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A study of the dusky Canada goose (Branta canadensis occidentalis) in the Willamette Valley, Oregon, was conducted between 1964 and 1967.[1] During the three year study sex and age data were collected from approximately 5,000 geese. More than 95 percent of the geese examined were dusky Canada geese. A large portion of this subspecies wintering in Oregon do so on the Oak Knoll Complex, a group of hunt clubs located about 7 miles east of Corvallis, Oregon. Large numbers of these geese left the "complex" earlier in each succeeding year of the study and moved to the William L. Finley National Wildlife Refuge which was established in 1964. Hunters at the Oak Knoll Hunt Club (largest club in the "complex") killed an average of

[1]This study was supported by the Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, and the Oregon Agricultural Experiment Station, Corvallis.

more than two geese per hunter per day, while Henny (1967) found that in the remainder of the Willamette Valley hunters killed an average of less than one goose per year. Of the 4,000 to 5,000 dusky Canada geese killed annually in the Willamette Valley, between 50 and 67 percent were taken on the Oak Knoll Complex. Immatures made up a disproportionately high percentage of the kill on the "complex" in all three years of the study. In the remainder of the Willamette Valley, immatures and adults were killed in nearly equal numbers. The peak of the kill of immatures occurred early in the hunting season and the peak of the adult kill occurred late in the hunting season on the Oak Knoll Complex. There appeared to be little correlation between numbers of geese present and goose kill on the "complex," however, in the remainder of the study area the reverse appeared to be true. More adult males than females were killed in all three years of the study. In 1964 and 1965 fewer subadult males than females were killed, but in 1966 subadult males and females were killed in nearly equal numbers. Immature males and females were killed in nearly equal numbers except in 1965 when more males than females were killed. The Oregon pre-season population was between 18,000 and 23,000 geese. The sex and age composition of the Oregon pre-season population was calculated using a relative recovery rate and data collected on the Oak Knoll Complex. The primary breeding ground of the dusky Canada goose

is the Copper River delta of Alaska and in 1964 a severe earthquake raised the delta approximately six feet. It appeared that the earthquake and other factors were responsible for very poor production of young in 1964. The percentage of immatures in the population increased in each year of the study. The percentage of adults in the population was stable in 1964 and 1965, but in 1966 a decline in their number was noted. The percentage of subadults in the population in 1965 and 1966 was lower than in 1964. The population was composed of nearly 50 percent immatures in 1966 indicating that the population may be undergoing excessive mortality. Productivity was low in 1964, but near its maximum in 1965 and 1966. A theoretical maximum and minimum productivity were applied to the 1966 pre-season population and it was found that the population may decrease even though the population is maintaining the theoretical maximum productivity. It appears that some form of hunting restrictions are necessary to prevent a decline in the population. The possible methods of reducing the mortality of dusky Canada geese are discussed.

POPULATION CHARACTERISTICS, HUNTER KILL, AND PRODUCTIVITY OF DUSKY CANADA GEESE

by

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POPULATION CHARACTERISTICS, HUNTER KILL, AND PRODUCTIVITY OF DUSKY CANADA GEESE

INTRODUCTION

The dusky Canada goose (Branta canadensis occidentalis) is the most common goose wintering in the central Willamette Valley, Oregon, accounting for approximately 95 percent of the geese killed in Benton, Linn and Polk counties. The population is smaller than that of most other races of Canada geese. It numbers between 18,000 and 23,000 geese upon arrival in the Willamette Valley. This goose population provides a unique opportunity for research because of its well defined breeding ground, migration route, and wintering ground.

A hunt club, near Corvallis, provided an opportunity to examine large numbers of geese. Daily hunter bag checks on this club were a primary source of data. Other well defined harvest areas of the dusky Canada goose made it possible to conduct additional hunter bag checks whenever time permitted.

In 1964 a refuge program primarily designed to benefit the dusky Canada goose was inaugurated by the Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service. The development of the refuge made it possible to study the effects of a newly formed refuge system on this population of geese.

In 1964 a study of the dusky Canada goose was initiated by the Department of Fisheries and Wildlife at Oregon State University. The purpose of this study was to determine the status and condition of the dusky Canada goose population wintering in the Willamette Valley. The study was continued during the 1965-66 and 1966-67 hunting seasons as a cooperative study with the Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service.

The primary objectives of this study were to obtain estimates of the following:

1. The sex and age composition of dusky Canada geese killed by hunters in the Willamette Valley.
2. The sex and age composition of the dusky Canada goose population.
3. The number of geese killed by sex and age class in relation to time and area of harvest.
4. The size of the population wintering in the Willamette Valley.
5. The productivity of this goose flock.

The dusky Canada goose has not been studied as extensively as many of the other races of Canada geese. The most complete paper concerning this goose (Hansen 1962), outlined distribution, migration, reproduction, population size, and mortality. Hansen (1962) pointed out that the primary breeding ground of the dusky Canada goose is the Copper River delta of Alaska. These geese complete

breeding activities and begin to leave the breeding ground by late September. By early October they begin to arrive at Queen Charlotte and Vancouver Islands, their first stopping point. Their migration route completely bypasses the Alaska mainland. It was estimated that about 2,000 of these geese spent the winter on these islands and along the coast of Washington. However, the majority migrate into the Willamette Valley, Oregon,and spend the winter in Benton, Linn and Polk counties. An estimated 1,500 dusky Canada geese spend the winter on Prince William Sound, Alaska, and are believed to be relatively non-migratory (Hansen 1962). He further stated that these 1,500 geese, and the 2,000 which winter along the coast of Washington and British Columbia, together with the birds which winter in the Willamette Valley, comprise a flock numbering between 10,000 and 20,000.

In an earlier paper Hansen (1961) discussed tidal floodings on the Copper River delta and its effect on the dusky Canada goose nest success. Studies on the breeding ground were conducted by Peter E. K. Shepherd (1965, 1966a, 1966b) and Charles Trainer (1959); some of their unpublished data were made available in the form of personal communications to the author.

Dusky Canada goose banding operations were conducted on the breeding ground from 1952 to 1963. During this period about 400 of these geese were banded annually. Banding operations were resumed

in 1965 and 1966 at the request of the Department of Fisheries and Wildlife at Oregon State University.

THE STUDY AREA

This study was concerned primarily with that segment of the dusky Canada goose population which spends the winter in the central Willamette Valley, Oregon. The study area extended from McMinnville south to Eugene, a distance of approximately 100 miles. Most of the data were gathered within ten miles of Corvallis. Some data were also collected in the Sauvie's Island area north of Portland.

The study area was divided into five units (Figure 1). A description of each of these is presented in the following sections.

The Oak Knoll Complex

The Oak Knoll Complex, located five miles east of Corvallis, Oregon, on U.S. Highway 34, was composed of the Fly-way Duck Club, more commonly known as Glaser's Duck Club, the Oak Knoll Farm, and the Ludlow Hunt Club (Figures 2,3).

The Fly-way Duck Club was formed in 1955, but it was not until 1959 that large numbers of dusky Canada geese began to use the club property. Eventually the majority of the Willamette Valley dusky Canada goose flock spent the winter on the Oak Knoll Complex (Long 1967).

In the spring of 1965 the Fly-way Duck Club was disbanded. The following summer the club was leased by the owners of the Oak

Knoll Farm, with the exception of about ten acres of land formerly leased on the extreme eastern edge of the club. These ten acres were operated as the Ludlow Hunt Club. The Fly-way Duck Club and the Oak Knoll Farm were combined into what became the larger Oak Knoll Hunt Club, encompassing approximately 1,600 acres. The Oak Knoll Hunt Club together with the Ludlow Hunt Club made up the Oak Knoll Complex (Figures 2,3).

The Oak Knoll Fringe Unit

There were two hunt clubs bordering the Oak Knoll Complex. The Sullivan Hunt Club on the west, and the Dourfler Hunt Club on the south (Figure 2). These clubs were not included in the "Complex" because there hunting methods differed from those of the Oak Knoll Complex.

The South Corvallis Unit

A few geese were killed in an area south of Corvallis in Benton County. This area included the William L. Finley National Wildlife Refuge established in 1964, on which no waterfowl hunting was permitted, and the McFadden Hunt Club, a large natural marsh. Since the development of the 5,000 acre William L. Finley National Wildlife Refuge, the wintering population of dusky Canada geese in the South Corvallis Unit increased in each succeeding year of the study.

