration. As shown in Tables 14 and 16, the dates of arrival and periods of greatest influx show little or no correlation with the period of

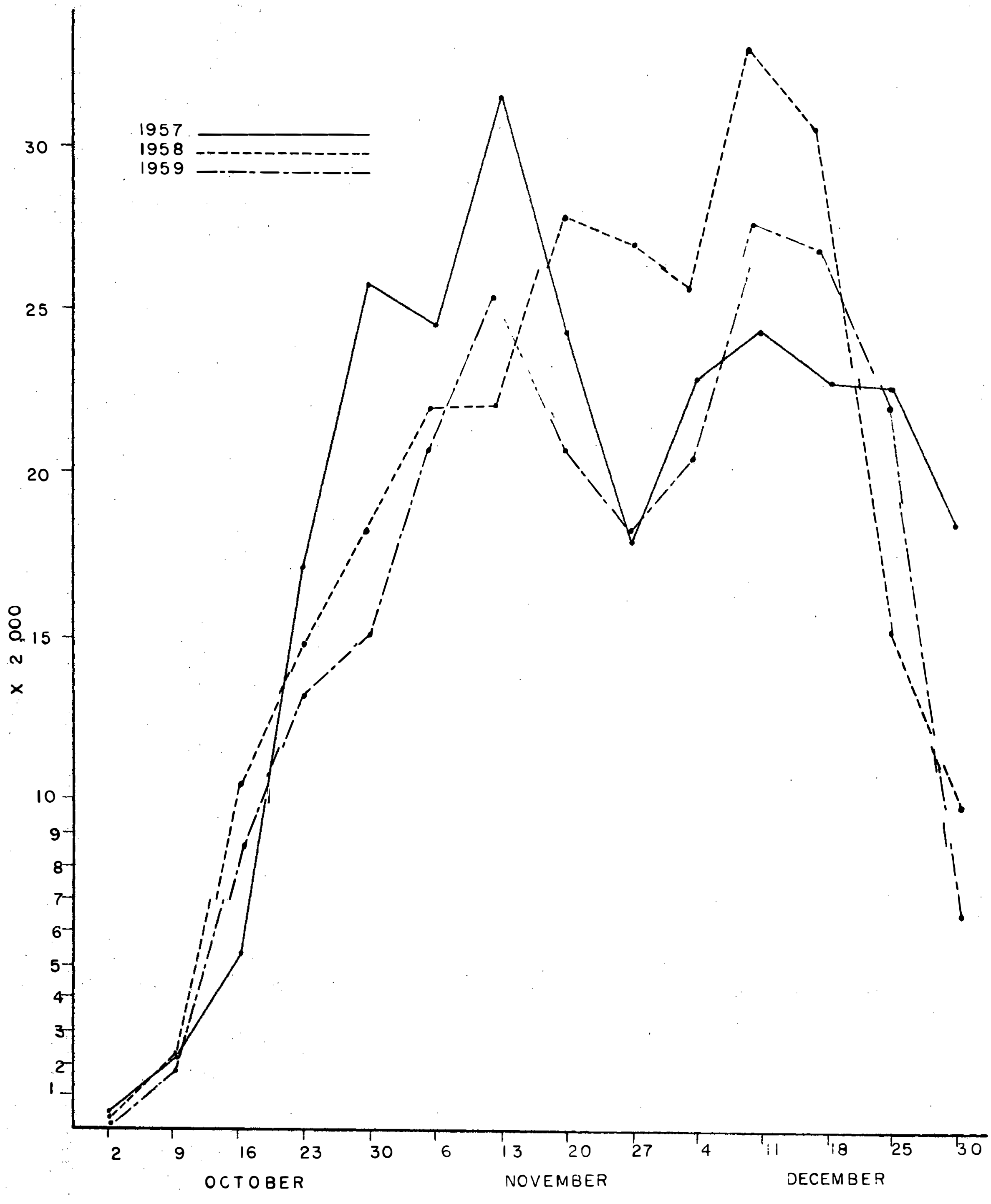


Figure 15. Total numbers of Canada geese censused by weekly periods, 1957-1959, at Salt Plains, Tishomingo, Hagerman, Aransas, and Laguna Atascosa (Appendix II, 5-7).

drought, 1953-1956, or the period of abundant moisture, 1957-1959. Yet, the total number of geese censused by period and year on the several refuges in the southern tall-grass prairie differ markedly between the two periods (Figures 14 and 15). In a wet year (Figure 15) the migration appears to be early and there is often discussion of the "early flights". In a dry year (Figure 14) the migration appears to lag and a lack of early flights or large flights is singled out as the cause. The apparent difference in chronology of the overall migrations in dry years and wet years is somewhat misleading. The actual phenomenon observed is the rate of population build-up on a number of census areas. When habitat values are high on the refuge areas geese tend to congregate and remain on these areas for varying lengths of time. The appearance is one of early flights and large numbers. In years when habitat values on the refuge areas are low, the apparent pattern of migration and magnitude is the opposite. The 1955 migration (Figure 14) is interesting in that it combines characteristics of both the wet years and the dry years. September, 1955 offered some temporary relief from the drought on most refuges in the southern tall-grass prairie. Therefore, in October and early November food and water was adequate and this is reflected in the rate of population build-up in this period. A relative lack of precipitation in November and December resulted in a rapid decline in habitat values on the refuges and the number of geese using the refuges quickly declined. Based on the data in Table 14, it would appear that the actual chronology of the early migration is probably not greatly influenced by habitat conditions existing on the refuges. However, in the late stages of the southward migration year to year differences in habitat value do show some effects on chronology. Two individual years representative of the drought period, 1956, (Figure 16), and of the wet period, 1958, (Figure 17) are given for comparison of the migration pattern as observed at individual refuges. The difference in the apparent magnitude of the migration in the two years is marked, and is a reflection of the difference in habitat values on the several refuges during these years. In a dry year (Figure 16) there is a tendency for population numbers on a given refuge to reach a peak or near peak early in the season and then level off and remain relatively stable with only a slight or moderate decline to the end of the year. With some exceptions population fluctuations are slight and a loss in numbers on one refuge is seldom well correlated with a gain in numbers on another refuge. In contrast during a wet year, (Figure 17), the pattern of migration on a given refuge often shows fluctuation of a large magnitude and these are regularly correlated with population fluctuations at other refuges. Thus, in Figure 17 the population loss in late October at Tishomingo is well correlated with a population increase at Hagerman; at Salt Plains the population loss in mid-November is reflected in increases at both Tishomingo and Hagerman; the continuing loss in numbers at Tishomingo through late November and early December matches the continuing increase in numbers at Hagerman; the losses at Salt Plains from late November through mid-December are reflected in the increased numbers censused at both Aransas and Hagerman. The rapid decline from peak numbers is a consistent characteristic of goose populations on refuges during wet years. At Salt Plains and Tishomingo it had been observed that this decline is associated with the reduction of available food, particularly the green feeds, and this lack of food is, in turn, a consequence of the peak

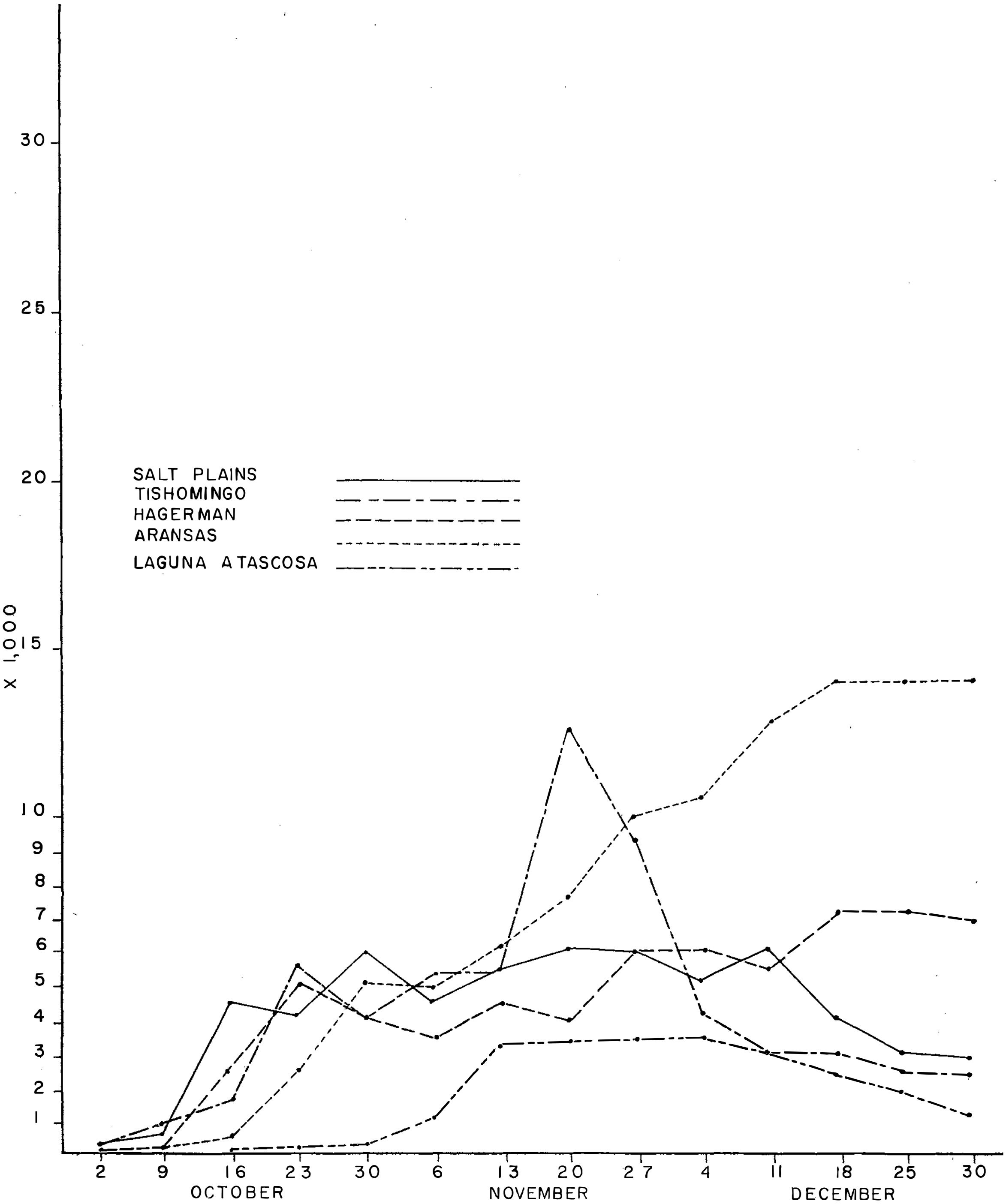


Figure 16. Population numbers of Canada geese in weekly census periods as reported by five refuges in the southern tall-grass prairie, 1956. The date given is the mid-point of a weekly report period (Appendix II, 4).

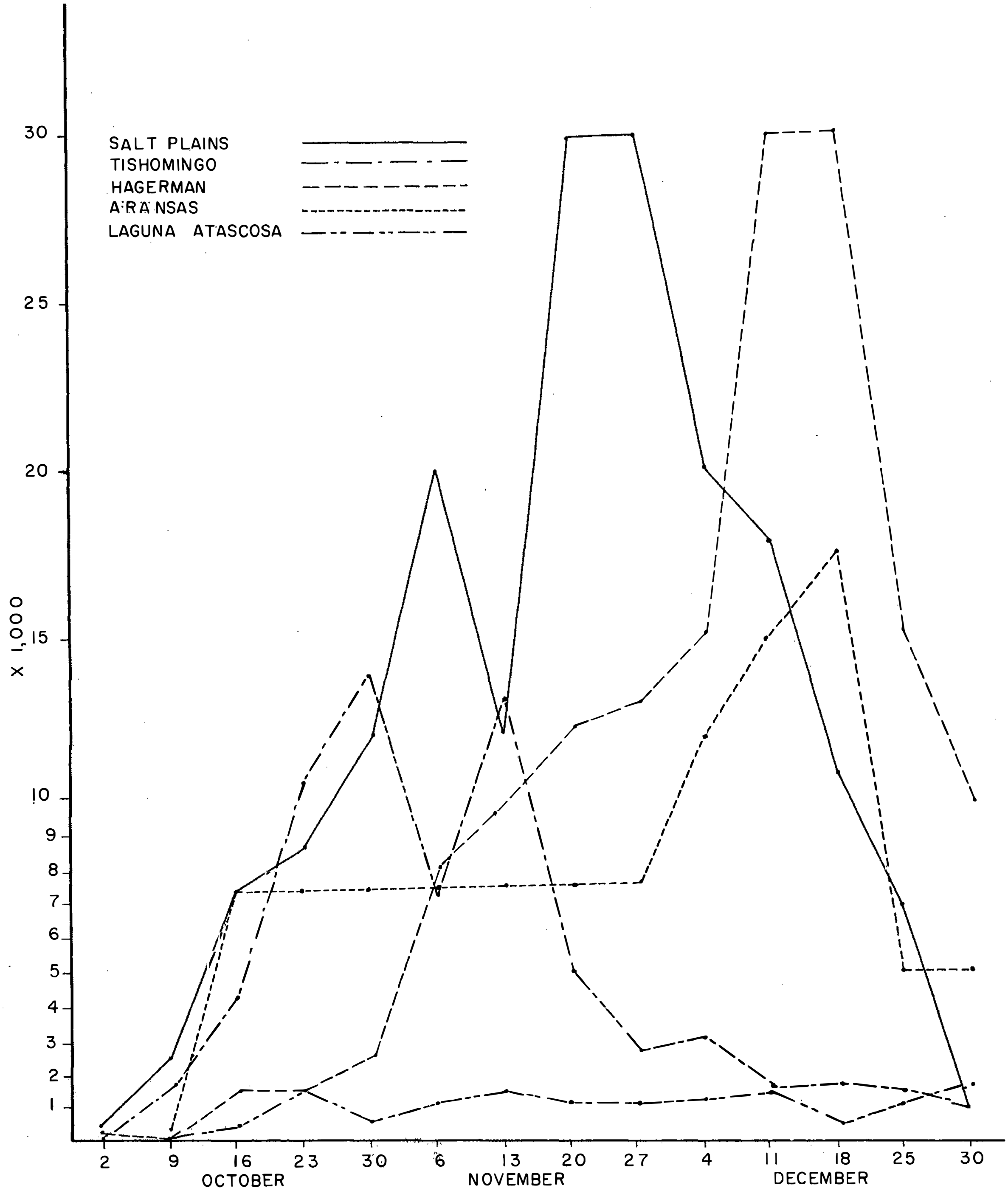


Figure 17. Population numbers of Canada geese in weekly census periods as reported by five refuges in the southern tall-grass prairie, 1958. The date given is the mid-point of a weekly report period (Appendix II, 6).

population. Thus, in years with high habitat values there is a tendency for geese to congregate and greatly exceed the seasonal carrying capacity of a refuge. Overuse leads to rapid deterioration of the habitat and subsequent departure of the large flocks. The mass arrival of these flocks at refuges to the south alters the chronology of the migration pattern not only of the individual southern refuges, but, in a given year, by creating a late-in-the-season flight may alter the chronology of the migration pattern for the entire southern tall-grass prairie (Figures 14 and 15).

Population Status

At the time this study was initiated, it was felt that the numbers of small Canada geese censused at the several refuges could provide an index for estimating the annual total population in the south central United States. As the study progressed it became apparent that this would be true only if habitat conditions in the study area remained relatively stable from year to year. In fact, it now appears that the census records from the refuges may better be used as a habitat index than a population index.

Numbers. In the short-grass prairie route wintering Canada geese congregate in large flocks on a relatively few areas. Intensive efforts to census geese wintering in this route after the hunting season in 1959-1960 and 1960-1961 yielded estimates of 84,600 and 97,000, respectively, Grieb (1960 and 1961). Grieb (1961) suggested that the population of Canada geese in the short-grass prairie is increasing each year, though he does admit some of the apparent increase may be the result of recent intensified census methods.

Numbers of the Canada goose population wintering in the tall-grass prairie route following the hunting season are not well known. A rough estimate can be made from the data available for the 1959-1960 season. These figures provide a comparison with the short-grass prairie census figures for the same general period. The peak number of Canada geese censused on the system of five refuges in the tall-grass portion of the study area was 56,178 (Appendix II-7), occurring in the December 8 to 14 report period. During the last of November and the first half of December Mr. Roger Williams, Manager of the 128,000 acre O'Conner Ranch west of the Aransas Refuge reported approximately 20,000 Canada geese were feeding in a 200 acre cornfield on the ranch. This would bring the total censused geese for this period to 76,178 birds, of which 55,898 were in Texas. Band return data indicate that 40 to 55 per cent of the migrating and wintering Canada goose population in Texas is distributed in areas along the coast not within the immediate influence of the Aransas and Laguna Atascosa refuges and therefore, are not included in the weekly censuses (Chart 7). This would mean that for this particular period between 22,359 and 30,744 Canada geese could have been present in uncensused areas in Texas. This would increase the total for Texas to between 78,257 and 86,642 and would increase the total for the tall-grass portion of the study area to between 98,537 and 106,922. This does not seem an unreasonable number when it is considered that the total does not include tall-grass prairie geese present south of Texas or north of Oklahoma. The calculated total is therefore believed to be conservative and would probably not be affected by hunting mortality occurring between the period of the estimate and the end of the hunting season. The majority of the Canada geese wintering north of Oklahoma are of the large subspecies and are of lesser interest to this study. Grieb (1961) estimated that approximately ten per cent of the geese censused in the short-grass prairie are of the large subspecies and this is consistent with observations in the tall-grass prairie. Thus, the estimated total of the wintering population of small white-cheeked geese in the short-grass prairie in 1959-1960 would be about 76,140 birds and in the tall-grass prairie between 88,683 and 96,230 birds. The combined estimated total would be 164,823 to 172,370 small white-cheeked geese wintering in the south central United States. Using mid-points to ease calculation, there would be approximately 92,456 small Canada geese in the tall-grass prairie and the combined estimated total of these birds for both the tall and short-grass prairie would be approximately 168,596.

Assuming a uniform crippling loss for all species of geese in 1959-1960, the estimated number of Canada geese killed in the Central Flyway, within the United States, was 144,698 birds (Atwood and Wells, 1960). The kill of large and small Canada geese is probably nearly proportional to their frequency in the total population. Thus, it is assumed that in the short-grass prairie and in the tall-grass prairie south of South Dakota ninety per cent of the kill consists of small Canada geese. From personal observation of hunting areas, and discussion of hunting kill with hunters and state and federal conservation personnel, it appears that in North and South Dakota the kill of large Canada geese may represent as much as thirty per cent of the total kill. If this is true, then from the data presented for Two Buttes and Sand Lake in Tables 8 and 11, 23.73 per cent or 34,335 Canada geese were killed in North and South Dakota and of this seventy per cent or 24,035 were small Canada geese. Of the 110,363 Canada geese killed in the remainder of the Central Flyway 99,327 were of the small size. This would be a total of 123,362 small Canada geese killed in the Central Flyway within the United States. Again, assuming susceptibility to gunning is uniform between the tall and short-grass prairie segments, then 45 per cent or 55,513 birds were killed in the short-grass prairie of the United States and 55 per cent or 67,849 birds were killed in the tall-grass prairie of the United States. In the tall-grass prairie the kill of small Canada geese within the United States represents 93.5 per cent of the total kill in this route (Table 8). Thus, the total kill in the tall-grass prairie route in the United States and Canada was 72,566. In the short-grass prairie the kill in the United States represents 47.4 per cent of the total for the route. Therefore, in the short-grass prairie route of the United States and Canada the total kill was 117,116. Combined, the total kill of small Canada geese in the Central Flyway of the United States and Canada was 189,682. The kill figure added to the wintering total indicates that about 358,278 geese must have begun migration in the Central Flyway. Of this total about 193,256 used the short-grass prairie route and about 165,022 the tall-grass prairie route. Assuming a relatively stable population during the three year period (1957-1959) would require an annual increment of 60.6 per cent in the short-grass prairie, 44.0 per cent in the tall-grass prairie, and 52.9 per cent for the Central Flyway as a whole.

Composition.