The South Corvallis Unit was approximately 40 miles long and 15 miles wide, extending from Corvallis to Eugene. About 500 geese spend the winter at the Fern Ridge Reservoir near Eugene. Few dusky Canada geese winter further south than Fern Ridge Reservoir (Figure 1).

The Rickreall-McMinnville Unit

The Rickreall-McMinnville Unit extended from Corvallis north to McMinnville, a distance of approximately 60 miles, and included parts of Benton, Polk, Linn, Marion and Yamhill Counties. The majority of the geese killed in this unit were taken in the vicinity of the Baskett Slough Refuge near Rickreall. This refuge is a satellite of the William L. Finley National Wildlife Refuge (Figure 1).

The Sauvie's Island Unit

This unit included Sauvie's Island, the Portland vicinity and the Columbia River from Portland to Astoria. There was a substantial number of geese killed in this unit, but less than 50 percent of them were dusky Canada geese. Data from Sauvie's Island are presented only when pertinent to this study (Figure 1).

Management of Hunt Clubs in the Study Area

The management of the Oak Knoll Hunt Club was similar to

that of many refuges. Hunting was developed around a refuge area of approximately 150 acres planted to rye grass (Lolium sp.). Geese were never hunted in the refuge portion of the hunt club. The refuge area was surrounded by several areas of flooded corn (Zea mays), in which geese were hunted. The hunters were allowed to shoot from 7:30 a.m. to 12 noon daily. The three major hunting areas on the Oak Knoll Hunt Club were hunted successively. During the last week of the season hunters were allowed to shoot all day. The geese used the hunting area for feeding, watering and loafing during the afternoon and night. The geese were flushed from the hunting areas early in the morning, whereupon they moved to the refuge area. The majority of the flock usually remained there until the afternoon. Small bunches of geese returned to the shooting areas during the morning to feed and water. The geese on the refuge area did not appear to be disturbed by the hunting activity only 200-300 yards away. If large numbers of geese moved to the hunting area during shooting hours they were permitted to return to the refuge area without being shot. Three watchmen patrolled the club lands 24 hours a day to keep poaching at a minimum.

A situation similar to that on the Oak Knoll Complex was reported by Hanson and Smith (1950). They stated that:

> Although the Canada goose possesses mental powers that at times seem to be superior to those of most birds, and that are undoubtedly of great survival

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

Most of the shooting throughout the remainder of the study area was either "pass shooting" or "Decoy and Blind" shooting. Most of the "Decoy and Blind" type of hunting was done in rye grass or ploughed fields. None of the hunt clubs in the remainder of the study area had the large scale "refuge-type" management of the Oak Knoll Complex.

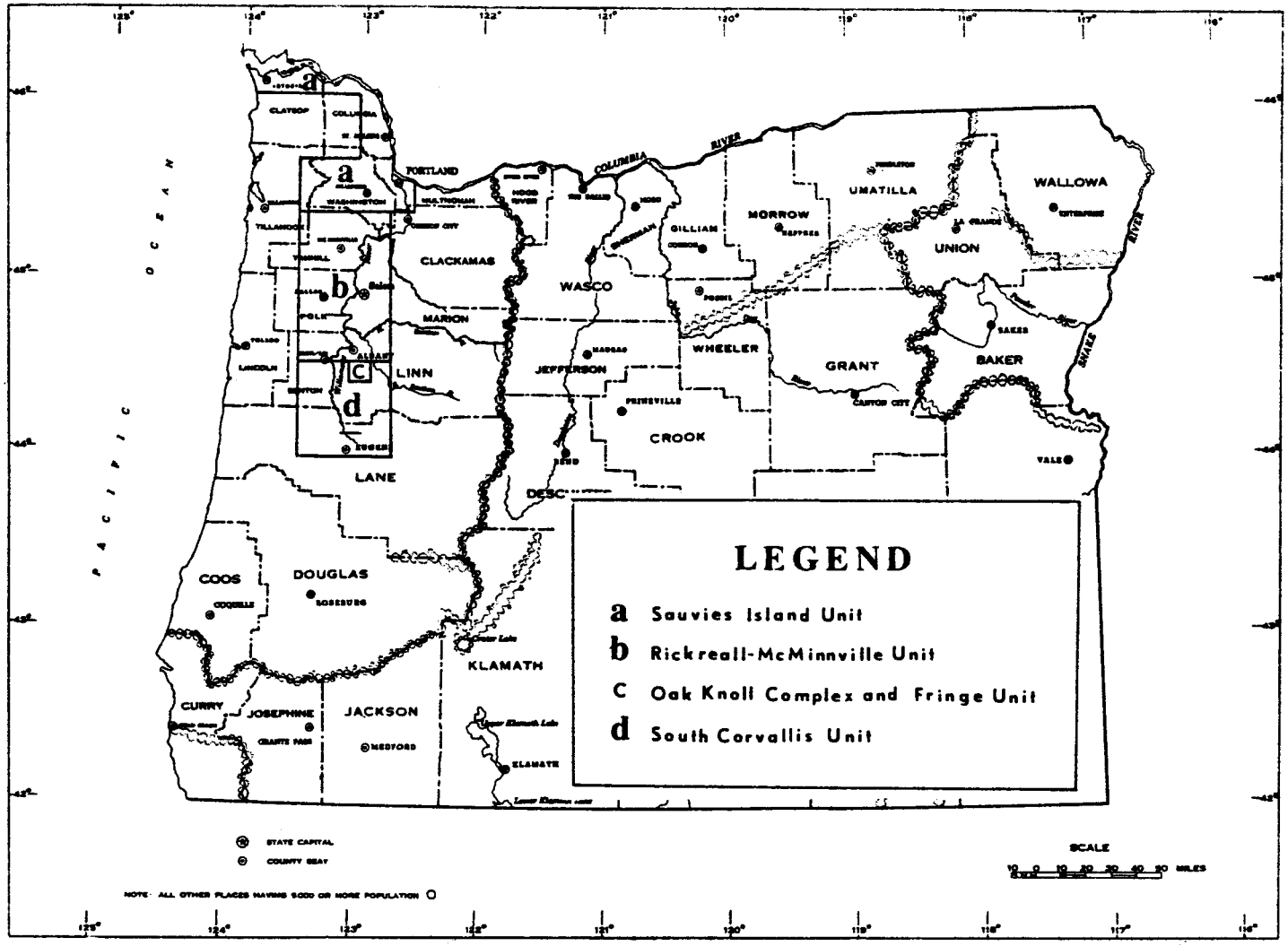

Figure 1. Map of the study area showing the harvest units.

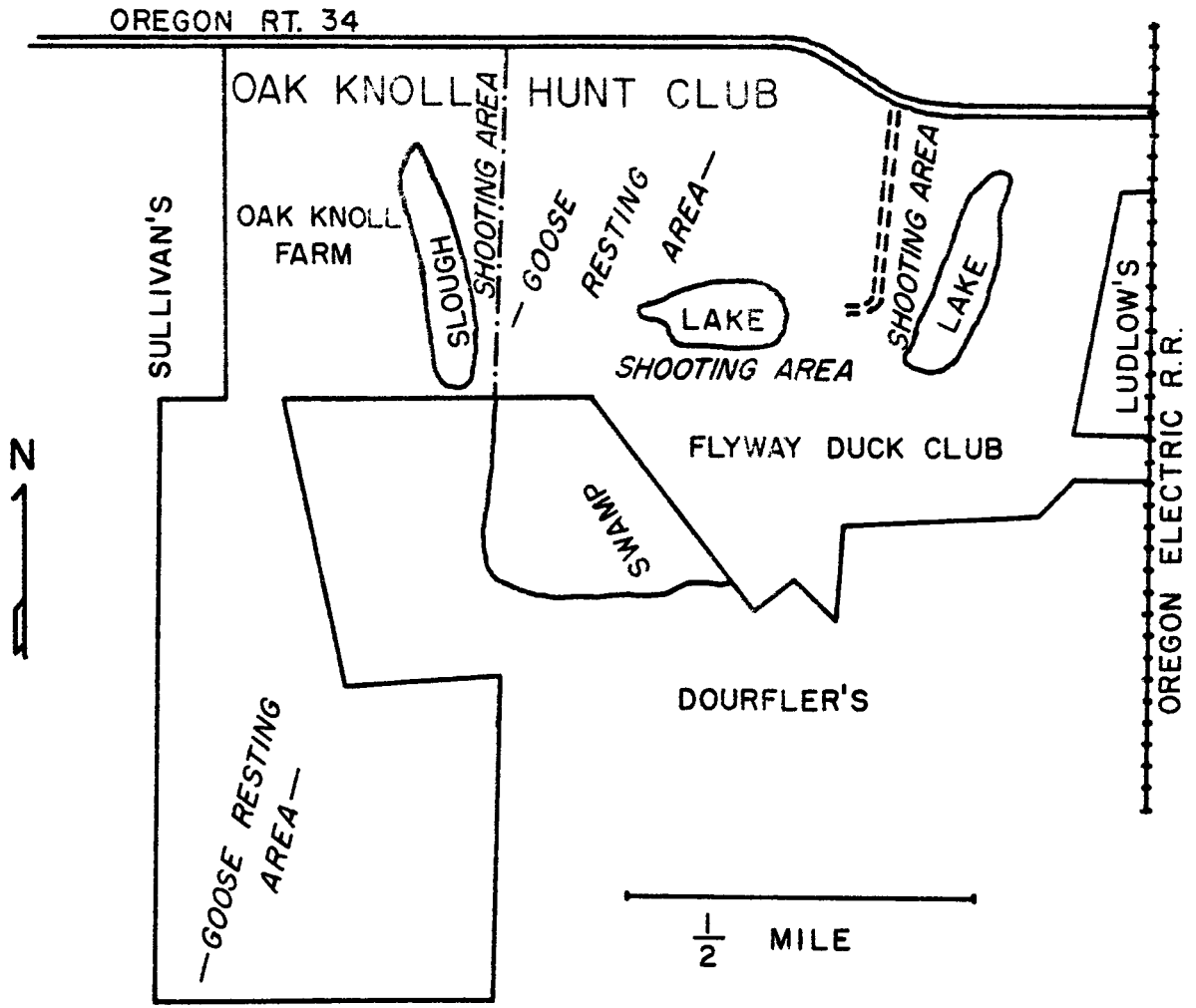

Figure 2. Map of the Oak Knoll Complex and fringe unit.

Figure 3. Photograph of the Oak Knoll Complex taken in October 1964. The primary refuge area is left of the road in the center of the photograph, the primary hunting area on the right. (Photo by David Marshall, Bureau of Sport Fisheries and Wildlife).

METHODS

Hunter Bag Checks

During the three year study, hunter bag checks were conducted at the Oak Knoll Complex. In the 1964-65 season, checks were made on all but ten days; daily checks were made in the 1965-66 and 1966-67 seasons. An effort was made to examine all geese bagged, however, some geese were known to have been missed.

Bag checks were conducted on other parts of the study area whenever time permitted.

Techniques Used for Determining Sex and Age

The sex and age of geese were determined by using the methods and characters described by Hanson (1962). The sex and age of most geese were determined by cloacal examination. Characteristics of the tail feathers were used as an additional criterion of age, however, tail feathers were of no value in determining the sex of the bird or for differentiating between subadults and adults. When sex and age were not determined by cloacal examination, the ages of the geese were determined by the tail feather method.

Species Identification

Geese Examined

The Canada geese examined during the study period were identified using characters described by Hansen and Nelson (1964). Harold C. Hanson of the Illinois Natural History Survey who has worked extensively with the taxonomy of Canada geese, visited the study area in 1965 and 1966 and also aided in the identification of the Canada geese.

Tail Feathers

Tail feathers collected during the study were divided into three size groups; large, medium, and small. Species composition of the geese from which tail feathers were collected during the Random Hunter Survey were derived primarily by this method. The large tail feather size group included B. c. fulva and B. c. occidentalis; the medium size group included B. c. hutchinsii, B. c. taverneri, B. c. leucopareia and an undescribed Canada goose (Hanson 1967); and the small size group included B. c. minima. Table 1 shows the length of the center tail feathers used to differentiate between the three size groups. Tail feathers of known species of Canada geese were used to help differentiate between immatures of medium sized

geese, and small geese. The width of the feather vane of B. c. minima was much narrower than that of the medium sized geese.

Table 1. Means and standard errors of the means of center tail feather lengths from known species of Canada geese divided into three size groups.

	Large geese*		Medium geese**		Small geese*** #	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Immature	140.3	1.55 (20)##	119.1	2.49 (10)##	116.4	1.58 (5)##
Adult	158.1	1.43 (20)##	141.3	1.76 (9)##	---	---

* Includes B. c. occidentalis and B. c. fulva.

** Includes B. c. hutchinsii. B. c. taverneri. B. c. leucopareia and an undescribed Canada goose (Hanson 1967).

*** Includes B. c. minima.

\# Includes both adults and immatures.

Sample size.

Random Hunter Survey

During the 1964-65 and 1965-66 hunting seasons, stamped, self-addressed business reply envelopes were given to hunters in the Rickreall-McMinnville and South Corvallis Units. These hunters were asked to mail the tail feathers from the geese they shot to the Department of Fisheries and Wildlife at Oregon State University. Space was provided on the envelope for pertinent information (See Appendix 1). During the 1966-67 hunting season an extensive effort was made to collect data from areas other than the Oak Knoll Complex. Henny (1967) conducted a survey by mail, of persons buying

duck stamps to compare the success of hunters on club and non-club lands. Hunters who reported that they killed geese in the study area were mailed a package of envelopes for tail feathers and a letter explaining the study (Appendix 2). Tail feathers from additional geese were collected by personally interviewing hunters during the hunting season.

Aerial Census

Estimates of the post-season population of dusky Canada geese throughout the study area were made by the Bureau of Sport Fisheries and Wildlife during the Willamette Valley aerial goose survey. Other flights were made at two week intervals during the hunting season to determine the distribution of geese.

Statistical Tests

The appropriate statistical tests used in analysis of the data collected during this study were those outlined in Steel and Torrie (1960).

Definitions

Age Ratio: number of immatures per adult in the kill.

Age Structure:

Immatures - geese in their first year of life after hatching

(become subadults at the end of their second summer of life).

Subadults - geese in their second year of life after hatching (become adults at the end of their third summer of life).

Adults - geese in their third year of life after hatching or older.

Crippled Goose: a goose that dies as a result of being shot by hunters but is not retrieved.

Crippling Loss: percentage of the total goose kill that is not retrieved by the hunters.

Direct Band Recovery: a banded bird recovered during the hunting season following banding.

Flock: any portion of the goose population.

Hunter Bag: geese shot and taken into possession by hunters.

Population: all components of a given group utilizing fairly well defined breeding grounds, migration routes, and wintering grounds. A population may be comprised of many flocks.

Post-season: immediately after the hunting season ends in Oregon.

Pre-season: immediately prior to the arrival of geese on the study area.

Productivity Rate: the number of immature geese per female that nested successfully.

Relative Recovery Rate: a measure of the differential vulnerability of one age or sex group to the other. It is determined by comparing the direct band recovery rates for each group.

Study Period: period of time from the arrival of geese in the study area to the end of the hunting season.

Total Kill: the total yearly hunter bag plus the total yearly crippling loss.

Vulnerability: the susceptability to hunting pressure of one age or sex class to another. Expressed by relative recovery rates.

RESULTS

Species Composition and Distribution of Geese On the Study Area

Species Composition

During the 1965-66 and 1966-67 hunting seasons an effort was made to determine the species composition of geese killed on the study area. Well over 90 percent of the geese examined during the 1965-66 study period were dusky Canada geese; however, the Vancouver Canada goose (B. c. fulva) winters in a portion of Yamhill County (which borders Polk County on the north) and is morphologically very similar to the dusky Canada goose (Hansen 1962). For this reason, it was possible that some fulva might be included among those data which were collected during this study.

An attempt to differentiate between fulva and occidentalis was made using culmen measurements supplied by Aldrich (1965), but these measurements proved inadequate. However, during a ten year period (1956 through 1965) only 39 out of 325 band recoveries from fulva occurred in Oregon. No accurate figures of the size of the population of Vancouver Canada geese wintering in Yamhill County were available, but Hansen (1962) estimated it to be about 300 birds. Hansen's estimate of 300 birds lends further support to my belief that B. c. fulva is of little consequence in the study area.