Efforts in this study to obtain adequate indices of the sex and age composition of the small Canada goose population in the south central United States were largely unsuccessful. The small samples from the 1957-1958 and 1958-1959 seasons (Tables 17 and 18) are not of sufficient scope to allow a meaningful interpretation. The ratio of immatures in the 1957-1958 samples is consistently high and in the 1958-1959 samples the ratio for the same age class is consistently low. Circumstances surrounding the 1957-1958 trapping program at Salt Plains introduced a strong bias in favor of the capture of immatures in the trapping sample. The author was not present at Aransas during the period in 1957-1958 in which the majority of geese were trapped. Information concerning the behavior of the geese on the trap site during this latter trapping operation is not available, and without this specific information an interpretation of the significance of the age ratios obtained from trapped birds is not feasible. There is a lack of agreement among authors concerning the bias involved in age structure data obtained by either trapping or hunter kill. Hanson and Smith (1950) indicated the belief that trapped samples provided valid age structure data for their study. On the other hand, Grieb (1961) suggested that "firing-line harvest" may provide a sample which is less biased than trapping for both sex and age data. In the Illinois study Hanson and Smith (1950) presented considerable data to support their contention that the immature age class may be several times as vulnerable to gunning as the adult age classes. Data from Salt Plains also indicate that the immature age class is somewhat more susceptible to hunter kill.

Observations of goose behavior during trapping operations at Salt Plains and Tishomingo indicate that if the trapping is done on small flock units (5 to 15 birds) the sample obtained is biased in favor of the immature age class. It is believed that this is the

Table 17. Adult: Immature Age Ratio Data From Small Canada Geese in the Tall-grass Prairie Gathered By Various Methods, 1957-1960.

Station and data source	Year 1959-1960	1958-1959	1957-1958
Salt Plains (trapping)	(553)* 100:61	(136) 100:19	(28) 100:250
Salt Plains (hunter kill)	(134) 100:185	(43) 100:79	(37) 100:118
Salt Plains (field observ.)	(299) 100:100		
Tishomingo (trapping)		(44) 100:26	
Tishomingo (field observ.)	(468) 100:89		
Aransas (trapping)			(55) 100:293
Aransas (field observ.)	(166) 100:50		
Laguna Atascosa (field observ.)	(113) 100:69		

* Number in parentheses indicates size of sample.

Table 18. Summary of Male : Female Sex Ratio of Small Canada Geese of the Tall-grass Prairie, 1957-1960.

Station and data source	Year 1959-1960	1958-1959	1957-1958
Salt Plains (trapping)	(553)* 100:95	(136) 100:103	(28) 100:47
Salt Plains (hunter kill)	(91) 100:78	(43) 100:126	(37) 100:61
Tishomingo (trapping)		(44) 100:83	
Aransas (trapping			(55) 100:38

* Number in parentheses indicates size of sample.

result of trapping family units and perhaps unattached immatures which appear to be less wary than adults. If the trapping is done on a large, actively feeding flock (100 or more) it appears that there is a bias in favor of the adult age classes. In these large flocks feeding on a baited area of limited size, the hierarchy described by Hanson (1953) apparently breaks down and the larger, more aggressive adults crowd the immatures out of the baited area. It is assumed that the adult sample obtained includes individuals of the pre-breeding, breeding, and post-breeding adult age classes.

It is believed that the gathering of age ratio samples directly from field flocks using the method described by Marquardt (1962) holds the greatest promise of providing unbiased data. This method was first used as a means of procuring age ration data from Canada geese in 1959 at the Salt Plains refuge, Table 17. The samples are mostly small, lack comparable data from either past or previous years, and as is discussed by Marquardt (1962), those gathered in the latter part of the 1959-1960 waterfowl season, Aransas and Laguna Atascosa, may be slightly biased in favor of the adult age classes. In spite of these shortcomings the age ratio data gathered by this method indicate population phenomena which might be expected on the basis of present knowledge concerning the migration of small Canada geese in the tallgrass prairie. The samples at Salt Plains were taken in October and November, those at Tishomingo in early December, and these at Aransas and Laguna Atascosa near mid-January. Using the ratio obtained at Salt Plains as a starting point, the decreasing ratio of immatures to adults southward to the Texas coast is what would be expected if immatures are more susceptible to gunning. The difference between the age ratio data collected at Aransas and Laguna Atascosa may be the result of small samples or differential kill in the two areas, and in addition, may contain an unknown amount of bias in favor of the adult age classes. The matter of differential kill sustained by flocks subsequently wintering at Aransas and Laguna Atascosa could be important as concerns the age ratio data collected at these two stations. On the basis of band return distribution, the geese migrating through and wintering in the lower Rio Grande Valley experience less gunning pressure (less than nine per cent of Texas returns) than those arriving in the vicinity of the Aransas refuge (more than eighteen per cent). Further analysis without comparable data from succeeding years does not appear justified. Age ratio data for preceding years is not available.

Kind and Extent of Attrition

Observations in this study indicate that sources of attrition other than hunting are insignificant insofar as losses in the small white-cheeked geese of the south central United States during the migration and wintering period are concerned. No single verifiable case of primary predation by any mammalian or avian predator was observed during the three years of this study. There were no reported losses of Canada geese to disease or parasites during the course of this study.

Whether to consider the sign left at the carcass of a goose as evidence implicating a particular species of predator or as an evidence of scavenging is a moot question. Both eagles [*Aquila chrysaetes* (Linnaeus) and *Haliaetus leucocephalus* (Linnaeus)] and coyotes, [*Canis latrans* Say] were observed harrassing goose flocks and it appeared this harrassment was for the purpose of separating cripples from the flocks.

Of 25 carcasses examined in situ, avian species were implicated in fifteen cases, mammalian species in nine cases, and an unknown scavenger in one case. At none of these carcasses was there signs of struggle which would have indicated predation on a strong, healthy goose. At seven of the carcasses the raccoon [*Procyon lotor* (Linnaeus)] was responsible for the majority of the feeding, the coyote at two, the eagles at two, the marsh hawk [*Circus cyaneus* (Linnaeus)] at one, a combination of the herring gull [*Larus argentatus* Pontoppidon], eagles, marsh hawk and possibly the Swainson's hawk [*Buteo swainsoni* Bonaparte] at twelve, and an unknown scavenger, possibly the domestic dog, at one. In the course of time, nearly all carcasses showed signs of visits from several flesh eating species.

CHAPTER VI

DISCUSSION AND CONCLUSIONS

The Species Concept and its Significance as Related to the Small White-Cheeked Geese of the Central Flyway.

Probably no goose species of the North American continent is better known to the general public than the Canada goose. As either a migrant or resident some representative of this species is found in every territory and province of Canada, every state in the United States, and is recorded from most of the northern states of Mexico. Taverner (1928) has stated,

> "Although few birds are as well known to the sportsman and general public, none is so little understood systematically by either scientist or layman. It is a variable species.. .".

This general thought has been echoed, with minor variations by innumerable persons who have had occasion to study or discuss some phase of the biology of the Canada goose. A review of the literature quickly leads to the conclusion that considerable difference in opinion exists among authorities concerning the taxonomic status of these white-cheeked geese. Some aid in visualizing the complexity of the situation may be gained from an examination of the different specific and subspecific characterization given this group by three recognized authorities, Aldrich (1946), Conover (1948), and Delacour (1951) as compared to the A.O.U. classification (1931, 1945, 1947, 1949), Figure 18. Obviously, differing as greatly as they do, all four cannot be a correct presentation of the species relationships.

Aldrich (1946)		Conover (1948)				Delacour (1951)	A.O.U. (1931, 1945, 1947, 1949)
Branta		Branta				Branta	Branta
canadensis	hutchinsii	canadensis	leucopareia	minima	hutchinsii	canadensis	canadensis
canadensis	hutchinsii	canadensis	leucopareia	minima	hutchinsii	canadensis	canadensis
interior	minima	moffitti	occidentalis			interior	hutchinsii
parvipes	asiatica	parvipes				parvipes	leucopareia
moffitti		interior				moffitti	parvipes
leucopareia						maxima	occidentalis
occidentalis						occidentalis	minima
						fulva	interior
						leucopareia	moffitti
						asiatica	
						minima	
						taverneri	
						hutchinsii	

Figure 18. Graphic representation of the systematics of the white-cheeked goose complex by four authors. No phylogenetic order is intended.

The problem now is, how nearly can one of these systems be reconciled with our present knowledge of the species, and the criteria established for the classification of biological units.

Before proceeding further with a discussion of the proposed classfications it is proper to examine briefly the basic concepts which serve as a framework for structuring such a classification. The indicated upper level of disagreement is that of the species. Therefore, a review of the characteristics of the species and its sub-units is in order.

Mayr (1957) pointed out that recent definitions of species are essentially variations of the definition offered by Dobzhansky (1935), namely interbreeding and reproductive isolation.

> "Mayr (1940) defined species as 'groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups'. Simpson (1943) gave the definition 'a genetic species is a group of organisms so constituted and so situated in nature that a hereditary character of any one of these organisms may be transmitted to a descendant of any other', and Dobzhansky (1950) defined the species as 'the largest and most inclusive....reproductive community of sexual and cross-fertilizing individuals which share in a common gene pool'." Mayr (1957).

This was succinctly summarized by Simpson (1951).

> "The group defined is co-extensive with the continuity and bounded by discontinuity. A species under this definition is the largest group with non-arbitrary exclusion and the smallest group with non-arbitrary inclusion."

For sexually reproducing populations these criteria are purely objective and while strict adherence to them can create numerous instances of conflict with present classification, they can also be expected to lead to uniformity and realism in classification.

If the classifications offered in Figure 18 are examined critically, there are some striking deviations from the criteria offered in the species' definition above. Aldrich (1946) has proposed two species, canadensis including six subspecies, and hutchinsii including three subspecies. If, indeed, a species is bounded by discontinuity we would expect nowhere to find a mingling of the gene pools of these two species. However, Bailey (1948) and Delacour (1951, 1954) have suggested that intergrades between minima and leucopareia (Delacour's taverneri) do exist in the area between Wainwright and Point Barrow, Alaska. John W. Aldrich presumably accepted the minima-leucopareia intergrade from the vicinity of the Colville River, Alaska contained in his compilation of mensurational data from United States National Museum specimens and made available to this investigator. In addition, Swarth (1913) discussed the apparent minima-hutchinsii (hutchinsii=leucopareia) intergrades contained in the California specimens examined by him.