Table 2. Species composition of geese examined on the Oak Knoll Complex during the 1965-66 and 1966-67 hunting seasons.

Subspecies	1965-66		1966-67	
	Number	Percent	Number	Percent
Anser albifrons albifrons	0	0	2	Trace
Branta canadensis minima	13	0.9	7	Trace
Medium sized Canada geese*	28	2.2	12	0.5
B. c. leucopareia	1	Trace	1	Trace
B. c. moffitti	2	Trace	0	0
B. c. occidentalis**	1,289	96.5	1,838	99.0
Totals	1,333	100.0	1,860	100.0

* Includes B. c. taverneri, B. c. hutchinsii, and an undescribed Canada goose (Hanson 1967).

** Possibly includes a small percentage of B. c. fulva.

About two percent of the kill during the 1965-66 hunting season was composed of medium sized Canada geese, primarily Richardson's Canada geese (B. c. hutchinsii). Cackling geese (B. c. minima) and western Canada geese (B. c. moffitti) accounted for less than one percent of the geese killed (Table 2).

During the 1966-67 study period, dusky Canada geese accounted for nearly all of the geese killed on the Oak Knoll Complex. A small undetermined percentage of Vancouver Canada geese was again included in this sample. Medium sized Canada geese, cackling geese and white-fronted geese (Anser albifrons albifrons) combined accounted for about one percent of the kill (Table 2).

Data collected on the Rickreall-McMinnville Unit, the South Corvallis Unit, and the Oak Knoll Fringe Unit indicated that approximately 95 percent of the geese shot in these units were dusky Canada geese. This 95 percent also included a small undetermined percentage of Vancouver Canada geese. Medium sized Canada geese accounted for approximately four percent of the kill and cackling geese approximately one percent of the kill (Table 2).

Random Hunter Survey data from Sauvie's Island indicated that approximately 43 percent of the geese shot in that area were dusky Canada geese. Band returns from fulva indicated that this goose would probably constitute an even smaller percentage of the kill in this unit. Cackling geese accounted for approximately 39 percent of the geese killed on the Suavie's Island Unit. Medium sized Canada geese accounted for approximately 18 percent of the total kill (Table 3).

Distribution of Geese

An effort was made to determine movements of geese on the study area. Emphasis was placed on the effect of the William L. Finley National Wildlife Refuge on goose distribution in the Willamette Valley, especially on that portion of the population found on the Oak Knoll Complex.

Table 3. Species composition of the Canada geese from which tail feathers were collected during the 1966-67 Random Hunter Survey.

Unit	B. c. occidentalis* number	percent	Medium sized Canada goose** number	percent	B. c. minima number	percent
Oak Knoll Fringe	188	98.4	3	1.6	0	0
Rickreall-McMinnville	72	96.0	3	4.0	0	0
South Corvallis	68	93.2	3	4.1	2	2.7
Sauvie's Island	48	43.3	20	18.0	43	38.7

* Possibly includes a small percentage of B. c. fulva.

** Includes B. c. hutchinsii, B. c. taverneri, B. c. leucopareia and an undescribed Canada goose (Hanson 1967).

During the 1964-65 hunting season the first geese were observed on the study area early in November. At this time the Finley refuge had undergone limited development. Few geese moved from the Oak Knoll Complex to the Finley Refuge prior to the end of the hunting season. The gradual build-up of numbers of geese on the Finley refuge reached its peak after the end of the hunting season (Table 4).

The first geese were observed on the Oak Knoll Complex 4 November during the 1965-66 study period. The peak in the numbers of geese on the Oak Knoll Complex occurred early in December. By 15 December most of the geese on the Oak Knoll Complex had moved to the Finley Refuge. Movement occurred approximately 20 days earlier in 1965 than large scale movement in 1964 (Table 5).

Table 4. Number of Canada geese wintering on the Oak Knoll Complex and the William L. Finley National Wildlife Refuge, 1964-65.

Census Dates	Number of Geese	
	Oak Knoll Complex	William L. Finley* Refuge
November 8-14	---**	50
November 22-28	---**	100
December 6-12	---**	500
December 13-19	4,000	1,200
December 20-26	3,500	1,500
December 27-January 2***	---**	2,500
January 19	2,200	2,800
February 1	500	3,900

* Data supplied by the Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service.

** No counts were made.

*** Hunting season opened 10 October, 1964, and closed 7 January, 1965.

Table 5. Number of Canada geese wintering on the Oak Knoll Complex, the William L. Finley National Wildlife Refuge, and the Baskett Slough Satellite Refuge, 1965-66.*

Census Dates	Number of Geese		
	Baskett Slough	Oak Knoll Complex	William L. Finley Refuge
November 6	---**	1,000	0
November 23	2,300	7,000	0
December 6	---**	7,000	500
December 15	4,700	1,000	7,500
December 19-26***	---**	---**	9,000
January 10	---**	500	7,700

* Data supplied by the Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service.

** No counts were made.

*** Hunting season opened 9 October, 1965, and closed 6 January, 1966.

Geese were first observed on the Oak Knoll Complex on 11 October during the 1966-67 hunting season. The early migration was believed to result from an early freeze on the breeding grounds (Trainer 1967). Large numbers of Canada geese began to appear on the Oak Knoll Complex and William L. Finley National Wildlife Refuge almost simultaneously. The peak in numbers of geese on the Oak Knoll Complex occurred on 29 November. This was followed by an increase in the numbers of geese using the Finley refuge (Table 6).

Table 6. Number of Canada geese wintering on the Oak Knoll Complex, the William L. Finley National Wildlife Refuge, and the Baskett Slough Satellite Refuge, 1966-67. *

Census Dates	Number of Geese		
	Baskett Slough	Oak Knoll Complex	William L. Finley Refuge
October 10-12	140	175	50
November 17	200	3,000	1,400
November 29	400	9,000	4,000
December 12	1,500	3,000	4,650
December 23	3,000	650	6,000
January 5***	500	---**	11,050

* Data supplied by the Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service.

** No counts were made.

*** Hunting season opened 8 October, 1966, and closed 5 January, 1967.

Dusky Canada Goose Kill on the Study Area

Annual Hunter Bag

Hunter Bag 1964-65. Most of the data during the 1964-65 hunting season were collected at the Oak Knoll Hunt Club. An effort was made to check all geese killed by the members of the club from 7 November through 7 January. However, geese were not examined on 10 of the 65 days. The average daily kill was substituted for the kill on those days that no bag checks were conducted. Twenty

percent of the total hunter bag was added to the kill estimate calculated for the Oak Knoll Hunt Club to account for birds missed because of incomplete bag checks and birds missed in the surrounding area. The number of birds shot on the "Complex" and Fringe Unit during the 1964-65 hunting season was estimated to be 1,674.

The Morgan Hunt Club was operated on part of what was to become in 1965 the Baskett Slough Satellite Refuge. Officer Scripter, Oregon State Police, Salem, estimated that 350 geese were killed in the Baskett Slough area of Polk County. However, this figure does not account for the additional kill that occurred between Baskett Slough and McMinnville. Banding data analysed by Henny (1967) indicated that the total number of dusky Canada geese killed in this unit increased slightly until 1966. Henny (1967) estimated the kill for this unit in 1965-66 to be 1,604. His analysis indicated that the kill in 1965 was slightly higher than in 1964 when the kill was estimated to be 1,500.

The majority of the kill in the South Corvallis Unit occurred in the area surrounding the William L. Finley National Wildlife Refuge. In 1964 Philip A. Lehenbauer, Refuge Manager, estimated that 200 geese were killed in this unit.

The estimated total hunter bag on the study area in 1964 was 3,374.

Hunter Bag 1965-66. Daily bag checks were made on the Oak Knoll Complex from 6 November 1965 through 6 January 1966. During this period the sex and age of 1,289 dusky Canada geese were determined by cloacal examination and 268 sets of tail feathers were collected. During the 1966-67 hunting season 6 percent of the geese shot on the Oak Knoll Complex were missed due to incomplete bag checks. An additional 6 percent of the number of geese checked (99 geese) was added to estimate the total 1965-66 goose kill on the Oak Knoll Complex to account for incomplete bag checks. Hunters on the Oak Knoll Fringe Unit estimated that they killed 400 geese. Therefore, the total hunter bag for the Oak Knoll Complex and Fringe Unit was estimated to be 2,056 geese.

About one-fourth of the geese killed in the Rickreall-McMinnville Unit occurred in the vicinity of the Baskett Slough Refuge. The remainder of the kill occurred primarily north of the refuge. The total kill in 1965 for this unit was calculated by Henny (1967) to be 1,604.

Since the development of the William L. Finley Refuge the number of geese killed on the South Corvallis Unit has been increasing. Henny (1967) calculated the kill for this unit to be 365 geese in 1965.

The estimated total hunter bag for the entire study area in

1965-66 was 4,025 geese.

Hunter Bag 1966-67. During the 1966-67 hunting season hunters on the Oak Knoll Complex and Fringe Unit were checked daily from 31 October through 5 January. The sex and age of 1,838 dusky Canada geese were determined and an additional 206 sets of tail feathers collected. One-hundred and twenty-three geese (6 percent) were known to have been missed due to incomplete bag checks. The total kill for the Oak Knoll Complex was 2,167 geese. Hunters at the Oak Knoll Fringe Unit collected 188 sets of tail feathers. They estimated that an additional 300 geese had been killed on this unit, making the total kill 488. The total kill for the Oak Knoll Complex and Fringe Unit was estimated to be 2,655 geese.

Craighead and Stockstad (1956) studying western Canada geese in Montana, found a direct relationship between goose numbers and goose kill in two out of three years in which their study was conducted. Approximately half as many geese spent the winter on the Rickreall-McMinnville Unit in 1966-67 as in 1965-66 (Tables 5, 6). The number of geese on the Oak Knoll Complex and the South Corvallis Unit was substantially greater in 1966-67 than in either of the two previous years of the study (Tables 4, 5, 6). The kill per hunter during the 1965-66 season was 0.58 geese on all units except the Oak Knoll Complex and Fringe Unit (Henny 1967) where the

number of geese killed per hunter was about 20 to 25 per season. The goose kill on the Oak Knoll Complex was dependent on the number of hunters rather than on the number of geese, while throughout the remainder of the study area the reverse appeared to be true. Because the goose kill appeared to be dependent on the number of geese on the Rickreall-McMinnville Unit (which was less than in previous years) the estimated total hunter bag in this unit was 800 geese.

In 1966-67 the number of geese on the South Corvallis Unit was greater than in the two previous years of the study (Table 6). Correspondingly, the estimated hunter bag for this unit in 1966-67 increased to 500 geese.

The estimated total hunter bag on the study area in 1966-67 was 3,955 geese.

Hunter Success

The average goose kill per hunter-day at the Oak Knoll Hunt Club in 1965-66 was 2.14, and in 1966-67 was 2.30 (Table 7, 8). It should be pointed out that the average hunter-day on the Oak Knoll Hunt Club lasted approximately three hours. Early in the season it was not uncommon for hunters to kill their limit of three geese in less than one hour. On 6 November, 1966, twenty hunters on the Oak Knoll Complex shot 60 geese in approximately 30 minutes.

Table 7. Average kill per hunter day on the Oak Knoll Hunt Club by two-week periods during the 1965-66 hunting season.

Time period	Number of hunter trips	Number of Canada geese killed	Number of geese killed per hunter-day
Oct. 31-Nov. 14	48	75	1.56
Nov. 15-28	159	457	2.87
Nov. 29-Dec. 12	153	418	2.73
Dec. 13-26	151	247	1.63
Dec. 27-Jan. 5*	100	114	1.14
Totals	611	1,311	----
Averages	122	262	2.14

* Approximate number of hunters on the last day of the season.

Table 8. Average kill per hunter day on the Oak Knoll Hunt Club by two-week periods during the 1966-67 hunting season.

Time period	Number of hunter trips	Number of Canada geese killed	Number of geese killed per hunter-day
Oct. 31-Nov. 14	179	500	2.79
Nov. 15-28	157	410	2.61
Nov. 29-Dec. 12	138	339	2.45
Dec. 13-26	128	226	1.76
Dec. 27-Jan. 5	112	174	1.55
Totals	714	1,649	---
Averages	143	330	2.30

The hunter success on the Oak Knoll Hunt Club was substantially higher than on two other prime Canada goose hunting areas in the United States. Vaught and Kirsch (1966) found that the average goose kill per hunter-day at the Swan Lake Public Hunting Area,

Missouri, was 0.58. Hanson and Smith (1950) stated that the average number of geese bagged in the vicinity of Horseshoe Lake, Illinois in 1944 was 1.44.

Estimates of Losses Due to Crippling

Estimates of losses of geese due to crippling were made at the Oak Knoll Hunt Club during the 1965-66 and the 1966-67 hunting seasons (Tables 9, 10). Geese which were shot and fell to the ground within the range of vision of the observer, but which were not retrieved by hunters were considered to be crippled and lost from the flock. Daily observations were attempted from the same locations on the hunt club, but limited visibility due to fog and hunters moving from place to place on the shooting areas prevented accurate counts of crippled birds on some days. The observations were not the same as the crippling loss defined in other studies because birds in this study which were hit but did not fall immediately were not considered crippled.

During the 1965-66 hunting season, hunters on the Oak Knoll Hunt Club were observed to shoot but not retrieve 14.3 percent of their bag, the loss dropped to 8.4 percent during the 1966-67 hunting season (Tables 9, 10). These observations represented the minimum crippling loss on the Oak Knoll Complex.

Hanson and Smith (1950) estimated the minimum Canada goose

Table 9. Crippling loss observations on the Oak Knoll Hunt Club 1965-66.*

Date	Number of hunters	Number of geese shot	Number of geese retrieved	Number crippled	Percent crippled
November 14	7	24	17	7	29.2
November 19	5	18	15	3	16.6
November 20	8	29	22	7	24.1
November 21	6	19	18	1	5.2
November 24	7	25	21	4	16.0
November 26	12**	41	34	7	17.1
November 30	9	29***	27	2	6.9
December 1-25	Unable to observe because of fog.				
December 26	9	26	22	4	15.4
December 27	7**	20	19	1	5.0
December 30	9	11	11	0	0
January 1	3	9	9	0	0
Totals	82	251	215	36	14.3

* Calculated as a percent of the total hunter bag.

** Approximate number of hunters.

*** Based on incomplete observations.

Table 10. Crippling loss observations on the Oak Knoll Hunt Club 1966-67.*

Date	Number of hunters	Number of geese shot	Number of geese retrieved	Number crippled	Percent crippled
November 2	11	32	30	2	6.3
November 6	9	31	27	4	12.9
November 11	21	75	65	10	13.3
November 16	8	26	24	2	7.7
November 17	11	35	33	2	5.7
November 19	5	14	4	0	0
November 27	10	30	30	0	0
December 1	9	26	26	0	0
December 2	9	26	26	0	0
December 3	7	23	21	2	8.7
December 7	5	14	14	0	0
December 8	11	27	24	3	11.1
December 12	9	24	22	2	8.3
December 19	6	23	17	6	13.0
December 24	1	2	2	0	0
December 26	6	4	2	2	50.0
January 1	3	6	6	0	0
Totals	141	418	383	35	8.4

* Calculated as a percent of the total hunter bag.

crippling loss at Horseshoe Lake, Illinois, to be 30 percent. Hunt, Bell, and Jahn (1962) estimated the crippling loss for Canada geese at Horicon Marsh, Wisconsin, to have been as high as 40 percent but in recent years it is estimated to be between 20 and 25 percent. Green, Nelson, and Lemke (1963) found the crippling loss on Horicon Marsh to be 22.5 percent. Craighead and Stockstad (1956) found the crippling loss in the Flat Head Valley, Montana, to be 24.7 percent of the hunter bag.