This investigator has examined two specimens, one from the Colville River area and presently in the Denver Museum of Natural History collection which has every appearance of being an intergrade between minima and leucopareia and a Texas specimen from the collection at the Welder Foundation Museum which in size resembles minima, but which has the color of leucopareia. Further, personal examination of specimens at the United States National Museum and the Chicago Museum of Natural History points to the possibility that intergrading between hutchinsii and leucopareia may also occur in the Arctic northeast. Either of these inclusions would destroy the discontinuity of the proposed species gene pool and therefore invalidate the classification offered by Aldrich, (1946). More recently, investigations on the breeding grounds of minima, between the deltas of the Yukon and Kuskowin Rivers in Alaska, indicate there is little overlap between minima and leucopareia in this area, (Spencer, Nelson and Elkins, 1951). Nelson and Hanson (1959) pointed out that since 1948 minima has been found to nest along the Alaskan coast only between these two rivers. Spencer, Nelson, and Elkins (1951) indicated that the breeding grounds of the two races are well defined by vegetative and physiographic components of the nesting habitat. Murie (1959) also pointed out that the nesting areas of the two races are distinct. Nelson and Hansen (1959) relying upon the observations of Nelson (1883), Preble and McAtee (1923) and Murie (1937) suggested that previously the breeding range of minima might have been more extensive than at present. Nonetheless, regardless of what changes have occurred in the past ranges of these two taxa, or how discrete the breeding grounds appear to be at present, there is at least enough fragmentary evidence of intergrading available to make a hypothesis of reproductive isolation suspect.

In defense of Aldrich's proposal, it can readily be admitted that hutchinsii and minima appear to have much more in common with each other than with any other proposed race. They are, to the best of our knowledge, the two smallest races of white-cheeked geese, they replace each other geographically and, from rather meager accounts in the literature (Bailey, 1948) (Sutton, 1932), differ ecologically, for example, in choice of nesting site, type of nest construction, and physiography of breeding and nesting areas. Phenologically, it also appears these two races are similar in that they are relatively late arrivals on the breeding grounds and in this the possibility of a common physiological bond should not be overlooked. As to the problem arising from the intergrading of minima and leucopareia in the west and possible intergrading of hutchinsii and leucopareia (and perhaps parvipes as well) in the east, it is obvious that an occasional hybrid which is unable to enter the gene pool of either parental species, on account of reproductive incompatibility, would in nowise corrupt the discreteness of the hybridizing species. Evidence regarding the breeding capabilities of these intergrades is lacking, and in view of a statement by Delacour and Mayr (1945), asserting that there is a high degree of fertility in hybrids from crosses between species in the genus Branta, there is little reason to suppose such intergrades would not be entirely fertile. Attractive as the idea of separate species might be, in the absence of proof of genetic discontinuity between minima and leucopareia on the one hand and leucopareia and hutchinsii on the other, it seems necessary to reject the proposed species hutchinsii and accept the prior polytypic species canadensis on the grounds of taxonomic practice, law of priority (Schenk and McMasters, 1956), and scientific brevity, the principle of parsimony (Pearson, 1937... from Allee, Emerson, Park, Park, and Schmidt, 1949).

If the species classification of Aldrich cannot be reconciled with the known intergrades most of the species classification of Conover must be rejected for the same reason. The recognition of leucopareia as a species appears untenable in view of the many recognized intergrades, Swarth (1913, hutchinsii = leucopariea), Aldrich (1946), Bailey (1948), and Delacour (1951, 1954). Minima as a monotypic species fails to qualify for the reasons given in the discussion of Aldrich's classification in which it was considered a subspecies of hutchinsii. However, Conover also proposed hutchinsii as a monotypic species.... "because on Southampton Island it has been found nesting in close proximity to Branta candensis parvipes," .... and asserted that it is not conspecific with minima.... "because of the great differences in their downy young" (Conover, 1948). This assertion is derived, in part, from the observations of Canada geese on Southampton Island by Sutton (1932). Sutton was explicit in pointing out the difference in ecologic character between the nesting areas of hutchinsii and leucopareia (=parvipes). Sutton also suggested the possibility of intergrades between hutchinsii and parvipes with the discussion of a specimen he was unable to catagorize. Conover (1948), too, admitted to the possibility of intergrades between the two races with his discussion of a large specimen of hutchinsii taken during migration in North Dakota.

As pointed out there is reason to suspect intergrading between leucopareia and hutchinsii. Accepting the distribution given by Conover (1948) and Delacour (1951, 1954), such intergradation would be nearly impossible. However, specimens from the Perry River, Keewatin, N.W.T., Canada, collected by H. C. Hanson in 1949, (Hanson, Queneau, and Scott, 1956) and presently a part of the bird collection of the Chicago Museum of Natural History are, on the basis of standard measurements, general conformation, and color, referable to leucopareia. In addition Aldrich (1946) asserted that specimens examined by him from Baffin Island are referable to leucopareia, not parvipes. Altogether, this would tend to support the distribution of leucopareia proposed by Aldrich as opposed to the more limited distribution suggested by Conover and Delacour. Thus, insofar as our knowledge of distribution is concerned, intergradation between hutchinsii or parvipes and leucopareia is possible. Conover (1948) considered hutchinsii and parvipes to be sympatric and non-interbreeding populations on Southampton Island, but, as herein pointed out, ecologic barriers apparently limit, but probably do not exclude possible intergrading. The differences Conover asserted to exist between the downy young of minima and hutchinsii appear, from the plates presented by Scott (Delacour, 1954), to be largely a matter of degree and are effectively bridged by the downy young of B. c. leucopareia, which are intermediate between the two. Moreover, this difference in downy young plumage, applicable as it might be to subspecific identity, would seem entirely inadequate as proof of species identity defined on the basis of genetic discontinuity. Thus, in Conover's classification there is much the same problem faced in considering the classification of Aldrich. Until further and more detailed studies provide conclusive evidence of genetic discontinuity in the white-cheeked goose complex it seems the more reasonable choice to accept tentatively the simpler classification of a single polytypic species, canadensis, as is in current usage by the American Ornithologists' Union (1957).

During recent years the complexity of the species structure of Branta canadensis has been increased by the addition of several subspecies. Of the more recently proposed subspecies, B. c. fulva (Delacour, 1951) may be valid. By description it appears quite distinct from B. c. occidentalis (Baird), from which it was separated. The writer has examined only a few specimens from the range of this particular race and finds the overlap in size and color to be so great as to make certain identification impossible without prior knowledge of the collecting site. In a large series however, such irregularities might be expected to fall within the acceptable limits of racial variation. At the present time B. c. fulva has been accepted by the American Ornithologists'Union (1957). The American Ornithologists' Union has also accepted B. c. maxima (Delacour) which, in the words of Delacour (1951).

> "Bred in the great plains of the central United States, in the Dakotas, Nebraska, Kansas, Minnesota, Iowa, Missouri, western Kentucky, Tennessee, and northern Arkansas, where it was sedentary; now extinct."

The description of this race, as given by Delacour (1951, 1954) leaves much to be desired. By description, the plumage colors are apparently similar to those of B. c. moffitti, though, considering that the type had been stored 75 years before it was named, a question might be raised as to the validity of such a comparison. The average measurements of B. c. moffitti are somewhat smaller than those given for B. c. maxima, but many of the larger examples of B. c. moffitti are as large as the largest given for B. c. maxima. It is also of interest that of the three heaviest weights of Canada geese for which John W. Aldrich has authentic records (not published) two (19 lbs. 4 oz., 19 lbs. 3 oz.) were taken in California, and the other (18 lbs.), in Saskatchewan. These are, of course, well outside the proposed geographic range of the sedentary B. c. maxima. Many of the characteristics which aid in distinguishing B. c. maxima from B. c. moffitti are apparently observable only in the field and it is in this respect that Delacour (1951, 1954) relies heavily on an account of hunting these large geese published by W. B. Mershon in Field and Stream in 1925. Without detracting from Mershon's reputation as a naturalist, it would nonetheless seem reasonable to question an addition to the systematics of as complex a group as the Canada geese when so much of the argument is based on general impressions.

Two other proposed subspecies which require clarification are B. c. taverneri and B. c. asiatica. Both of these proposed races have been separated from B. c. leucopareia: B. c. taverneri by Delacour (1951) and B. c. asiatica by Aldrich (1946).

The naming of B. c. taverneri by Delacour (1951) has created considerable confusion concerning the Branta canadensis complex over the past ten years. The confusion arises, in part, from the contradictions in plumage color given in 1951 (light as in parvipes) and 1954 (darker than parvipes). Nonetheless, the name has gained wide acceptance and has been much used by recent writers when dealing with Arctic populations of Canada geese (Hanson, Queneau, and Scott, 1956; Irving, 1960; Kessel and Cade, 1958; Gabrielson and Lincoln, 1959). It is recognized that many, but not all, of the specimens collected in the Aleutian Islands display a high bridged maxilla, which is quite strongly tapered to the tip and has a rather narrow nail. Altogether the maxilla shape is quite like the high bridged form in B. c. minima, well illustrated by Ridgeway (1896) and by Swarth (1913). The specimens, however, are lighter in color and larger in size and in no way referable to this latter subspecies. Delacour, believing birds having these maxilla characteristics to be racially distinct from Canada geese of the mainland and, apparently relying on the general description and range given by Brandt (1836 a), proceeded to split the Aleutian Island and Alaskan mainland geese into two races, referring the island form to B. c. leucopareia and naming the mainland form B. c. taverneri. The splitting of the island and mainland forms into two races may, after further analysis, prove to be a valid division. A later paper by Brandt (1836 b) giving a detailed description and plate of the type specimen indicates, however, on the basis of size, color, and maxilla shape, that B. c. leucopareia is the mainland race and not that of the islands, if indeed, division of the group into two races is justified in the first place. A critical comparison of the type specimens of _B. c. leucopareia_ and _B. c. taverneri_ is given in Table 19. It will be noted that the two specimens are nearly identical, particular for particular, in all of what might be considered diagnostic characteristic. There appears to be no alternative, but to consider _B. c. taverneri_ as a synonym of _B. c. leucopareia._

The circumstances surrounding the naming of _B. c. asiatica_ must be considered unfortunate. The type specimen, collected on Behring Island, June 9, 1883, is recorded as an adult male by Aldrich (1946) and this is repeated by Delacour (1951, 1954) and Diegnan (1961), but the breast and back plumage is that of an immature (probably entering the first adult plumage) and thus the color is lighter than if the plumage were that of an adult, a characteristic of juvenile plumage commented on earlier by Taverner (1928), and Conover (1948). In addition, the plumage is badly faded or "foxed", which by reducing the saturation of pigment renders a paler specimen. Both of these phenomena are important for they bear directly on the diagnostic characteristics separating this from the other races, e.g., darker above than _B. c. hutchinsii,_ lighter below than _B. c. minima._ In the description of _B. c. asiatica,_ Aldrich (1946) omitted comparison with _B. c. leucopareia,_ the nearest race geographically and also the nearest in size and color. Delacour (1951, 1954) in tenatively accepting _B. c. asiatica_ as an extinct race, however, pointed out the Behring Island specimens he had examined were distinctly lighter than the nearby Aleutian birds, e.g., _B. c. leucopareia._ The two examples of _B. c. asiatica_ examined at the U. S. National Museum, of which one is the type, are both badly "foxed" or faded, and therefore, do appear lighter than representatives from both the islands or the mainland. An estimate of the original plumage

Table 19. Some Comparative Diagnostic Criteria of the Subspecies *B. c. leucopareia* (Brandt, 1836 b) and the Proposed Subspecies *B. c. taverneri* (Delacour, 1951).

Character	*B. c. leucopereia* (Brandt)	*B. c. taverneri* (Delacour)
Culmen	38.1	37
Tarsus	83.6	82
Mid. Toe	69.85	76
Wing Chord	400.05	400
Tail	150.28	131
Neck ring	"... a very narrow white ring at the boundary of the neck.... almost disappearing at the dorsal boundary."	"... a small, usually incomplete white neck ring often present."
Beak	"The beak is glossy black, abbreviated, scarcely longer than one-half the head length, quite high;" (Brandt's drawing shows a rather broad maxilla with a moderately rounded nail.)	"... bill short and high at the base, but broad near the tip, with a small rounded nail."

color would be highly subjective, but it was observed that a number of the specimens of _B. c. leucopareia_ which have undergone "foxing" very nearly approach in color these Behring Island specimens. The Behring Island specimens do have the high-bridged, tapering maxilla characteristics. If these characteristics are considered sufficient evidence upon which to define a race, then it would seem proper to recognize the type specimen of _B. c. asiatica_ as non-typical and to redescribe the race to include its variability and also extend its range to include all of the Aleutian Islands.

A purely quantitative method of categorizing the subspecies of Canada geese has not been devised. For the most part, this may be the result of a lack of knowledge concerning the variation in size and color to be included in any given race. As a consequence, in museum series, highly varied individuals may be included among the representatives of a race purely on the basis of collection site. Considering the meagerness of knowledge concerning habitat requirements of the species on its breeding grounds, the migration pathways, and the wintering grounds such a practice seems unrealistic. Certainly, the practice removes any possibility of a critical quantitative approach to categorizing the subspecies of the _Branta canadensis_ complex.

Other, and possibly more important, reasons for the difficulties involved in quantitative analysis of this group are the clines in size and in color. The increase in size from north to south and the increase in pigmentation from east to west are features which have been recognized in the discussions of subspecies by Aldrich (1946) and Delacour (1951). Data presented in Figure 7 suggest that there may also be a clinal increase in size from the Aleutian Islands eastward along the

Arctic coast to the Queen Maud Gulf area and opposing this a clinal increase in size from Baffin Island westward along the Arctic coast, also terminating in the Queen Maud Gulf area. The emphasis given subspecies description by most authors has tended to project the image of a step-cline when, in fact, the true picture for the Branta canadensis complex may be one of a non-uniform continuum for either of the characters of size or color. To the degree that the breeding range of this species complex is continuous and changing in character in a given direction it is possible that the individuals which inhabit the range may reflect this same continuous, yet changing pattern for a given species characteristic. Such a phenomenon is suggested by the data gathered in this study, in that it was impossible to assign a majority of the specimens to a recognized subspecies. Even the use of a system involving eight categories, more than twice the number of recognized subspecies of small Canada geese in the Central Flyway, does not fully resolve the problem of critical identification. Indeed, it is probable that no adequate explanation of the diversity observed in the Branta canadensis complex will be forthcoming until there is a critical survey of the Arctic breeding grounds. Much that is at fault with the present classification of this species stems from the hiatus in knowledge created by inadequate or wholly nonexistent research on the relationships existing within the species complex in the only area it could conceivably be studied as an entity, the Arctic.

The Flyway Concept, the Life-form Concept, and Their Significance as Related to the Migration Routes of the Small White-cheeked Geese of the Central Flyway.

The flyway concept had its formal presentation by Frederick C. Lincoln in 1935. Based upon the analysis of thousands of band recoveries from waterfowl Lincoln proposed four major flyway systems and named them according to their regional association on the North American continent. The original illustrations (Lincoln, 1935) were somewhat revised and presented later (Lincoln, 1950) in an overall discussion of bird migration reminiscent of the earlier work by Cooke (1906). Lincoln (1950) stated that, "... the modern concept of a flyway is that it is a vast geographic region with extensive breeding grounds and wintering grounds connected with each other by a more or less complicated system of migration routes." As proposed, each flyway has its own population of birds which show broad overlapping on the breeding grounds, but are essentially segregated during the migration and wintering periods.

Few objections have been raised as to the validity of this concept insofar as waterfowl migration within the United States is concerned and it has formed the basis of the zoning for waterfowl hunting regulations adopted by the U. S. Fish and Wildlife Service since 1948. Despite this general acceptance, findings presented in this study would suggest that final verification of the flyway concept must await further critical studies of migration routes on an infra-species basis. On the whole, the small Canada geese of the central United States may be considered a Central Flyway population, but to do so requires some alteration of the pattern proposed by Lincoln. The short-grass prairie segment of this population fits the proposed flyway pattern rather nicely. Conversely, there is practically no relationship between the breeding grounds and the migration route of the tall-grass prairie segment of the small Canada goose population and the Central Flyway pattern proposed by Lincoln. The breeding grounds of the tall-grass prairie small Canada geese extend more than 1,000 miles eastward of the proposed breeding grounds for birds of the Central Flyway. That these geese, under ordinary circumstances, perform the majority of their migration within the administrative boundaries of the Central Flyway is perhaps more nearly an accident of political boundaries than any *a priori* knowledge of their migration resulting from adherence to the flyway concept. Moreover, these small Canada geese of the tall-grass prairie apparently do not adhere strictly to a single flyway. As was discussed earlier, adverse conditions in the Central Flyway may cause these birds to perform a considerable portion of their migration in the northern portion of the Mississippi Flyway.

It would be amiss to attempt to refute the flyway concept on the basis of the migration route of this one segment of the *Branta canadensis* complex, yet knowledge of this exception should temper acceptance of the concept until it is certain that other, little known, or little studied populations do not display the same phenomenon. Undeniably, the foundation of the flyway concept is based on a large number of recoveries, but this does not insure that the recoveries are from a representative sample of the total population. The year-by-year banding of waterfowl at a single favorable location will often provide a picture of a narrowly delineated migration route. On the other hand, band returns from a less suitable site (number-wise) and one which also may suffer from a lack of band returns because the migration pattern does not coincide with areas of heavy hunting may suggest, at best, a very sketchy route. In analysis it is tempting to regard the better-defined group as representative whereas, realistically, each group may be deserving of equal recognition, each being representative of a population segment. As the basis for a management plan, the Flyway Concept has been useful to the extent that it defines major areas of waterfowl banding and subsequent waterfowl mortality. As a description of a natural phenomenon relating to species migration and in which each population segment, regardless of numbers, should be given equal recognition, the concept is imcomplete. Finally, and more importantly, the concept fails completely to provide a foundation for the synthesis of an explanation of migration routes.

The life-form concept has evolved from the pioneer efforts of Raunkiaer (1934) to develop a statistical design based on bud exposure which would demonstrate the morphological response of plant species, regardless of their taxonomic status, to a given meterologic environment. Later efforts were broader, emphasizing the total physiognomic aspect of the vegetation and the morphologic response and relationships of the indigenous fauna, (Dice 1931; Dansereau, 1951; Harris, 1952; Horner, 1954).

The relationship between life-form, in a physiognomic sense, and avian distribution has been given special attention by Peterson (1942), Brecher (1943), Aldrich (1943), and more recently from a very special aspect dealing with cultural artifacts, by Stebler and Schemnitz (1955). These studies emphasized the importance of recognizing habitat components, not as taxonomic entities, but on the basis of the requirements fulfilled for a given species. Stebler and Schemnitz (1955) pointed out that use of the life-form concept should facilitate the comparative study of habitat for those species inhabiting extensive geographic areas where habitat components vary greatly taxonomically, but remain essentially the same in the physiognomic sense. This statement by the above authors bears particular significance to the present study. The segments of the Branta canadensis complex migrating and wintering in the central United States undeniably have an extensive geographic range, extending from north of the Arctic Circle to south of the Tropic of Cancer and in their travels, as a group, covering more than two-thirds of the North American Continent. However, this huge geographic block does not represent continuous habitat. Within the boundaries are large areas from which there are no records of the small Canada goose. This distribution clearly suggests a degree of habitat specificity, as it should if the concept of habitat is to be meaningful in an evolutionary context.

The search for a common denominator which will explain the observed distribution of the small Canada geese can be expected to transcend a recognition and discussion of plant species per se. As discussed in the section on migration routes and wintering areas, small Canada geese of the south central United States show a decided association with those areas offering a high degree of visibility, and a vegetation type perhaps best characterized by the winter wheat pastures. Comparison of observations of major goose congregation areas in the north-central United States and the photographs of areas known to be used by migrating geese in Manitoba given by Scoggan (1957) shows that this same relationship exists. From the standpoint of natural vegetation, these areas of use cannot be properly referred to as either short-grass or tall-grass prairie. In a physiognomic sense their closest counterpart would appear to be the arctic tundra, also characterized as the "barren" (Porsild, 1935), "meadows" (Porsild, 1955) and "subarctic prairies" (Raup, 1941). Ritchie (1959) mentioned the occurrence of "meadows" and sedge-grass meadows", penetrating the subarctic forest (taigia of Polunin, 1955) of northern Manitoba. The detailed survey of Arctic flora by Polunin (1947) showed the importance of grasses in the tundra regions and gleanings from the reports of other Arctic workers such as Sutton (1932), Gavin (1947), Hanson, Queneau, and Scott (1956) and Soper (1940, 1946) suggest association of small Canada geese with the areas in the tundra in which the grasses or grass-like forms are a dominant feature of the vegetation. From this literature it can be inferred that the areas of goose use in the Arctic have an overall aspect, both physiographically and physiognomically, that is markedly similar to the areas in which small Canada geese are found in the central United States. If the inference has validity then it seems probable that the distribution of the small Canada geese is largely a matter of association with a given life-form. Further, and the point may be academic, I would prefer to characterize this association as the Barren Ground life-form, not emphasizing the climate because this varies tremendously within the total area of goose habitat, but rather emphasizing the high degree of visibility and the sparseness of vegetation which appear to be common demoninators regardless of the climatic region in which the birds are found.