Most of the crippling losses found in the studies reviewed fell between 20 and 30 percent. Observations made on the Oak Knoll Complex indicated that there was no reason to believe that the crippling loss in the Willamette Valley was different than that found in other studies. Therefore, it was reasonable to assume that the crippling loss for dusky Canada geese in the Willamette Valley falls between 20 and 30 percent. An estimated 20, 25, and 30 percent crippling loss was used to calculate the number of birds lost to crippling. The largest difference between the 20 and 30 percent crippling loss occurred during the 1965-66 hunting season and was only 402 geese. By using an estimate of 25 percent for the crippling loss on the study area the maximum error is 201 geese (Table 11). For this reason an estimate of 25 percent was used to calculate the number of geese lost to crippling during this study.

Table 11. Numbers of dusky Canada geese lost to crippling based on the estimated yearly hunter bag at different crippling loss percentages.

Hunting season	Annual bag	20 Percent crippling loss	25 Percent* crippling loss	30 Percent crippling loss
1964-65	3,374	674	843	1,012
1965-66	4,025	805	1,006	1,207
1966-67	3,957	791	989	1,187
Mean	3,785	752	946	1,135

* Used as an estimate of crippling loss during this study.

Total Kill

The total kill during all three years of the study was calculated by adding 25 percent crippling loss to the hunter bag for the study area by units. The total kill on the Oak Knoll Complex increased in 1966, while the kill on the Rickreall-McMinnville Unit dropped substantially (Table 12). The kill on the South Corvallis Unit has been increasing at a relatively uniform rate since the establishment of the William L. Finley Refuge in 1964.

The Oak Knoll Complex and Fringe Unit accounted for approximately half the kill in the study area in 1964 and 1965, and over 60 percent in 1966 (Table 12).

Table 12. Estimated total numbers and percentages of geese killed in the four primary units of the study area by year.

Year	Oak Knoll Complex		Oak Knoll Fringe Unit		Rickreall-McMinnville Unit		South Corvallis Unit		Total kill
	Number of geese killed	Percent of total kill	Number of geese killed	Percent of total kill	Number of geese killed	Percent of total kill	Number of geese killed	Percent of total kill	
1964	2093*	49.6	---	----	1875	44.4	250	6.0	4218
1965	2070	41.1	500	9.9	2005	39.9	456	9.1	5031
1966	2709	54.8	610	12.3	1000	20.2	625	12.7	4944
Mean	2661*	56.2	---	----	1627	34.4	444	9.4	4732

*Includes the Oak Knoll Fringe Unit.

Sex and Age Composition of the Dusky Canada Goose Kill

Annual Sex and Age Composition of the Kill

The Oak Knoll Complex. The percentage of adults in the kill decreased, almost uniformly, and more adult males than females were shot in all three years of the study. A larger number of subadults were killed during the first year of the study as in either of the following years. During the first two years of the study a disproportionate number of subadult females were shot, but slightly more subadult males were shot during the third year of the study (Table 13). The percentage of immatures in the kill increased in all three years of the study. Immature males and females were shot in nearly equal numbers during the 1964-65 and 1966-67 hunting seasons. During the 1965-66 hunting season more immature males than females were shot (Table 13).

The age ratios (geese examined plus tail feather data) on the Oak Knoll Complex, the Oak Knoll Fringe Unit and the Random Hunter Survey are compared in Table 14.

The Oak Knoll Fringe Unit. During the 1966-67 study period, tail feathers were collected from the hunt clubs bordering the Oak Knoll Complex. All of these data were collected between 15 November and 2 January. The age distribution of tail feathers collected on

the Oak Knoll Fringe Unit fell between the age distribution of the Oak Knoll Complex and of the Random Hunter Survey (Table 14).

Table 13. Sex and age composition of the kill sample from the Oak Knoll Complex.

	1964-65		1965-66		1966-67	
	Number	Percent	Number	Percent	Number	Percent
Immature Females	349	30.7	429	33.5	713	38.9
Immature Males	344	30.3	499	38.7	709	38.6
Total Immatures	693	61.0	928	72.2	1,422	77.5
Subadult Females	101	8.9	50	3.8	52	2.8
Subadult Males	59	5.2	34	2.6	56	3.0
Total Subadults	160	14.1	84	6.4	108	5.8
Adult Females	121	10.6	120	9.3	129	7.0
Adult Males	162	14.3	157	12.1	179	9.7
Total Adults	283	24.9	277	21.4	308	16.7
Total (all geese)	1,136	100.0	1,289	100.0	1,838	100.0

The Random Hunter Survey. During the 1966-67 study period tail feathers were collected from hunters in the Rickreall-McMinnville, South Corvallis, and Sauvie's Island Units. The dusky Canada goose kill was composed of nearly equal numbers of immatures and adults (including subadults) (Table 14). Banding data analyzed by Henny (1967) indicated that immature and adult dusky Canada geese were killed in approximately equal numbers in areas other than the Oak Knoll Complex and Fringe Unit. The age ratio for the combined kill on all units except the Oak Knoll Complex and for all years was approximately one to one immature to adult (includes subadults) (Table 15).

Table 14. The age composition of the kill on the Oak Knoll Complex 1964-65, 1965-66 and 1966-67, the Oak Knoll Fringe Unit 1966-67, and the Random Hunter Survey 1966-67.

	Oak Knoll Complex*						Oak Knoll Fringe Unit*		Random Hunter Survey**	
	1964-65		1965-66		1966-67		1966-67		1966-67	
Year	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Immatures	849	61.5	993	69.4	1,587	77.7	110	58.5	96	51.3
Adults***	532	38.5	564	30.6	457	22.3	78	41.5	91	48.7
Totals	1,381	100.0	1,557	100.0	2,044	100.0	188	100.0	187	100.0

*Includes tail feathers collected, and geese from hunter bag checks.

**Data from tail feathers only.

***Includes subadults.

Table 15. Age ratios of 510 dusky Canada geese from the Oak Knoll Fringe Unit and the Random Hunter Survey 1964-67.

	Oct. 31 - Nov. 14		Nov. 15 - Nov. 28		Nov. 29 - Dec. 12		Dec. 13 - Dec. 26		Dec. 27 - Jan. 7	
	Adult*	Immature	Adult*	Immature	Adult*	Immature	Adult*	Immature	Adult*	Immature
	16	18	62	86	74	84	72	56	26	16
Immatures per adults**		1.12		1.38		1.13		0.77		0.61

*Includes subadults.

**Average number of immatures per adult 1.04.

Distribution of the Kill During the Hunting Season

Distribution by Time. The study periods for the 1964-65, 1965-66, and 1966-67 hunting seasons began with the arrival of geese on the study area; early November in 1964 and 1965 and mid October in 1966. Even though the geese arrived earlier in 1966, few were killed in the study area prior to 31 October 1966. In 1964 the peak kill on the Oak Knoll Complex occurred in the first week of the study period. In 1965 the peak kill occurred in the third week, and in 1966 in the second week of the study period. The peak of the goose kill was not related to the high in numbers of geese present on the Oak Knoll Complex (Figure 4).

The low point in numbers killed in 1964 was reached in the seventh week of the study period. This low occurred during a period of severe flooding which dispersed the geese and made hunter access difficult. The low in 1965 and 1966 occurred during the last week of the study period (Figure 4).

Distribution by Time and Age. During the 1964-65 hunting season the peak of the kill of immatures on the Oak Knoll Complex occurred in the first week of the study period. The percentage of immatures killed remained above that of the adults (including sub-adults) until the fourth week when immatures and adults were taken