Migration Movements of the Small White-cheeked Geese in the Central United States.

The migration of small Canada geese in the central United States has been discussed in the section on migration routes and wintering areas. It is perhaps most important here to reiterate that small Canada geese migrate south from the Arctic breeding grounds via two relatively distinct routes. These routes, because of their spatial relationship to two major vegetative associations, have been designated the tall-grass prairie route and the short-grass prairie route. Present data suggest that the small Canada geese indigenous to the two routes are nearly discrete segments of the <u>Branta canadensis</u> complex and other than the possibility of slight mingling in the Victoria Island-Queen Maud Gulf area there is no overlapping of their ranges except on their wintering grounds on the Waggoner Ranch near Vernon, Texas.

Available weather and census records are not sufficient in quantity or of the critical nature necessary to evaluate the effect of weather on migration. There are supporting data to suggest that during years of drought in the southern Great Plains the migration route of the small Canada geese in the tall-grass prairie may be shifted to the east well into the Missouri River Valley as far south as Missouri. There is also the possibility that many of the migrating flocks bypass or move quickly through areas in which they normally congregate because of reduced habitat resulting from drought conditions.

Population Status of the Small White-cheeked Geese in the Central United States.

To the extent that past and present census records are usable, the findings of this study indicate that the population of small Canada geese migrating and wintering in the tall-grass prairie is as large or larger than it has ever been since census records have been maintained. Apparent fluctuation in total population numbers appears to be primarily related to changes in weather with a subsequent effect on small Canada goose habitat. Reports concerning population numbers received from cooperators in the short-grass prairie indicated that the small Canada geese of that route are in a no less favorable position. The total of small Canada geese wintering in the south central United States following the gunning season is estimated to approach 170,000 birds. Of this residual wintering population it is believed that approximately 55 per cent are birds of the tall-grass prairie.

The hunter kill data on small Canada geese migrating through central North America are extremely gross and cannot be readily subjected to analysis. The figures presented suggest a rather high mortality from hunting, 44.0 per cent in the tall-grass prairie and 60.6 per cent in the short-grass prairie. To support this hunting pressure and still provide the residual wintering population calculated for the south central United States for the period of this study would require a population leaving the north via the short-grass route in excess of 193,000 birds and for the tall-grass prairie route, a population in excess of 165,000 birds. If these figures are valid, then these two segments of the *Branta canadensis* complex appear to be in a relatively secure position with a gene pool, possibly a common one, of sufficient size to provide the requisite variability for continued adaptation to a constantly changing environment.

CHAPTER VII

MANAGEMENT IMPLICATIONS

The management or judicious use of any species must always be tempered by the realization that our ability to ascertain a truth, a fact, may be limited by the spatio-temporal relationship within which we function. It may also be possible that the truths upon which management is to be structured are transitory, in a temporal or in a spatial sense, even as the identity of a species is transitory in an evolutionary sense. No management program for an evolving resource, therefore, can be considered final. It must include a continuous evaluation of species relationships - their ecology.

Species management generally is the ultimate goal of present day wildlife researchers and managers. If this goal is to be realized, it is axiomatic that the species must be known. Systematics is the vital first step in the management of a species, therefore, for this is the means of establishing the identity of a species, not just as a generalized whole, but through the entire range of its variability. This study does little to clarify the taxonomic complexities of *Branta canadensis*, but, perhaps more importantly, it does emphasize how meager is our knowledge concerning the relationships existing among the segments of this species.

From a management standpoint, identity of Canada geese in the Central Flyway appears to be limited presently to a recognizable division of the species into two catagories which can be designated large Canada geese and small Canada geese. Observations in the southern migration and wintering areas clearly indicate that habitat requirements for these two groups differ considerably. Also, from what is known of distribution of the two groups in the north, it would appear that differences exist in habitat requirements in the breeding areas. Small Canada geese seem to prefer feeding, resting, and roosting areas which offer a high degree of visibility. The minimum field size acceptable to birds of this group is not known. Possibly it varies with flock size, familiarity with an area, availability of food, and height and density of vegetation bordering a field. Small Canada geese were regularly observed in fields exceeding 100 acres in area and seldom seen in fields of less than fifty acres. Efficient use of refuge lands would surely be enhanced by a critical study designed to establish minimum limits of field size required by both large and small Canada geese.

Also related to area use by Canada geese was the availability and dispersal of fresh water. Shallow ponds located within the feed fields received almost constant use by small Canada geese during daylight hours. Often these ponds were intermittant, the result of precipitation runoff filling slight depressions in a field, and were available less than one week. During this short period of availability, their use by geese was often so intense that all vegetation in a twenty or thirty foot perimeter was completely destroyed. When these shallow ponds were available, it appeared that some of the small Canada geese did not return to a more distant lake for the mid-afternoon watering and resting periods.

During this study, both large and small Canada geese were observed always to roost on water. Usually, the small Canada geese were found on the open waters of large lake or bay areas offering a high degree of visibility. Conversely, the large Canada geese were often found on small ponds which, because of brush and tree growth on the borders, offered only limited visibility. Exceptions to these general observations occurred at the Waggoner Ranch, where small Canada geese were observed to roost on relatively small ponds of twenty acres or less. However, in this latter situation a lack of bordering vegetation allowed a high degree of visibility.

Small Canada geese appeared to prefer short, succlent, vegetation. Over most of the southern portion of their migration, this type of vegetation is provided principally by cultivated green winter grains. In one instance, however, a heavily grazed Bermuda grass pasture was the preferred feeding area for nearly all of the flocks of geese on the Laguna Atascosa National Wildlife Refuge. If permanent grass pastures can be included in a management plan for geese, the savings obtained by curtailment of an annual farming program are obvious. It is important that the pasture vegetation be short at the time migrating geese arrive. Small Canada geese were not observed on any ungrazed or lightly grazed pastures. It is probable that ungrazed pastures are unattractive to these small geese not only because of the modest amount of palatable food available, but also because the vegetation limits their visibility and offers an impediment to facile movement.

Our knowledge of the breeding habitat of the small Canada geese is limited, but it seems significant that the areas most used by small Canada geese in the southern migration and wintering areas are those which most closely resemble portions of the Arctic tundra. This should not be construed to mean that the habitat components are alike in a taxonomic sense, but rather that they are alike in a physiognomic sense, that is, in their life-form characteristics. One approach to the management of small Canada geese in the Central Flyway, therefore, might be the creation of a tundra grasslands life-form on a number of refuges throughout the southern migration and wintering areas.

This study has presented broadly the migration routes of small Canada geese in the central United States. It is clearly shown that there are two major routes, namely, one in tall-grass prairie and the other in short-grass prairie. For the most part, the two routes are used by separate populations. The habitat requirements for these two populations appear to be similar, and it may be that a common habitat development plan would suffice for both. This is an area of interest where further study is definitely indicated. On the other hand, their geographic distinctness dictates that each population must be considered separately insofar as harvest regulations are concerned. At present, most hunting mortality occurs in a relatively few areas. It is possible that the development of additional areas of suitable habitat in the Central Flyway would distribute this kill over a broader area and could, therefore, provide better regulation of the annual harvest.

SUMMARY

This study was initiated in 1957 as a result of the concern by the United States Fish and Wildlife Service and certain state agencies for an apparent decline in population numbers of small Canada geese censused during the fall migration at two important wildlife refuges in the Central Flyway.

The purpose of the study was to determine the present status and trend of the migrating and wintering population of small white-cheeked geese in the south central United States; to determine the major routes traveled in migration; and to investigate the kinds and extent of attrition among the small white-cheeked geese during their residence in the south central United States. Basic to the study was clarification of the species description and an analysis of its relationship to the variation in the species complex observed in the study area.

Field study was conducted primarily in Oklahoma and Texas from the fall of 1957 through the spring of 1960. Visits were also made to other areas in the Central Flyway having a history of use by Canada geese, and to museums having collections of Canada geese.

The results of the study are summarized as follows:

1. Among the recognized subspecies only B. c. minima can be differentiated from all other subspecies by criteria presently used. All other considered subspecies of the Branta canadensis complex show an overlap of measurements which would suggest a lack of subspecific identity. Of the five criteria most used; culmen length, tail length, wing chord, tarsus length, and middle toe length, the measurement of

the culmen appears to provide the best index for separating the species complex. The measurement of the tail is least useful for this purpose. A small amount of data suggest that measurement of the maxilla (chord of the tomium) may be a more reliable measurement for defining subspecific units and at the same time provide a more stable criterion for comparison of measurements of birds in the field and museum specimens.

2. It is shown that use of a maxilla height: culmen length ratio will satisfactorily differentiate between large Canada geese and small Canada geese except for a group found in migration in the short-grass prairie route. This group is considered by some authorities to be *B. c. parvipes*, but data presented suggest that *B. c. parvipes* is indigenous to the tall-grass prairie route and there is little liklihood that the two forms are members of the same race.

3. Data are presented suggesting a clinal increase in the size of small Canada geese from Alaska east to the Queen Maud Gulf along the Arctic coast and conversely a clinal increase in the size of small Canada geese from Baffin Island west to the Queen Maud Gulf.

4. Although variation in size and color in the small Canada geese is extreme it was found that about 80 to 85 per cent of the birds handled could be separated into eight categories. The relationship between these categories and recognized subspecies is discussed and their distribution in the south central United States is given.

5. Small Canada geese migrate through the central North American continent via two relatively discrete routes, the tall-grass prairie route and the short-grass prairie route. The extent of these routes is discussed

as well as the ecologic relationships which determine the distribution of geese within the boundaries of a route. The major features common to both routes were water, topography offering a high degree of visibility, and short, succulent vegetation. The effect of molestation, resulting from hunting pressure, on distribution is also discussed. Band return data show that the majority of band returns come from a relatively few areas and a series of charts and tables for the states contributing the major amount of small Canada goose kill are given.

6. Within the south central United States there is one area where small Canada geese from the two major migration routes co-mingle. An estimate of the proportions of small Canada geese from each of the routes involved in this area of co-mingling is given.

7. The number of small Canada geese censused at various areas within the south central United States appeared to be correlated with major weather changes. In general, the numbers declined during periods of drought and increased during years of abundant moisture. A small amount of data suggested that much of the prairie population of small Canada geese may shift eastward into the Mississippi Flyway during extended periods of drought and also that if drought conditions extended to the Texas Coast larger than normal numbers of small Canada geese wintered along the Coast of Mexico.

8. Generally, small Canada geese were the first arrivals on refuges within the south central United States. The pattern of first arrivals, the first major influx, and the peak migration period for stations in the south central United States showed little correlation

with recorded weather patterns. Drought periods and periods of abundant moisture appeared to have little effect on first arrival dates or periods of greatest influx. However, drought and abundant moisture, as expressed in habitat differences, had marked effects on the population build-up on a given refuge.

9. During the period of this study the numbers of small Canada geese in the tall-grass prairie route appeared to remain relatively stable. Reports from the short-grass prairie route indicated the numbers of geese might be increasing slightly. Using the 1959-1960 season as a comparative base it was estimated that there were about 168,596 small Canada geese wintering in the south central United States, 92,456 in the tall-grass prairie route and 76,140 in the short-grass prairie route. Based on calculations the total kill of small Canada geese in the Central United States and Canada was approximately 189,682, 72,566 in the tall-grass prairie route and 117,116 in the short-grass prairie route. To maintain stability would require an annual increment of 60.6 per cent in the short-grass prairie, 44.0 per cent in the tall-grass prairie, and 52.9 per cent in the Central Flyway as a whole.

10. Age ratio data obtained from hunter-kill sources appeared to be biased in favor of large numbers of immature birds. Data obtained from trapping may be biased in favor of either age class depending on circumstances involved in the trapping effort. A technique whereby age classes were differentiated by field observation appeared to offer the best solution for obtaining unbiased samples.

11. Observations in this study indicated that sources of attrition other than hunting were insignificant insofar as losses to the population of small white-cheeked geese of the south central United States during the migration and wintering periods were concerned.

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APPENDIX

APPENDIX I - 1

Approximate locations of recoveries from geese banded at Sand Lake National Wildlife Refuge, Columbia, South Dakota. Recoveries are from the years 1951-1959, inclusive.


BAFFIN IS.
SOUTHAMPTON IS.
GREAT BEAR LAKE
GREAT SLAVE LAKE
LAKE ATHABASKA
WOLLASTON LAKE
REINDEER LAKE
LAKE WINNIPEG
LAKE WINNIPEGOSIS
LAKE MANITOBA
LAKE OF THE WOODS
LAKE SUPERIOR
LAKE MICHIGAN
LAKE ERIE

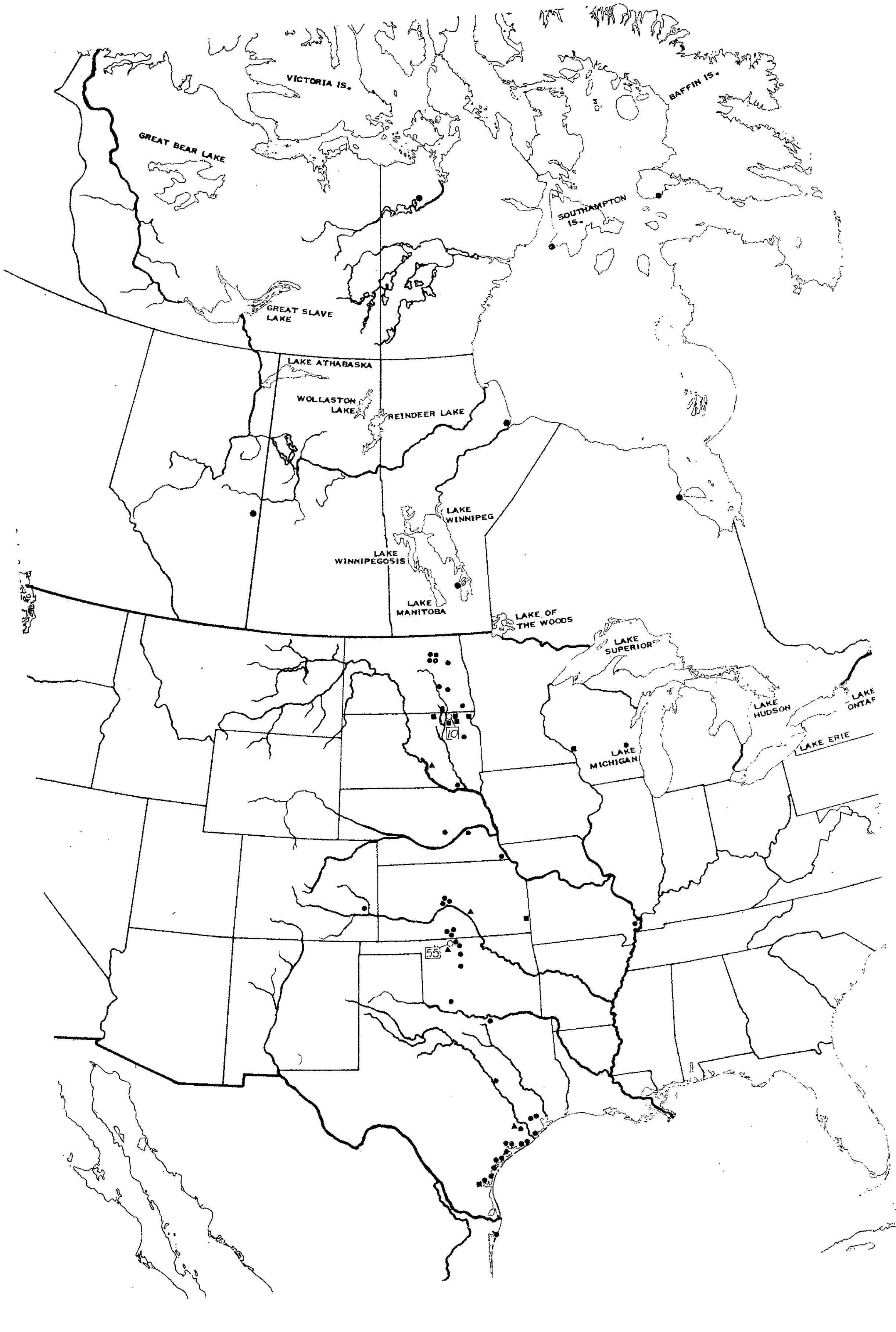
APPENDIX I - 2

Approximate locations of recoveries from geese banded at Salt Plains, Tishomingo, and Aransas National Wildlife Refuges which are located at Jet, Oklahoma, Tishomingo, Oklahoma, and Austwell, Texas, respectively. Recoveries are from the years 1957-1960, inclusive.

● Salt Plains N.W.R.

▲ Tishomingo N.W.R.

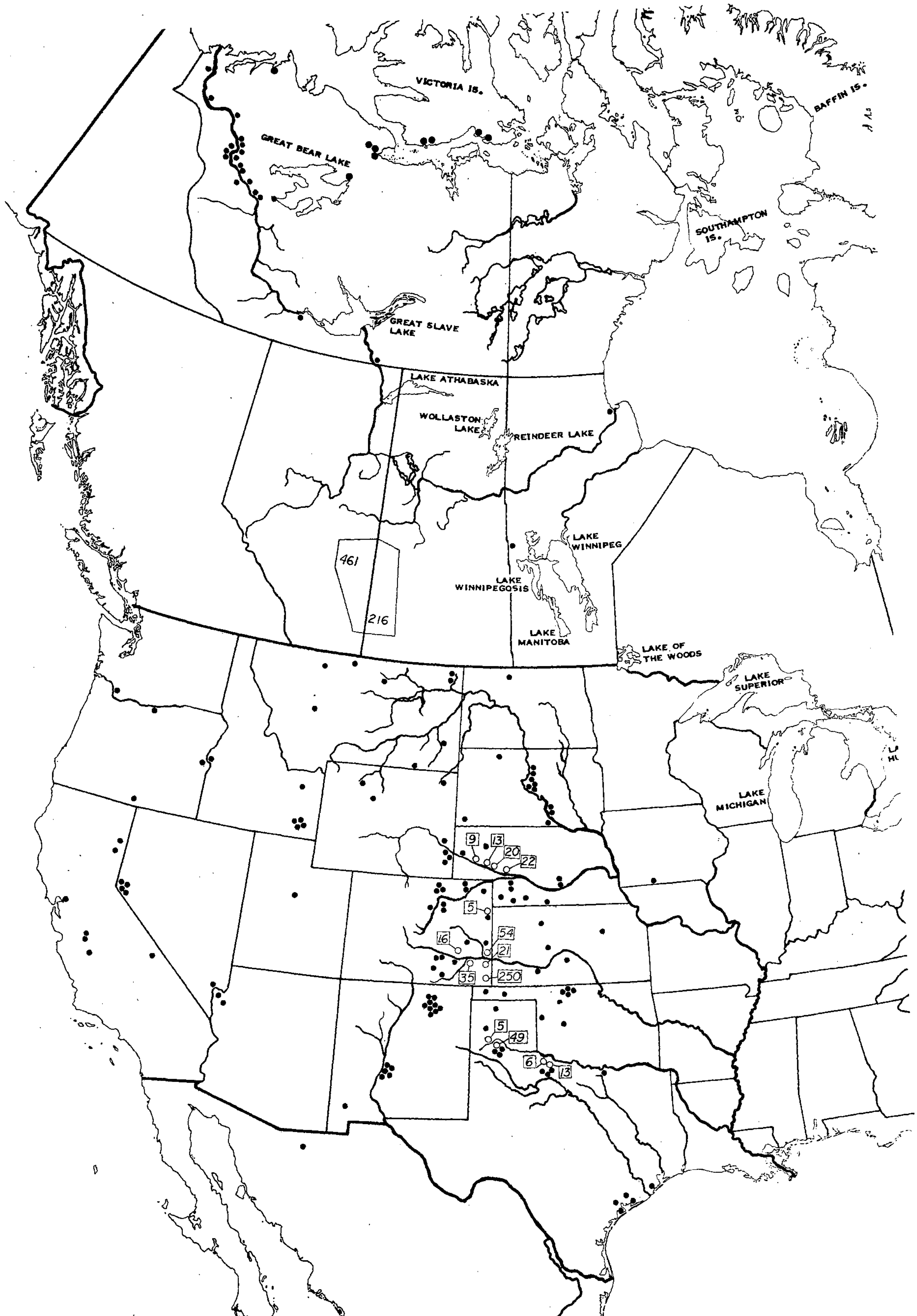
■ Aransas N.W.R.