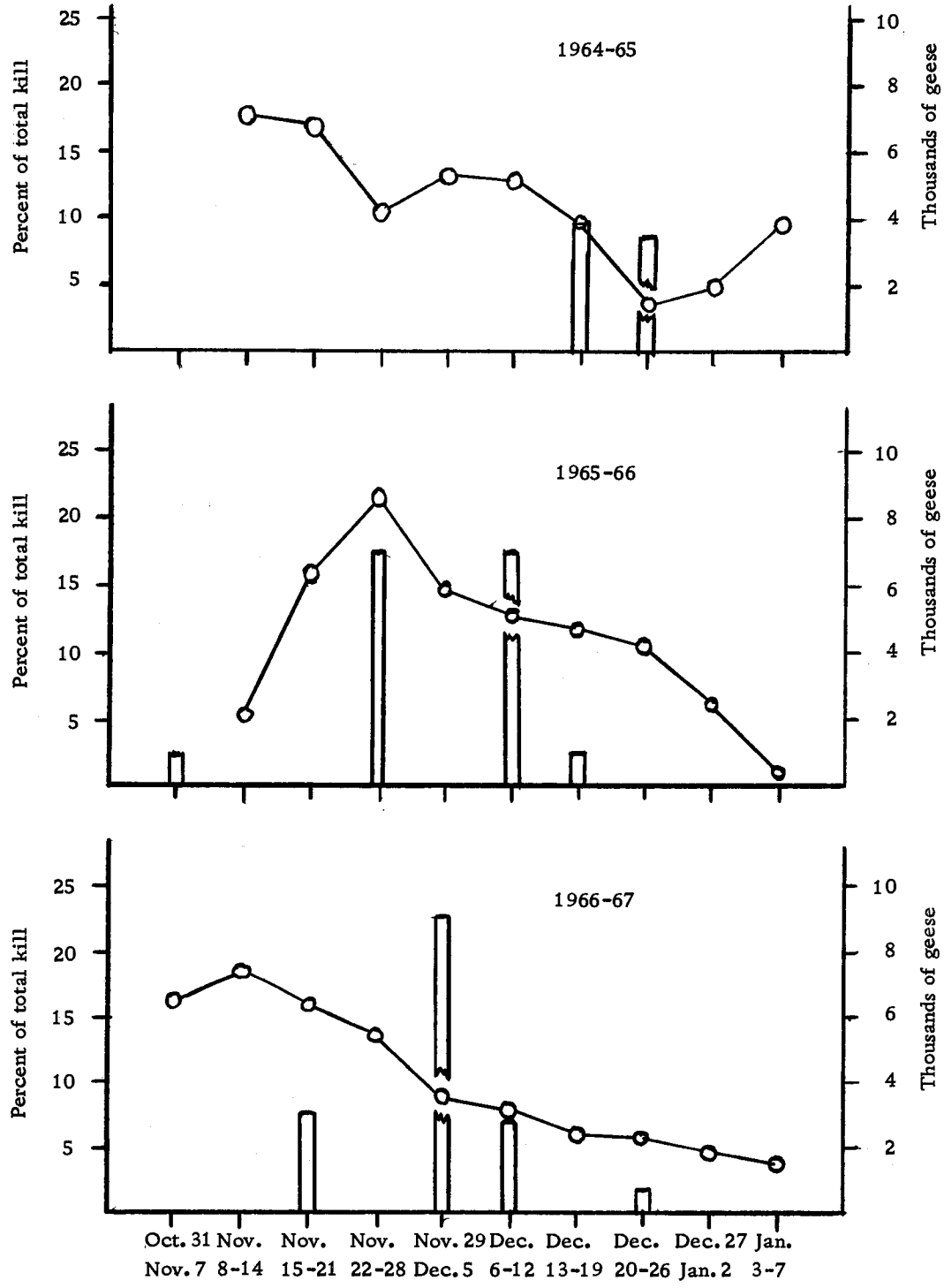

Figure 4. Graphs of the distribution of the total kill and histograms of the number of geese present on the Oak Knoll Complex in weeks aerial censuses were made during the three year study period.

in nearly equal numbers. From the fourth to the seventh week immatures were killed in greater numbers than adults. During the seventh week adults surpassed immatures in the kill and remained above them until the end of the season (Figure 5).

The peak of the kill of immatures on the Oak Knoll Complex occurred in the third week of the 1965-66 study period, followed by an abrupt drop in numbers killed. The peak of the adult kill occurred in the sixth week when adults slightly surpassed immatures. The kill of both immatures and adults dropped rapidly to a low point at the end of the season (Figure 5).

The peak of the immature kill on the Oak Knoll Complex occurred in the second week of the 1966-67 study period. The kill of immatures steadily decreased until the sixth week when the numbers of immatures killed began to level off. The low in the kill of immatures and the high in the kill of adults occurred during the last two weeks of the study period. The low in the adult kill occurred the first week of the study period (Figure 5).

In general, the peak in the immature kill and the low in the adult kill occurred early in the study period. The peak of the adult kill occurred near the end of the study period, as did the low in the immature kill.

The age structure of the kill during the last week of the 1964-65 hunting season at the Oak Knoll Hunt Club was of special interest.

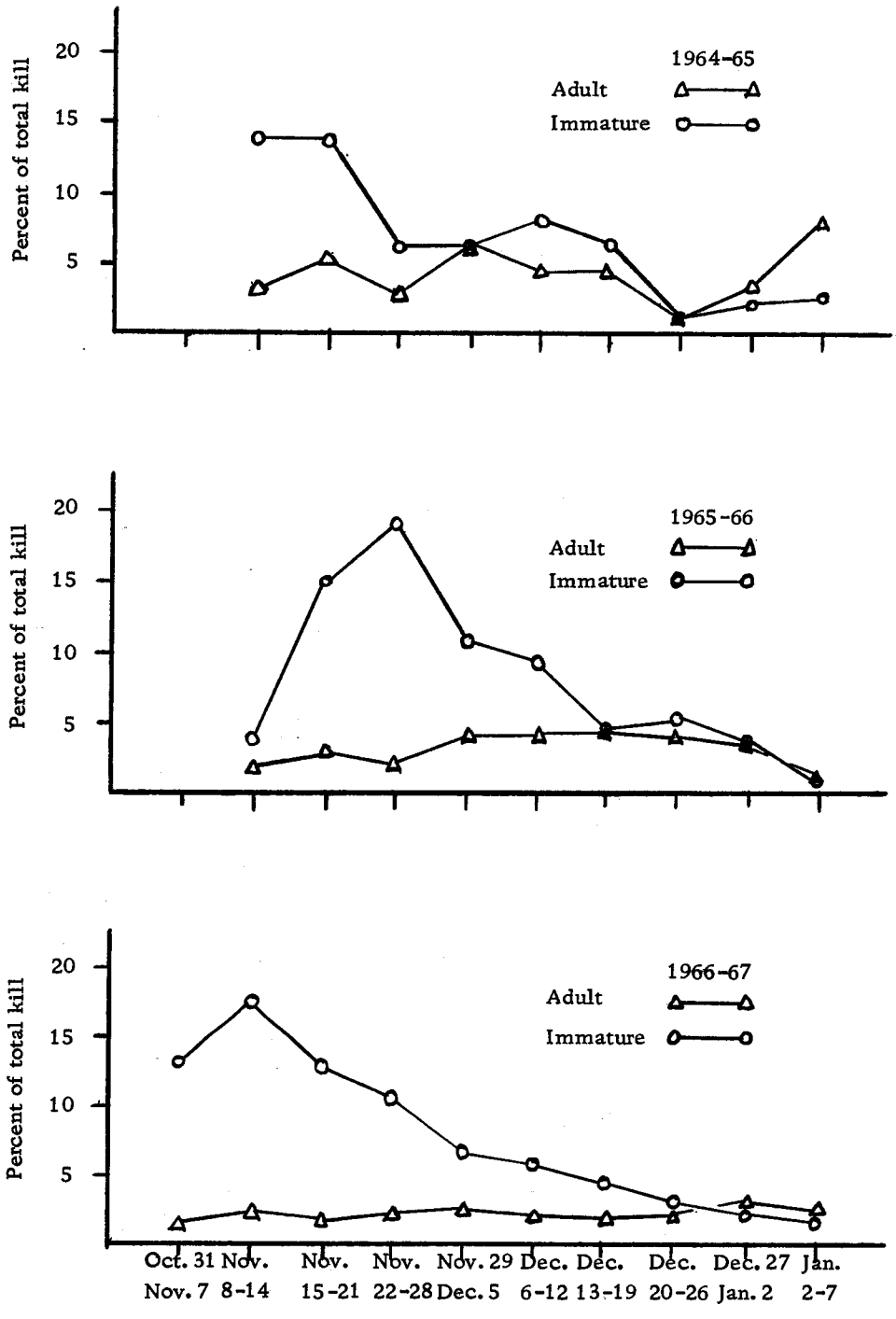

Figure 5. Age distribution of the kill on the Oak Knoll Complex each hunting season 1964-1967.

The last three days of the season, all-day hunting was permitted. The last two days a large number of hunters participated. The peak of the adult kill took place at that time. The change to all day hunting greatly increased the kill of adults, while the kill of immatures increased only slightly.