VICTORIA IS.
BAFFIN IS.
GREAT BEAR LAKE
SOUTHAMPTON IS.
GREAT SLAVE LAKE
LAKE ATHABASKA
WOLLASTON LAKE
REINDEER LAKE
LAKE WINNIPEG
LAKE WINNIPEGOSIS
LAKE MANITOBA
LAKE OF THE WOODS
LAKE SUPERIOR
LAKE HUDSON
LAKE MICHIGAN
LAKE ERIE
10
55

APPENDIX I - 3

Approximate locations of recoveries from geese banded at Two Buttes State Game Refuge, Springfield, Colorado. Recoveries are from the years 1951-1959, inclusive.


VICTORIA IS.
BAFFIN IS.
GREAT BEAR LAKE
SOUTHAMPTON IS.
GREAT SLAVE LAKE
LAKE ATHABASKA
WOLLASTON LAKE
REINDEER LAKE
461
LAKE WINNIPEG
LAKE WINNIPEGOSIS
216
LAKE MANITOBA
LAKE OF THE WOODS
LAKE SUPERIOR
LAKE MICHIGAN
9
13
20
22
5
54
16
21
35
250
5
49
6
13

APPENDIX I - 4

Approximate locations of recoveries from geese banded at the Waggoner Ranch, Vernon, Texas. Recoveries are from the years 1955-1959, inclusive.


VICTORIA IS.
BAFFIN
GREAT BEAR LAKE
SOUTHAMPTON IS.
GREAT SLAVE LAKE
LAKE ATHABASKA
WOLLASTON LAKE
REINDEER LAKE
LAKE WINNIPEG
LAKE WINNIPEGOSIS
LAKE MANITOBA
LAKE OF THE WOODS
LAKE SUPERIOR
LAKE MICHIGAN
LAK HUR
5
5
7
5
8
7

APPENDIX II - 1

Weekly Census Results for Canada Geese From Five Refuges in the Southern Tall-grass Prairie, 1953.

	Oklahoma		Texas			
Report Period	Salt Plains	Tishomingo	Hagerman	Aransas	Laguna Atascosa	Total Number
9/22-28			75			75
9/29-10/5	26	112	100			238
10/6-12	2,500	2,600	600	216	68	5,984
10/13-19	6,000	4,550	1,500	304	280	12,634
10/20-26	7,100	6,500	2,000	268	500	16,368
10/27-11/2	9,000	6,500	3,000	1,483	60	20,043
11/3-9	10,000	7,500	4,000	1,261	550	23,311
11/10-16	11,000	9,000	6,000	3,336	600	29,936
11/17-23	14,800	16,500	6,000	1,871	500	39,671
11/24-30	15,000	10,500	8,000	5,880	500	39,880
12/1-7	14,500	14,300	10,000	6,564	5,000	45,864
12/8-14	12,000	8,000	11,000		1,000	
12/15-21	10,000	5,000	12,000	6,589	230	33,819
12/22-28	6,100	2,000	14,000		250	
12/29-31	6,000	370	15,000	1,700	161	23,231

APPENDIX II - 2

Weekly Census Results for Canada Geese From Five Refuges in the Southern Tall-grass Prairie, 1954.

	Oklahoma		Texas			
Report Period	Salt Plains	Tishomingo	Hagerman	Aransas	Laguna Atascosa	Total Number
9/29-10/5	15					15
10/6-12	900	80	60			1,040
10/13-19	3,000	1,080	600	103	78	4,861
10/20-26	4,800	3,500	1,000		1,000	
10/27-11/2	5,500	7,320	3,000	2,157	500	18,477
11/3-9	6,000	17,000	5,000	4,701	500	33,201
11/10-16	6,000	20,000	6,000		500	
11/17-23	6,500	16,000	10,000	6,021	5,000	39,021
11/24-30	7,000	9,500	15,000		550	
12/1-7	7,000	10,000	15,000		1,000	
12/8-14	7,000	6,000	20,000	6,848	1,000	40,848
12/15-21	7,000	5,000	20,000		1,800	
12/22-28	5,000	1,200	20,000		1,800	
12/29-31	3,000	1,200	20,000	8,731	2,571	35,502

APPENDIX II - 3

Weekly Census Results for Canada Geese From Five Refuges in the Southern Tall-grass Prairie, 1955.

	Oklahoma		Texas			
Report Period	Salt Plains	Tishomingo	Hagerman	Aransas	Laguna Atascosa	Total Number
9/29-10/5	180	193				373
10/6-12	1,600	850	500	690	39	3,679
10/13-19	3,000	1,650	2,500	378	50	7,578
10/20-26	5,000	24,000	3,000	840	200	33,040
10/27-11/2	8,000	20,000	5,000	1,451	500	34,951
11/3-9	8,000	20,000	5,500	12,420	700	46,620
11/10-16	8,100	32,500	6,000	10,888	700	58,188
11/17-23	8,000	32,500	6,000	11,816	1,000	59,316
11/24-30	8,500	2,000	5,000	15,000	1,000	31,500
12/1-7	8,500	2,000	4,000	11,507	2,500	28,507
12/8-14	8,500	1,250	1,000	11,428	2,800	24,978
12/15-21	9,500	1,800	400	12,834	3,500	28,034
12/22-28	10,000	750	500	11,946	4,000	27,196
12/29-31	9,500	1,200	400	14,860	4,000	29,960

APPENDIX II - 4

Weekly Census Results for Canada Geese From Five Refuges in the Southern Tall-grass Prairie, 1956.

	Oklahoma		Texas			
Report Period	Salt Plains	Tishomingo	Hagerman	Aransas	Laguna Atascosa	Total Number
9/22-28	12					12
9/29-10/5	213	51	35			299
10/6-12	500	800	100	150		1,550
10/13-19	4,500	1,580	2,500	500	56	9,136
10/20-26	4,160	5,500	5,000	2,500	150	17,310
10/27-11/2	6,000	4,000	4,000	5,000	200	19,200
11/3-9	4,500	5,300	3,500	5,000	1,000	19,300
11/10-16	5,500	5,500	4,500	6,000	3,300	24,800
11/17-23	6,000	12,500	4,000	7,500	3,400	33,400
11/24-30	6,000	9,280	6,000	10,000	3,400	34,680
12/1-7	5,100	4,100	6,000	10,600	3,500	29,300
12/8-14	6,000	3,150	5,500	12,800	3,000	30,450
12/15-21	4,000	3,000	7,200	14,000	2,500	30,700
12/22-28	3,000	2,500	7,200	14,000	2,000	28,700
12/29-31	3,000	2,500	7,200	14,000	1,346	28,046

APPENDIX II - 5

Weekly Census Results for Canada Geese From Five Refuges in the Southern Tall-grass Prairie, 1957.

	Oklahoma		Texas			
Report Period	Salt Plains	Tishomingo	Hagerman	Aransas	Laguna Atascosa	Total Number
9/29-10/5	250	400	300	4		954
10/6-12	1,100	800	2,100	230	13	4,243
10/13-19	5,500	1,200	2,800	550	729	10,779
10/20-26	20,000	4,811	3,000	3,550	3,000	34,361
10/27-11/2	30,000	6,000	5,800	7,000	2,900	51,700
11/3-9	22,000	10,470	6,000	7,000	3,561	49,031
11/10-16	22,000	15,000	6,000	20,000	120	63,120
11/17-23	9,000	12,650	7,000	17,000	3,000	48,650
11/24-30	7,500	5,300	7,500	12,500	3,000	35,800
12/1-7	7,500	9,235	7,500	18,500	3,025	45,760
12/8-14	8,000	9,125	7,500	20,000	4,000	48,625
12/15-21	7,700	7,650	8,000	18,000	4,050	45,400
12/22-28	8,550	7,500	8,000	16,000	5,150	45,200
12/29-31	8,750	5,000	8,000	10,000	5,000	36,750

APPENDIX II - 6

Weekly Census Results for Canada Geese From Five Refuges in the Southern Tall-grass Prairie, 1958.

	Oklahoma		Texas			
Report Period	Salt Plains	Tishomingo	Hagerman	Aransas	Laguna Atascosa	Total Number
9/29-10/5	500	38	319			857
10/6-12	2,500	1,665	75	250	26	4,516
10/13-19	7,500	4,300	1,500	7,500	500	21,300
10/20-26	8,800	10,750	1,500	7,500	1,500	30,050
10/27-11/2	12,000	13,800	2,500	7,500	500	36,300
11/3-9	20,000	7,300	8,000	7,500	1,200	44,000
11/10-16	12,000	13,000	10,000	7,500	1,500	44,000
11/17-23	30,000	5,000	12,200	7,500	1,000	55,700
11/24-30	30,000	2,650	13,000	7,500	1,000	54,150
12/1-7	20,000	3,010	15,000	12,000	1,200	51,210
12/8-14	18,000	1,558	30,000	15,000	1,334	65,892
12/15-21	11,000	1,739	30,000	17,500	447	60,686
12/22-28	7,000	1,393	15,000	5,000	1,305	29,698
12/29-31	1,000	1,000	10,000	5,000	1,694	18,694

APPENDIX II - 7

Weekly Census Results for Canada Geese From Five Refuges in the Southern Tall-grass Prairie, 1959.

	Oklahoma		Texas			
Report Period	Salt Plains	Tishomingo	Hagerman	Aransas	Laguna Atascosa	Total Number
9/22-28			89			89
9/29-10/5		57	250	15		322
10/6-12	2,000	670	600	706	8	3,984
10/13-19	12,150	2,000	1,000	1,065	1,337	17,552
10/20-26	14,150	6,000	4,000	1,775	714	26,639
10/27-11/2	12,150	6,200	5,000	1,621	5,222	30,193
11/3-9	13,200	9,000	6,000	7,156	6,195	41,551
11/10-16	16,200	15,000	8,000	7,828	3,765	50,793
11/17-23	14,300	9,000	9,000	4,358	4,888	41,546
11/24-30	7,300	12,000	9,000	2,530	5,133	35,963
11/1-7	7,450	12,000	15,000	2,530	6,035	43,015
12/8-14	7,500	12,780	30,000	3,035	2,863	56,178
12/15-21	8,100	10,000	30,000	3,000	2,055	53,155
12/22-28	7,000	525	30,000	3,500	2,606	43,631
12/29-31	6,100	525	1,500	2,910	1,549	12,584

VITA

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Candidate for the Degree of

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