Figure 6 shows the kill of immatures and adults for an 11 day period preceeding the end of the 1964-65 hunting season. I believe that this greatly increased kill of adults was the result of a long preconditioning period of half-day hunting.

Sex Ratios in the Kill

The sex ratio of adult dusky Canada geese in hunter bag checks at the Oak Knoll Complex showed an average of 1.34 males per female (Table 16). The adult sex ratio was statistically tested for all three years and found significantly different from the expected one male per female (chi-square= 6.55, 1 df, $P < 0.02$). According to Hanson and Smith (1950) this is not unexpected because females undergo a disproportionate mortality during the breeding cycle. This fact, coupled with a surplus of males at hatching and possible differences in mortality rates of subadult males and females might account for a surplus of adult males. Hanson (1965) found sex ratios in adult giant Canada geese (*B. c. maxima*), which were caught in traps at Rochester, Minnesota, to range between 1.54 and 1.29

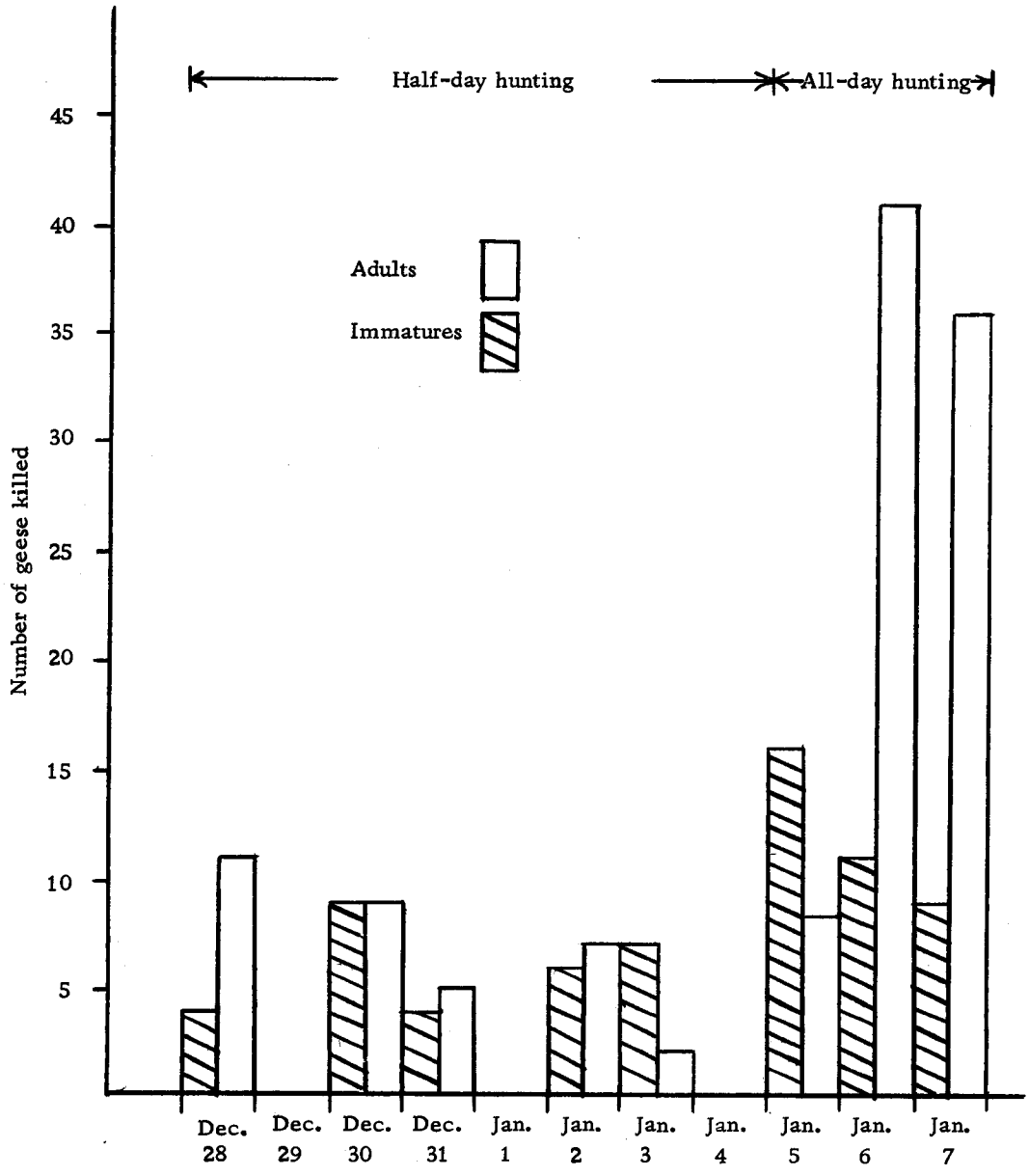

Figure 6. Comparison of the kill of adults and immatures on the Oak Knoll Hunt Club during half-day and all-day hunting at the end of the 1964-65 hunting season.

Table 16. Sex ratios of dusky Canada geese examined on the Oak Knoll Complex 1964-1967.

	Age Class											
	Adult				Subadult				Immature			
	Number of males	Number of females	Total	Sex ratio	Number of males	Number of females	Total	Sex ratio	Number of males	Number of females	Total	Sex ratio
1964	162	121	283	1.34:1	59	101	160	0.58 :1	344	349	693	0.99:1
1965	157	120	277	1.31:1	34	50	84	0.68:1	499	429	928	1.16:1
1966	179	129	308	1.38:1	56	52	108	1.08:1	709	713	1422	0.99:1
Totals	498	370	868	1.34:1	149	203	352	0.73:1	1552	1491	3043	1.04:1

males per female. Vaught and Kirsch (1966) at Swan Lake, Missouri, and Hanson and Smith (1950) at Horseshoe Lake, Illinois, found an average of 1.04 males per female in adult birds from hunter bag checks. No significant differences (chi-square= 0.31, 1 df, $\underline{P} < 0.5$) were found in the sex ratio between years of adult dusky Canada geese during the three year study period. The above analysis of hunter bag checks indicated that there were no changes in vulnerability or the sex ratio of adult geese shot on the Oak Knoll Complex during the three year study period.

The sex ratio of subadult dusky Canada geese varied from 0.58 males per female in 1964 to 1.08 males per female in 1966 (Table 16). The surplus of females was found to be statistically significant in both 1964 (chi-square= 11.02, 1 df, $\underline{P} < 0.001$) and 1965 (chi-square= 3.04, 1 df, $\underline{P} < 0.1$). The difference in the sex ratio between 1964 and 1965 was statistically tested and found not to be significant (chi-square= 0.30, 1 df, $\underline{P} < 0.5$). The 1.08 males per female in the kill on the Oak Knoll Complex during the 1966-67 hunting season was tested against the expected one to one sex ratio and found to be not significant (chi-square= 0.14, 1 df, $\underline{P} < 0.5$). Hanson (1966) found a sex ratio in subadult giant Canada geese ranging between 0.60 and 0.93 males per female in trap catches at Rochester, Minnesota. Hanson (1965) further stated that he believed those sex ratios were representative of the population.

The sex ratios of immatures killed on the Oak Knoll Complex showed no significant difference (chi-square= 0.01, 1 df, $\underline{P} < 0.5$) from the expected one to one sex ratio in 1964 and 1966. However, a significant excess of males was found in the kill in 1965 (chi-square= 5.28, 1 df, $\underline{P} < 0.05$) (Table 16). The reason for this change in immature sex ratios between years was not known. Henny (1967) found a slight but statistically significant surplus of immature male dusky Canada geese banded on the breeding ground. Hanson and Smith (1950) found a sex ratio in immature Canada geese of 1.10 males per female in hunter bag checks at Horseshoe Lake, Illinois.

Differential Hunting Losses

Vulnerability. Hanson and Smith (1950) calculated the vulnerability ratio in the Horseshoe Lake area, Illinois, in 1943 to be 8.3 immatures per adult. Vaught and Kirsch (1966) found that immature Canada geese shot at Swan Lake, Missouri, were twice as vulnerable to hunting as adults. Immatures were 3.8 times as vulnerable as adults during the first ten days of the season. The age ratio of Canada geese checked at Swan Lake, was 3.55 immatures per adult in October; 2.29 in November, and 1.97 in December. They believed this change in the age ratios was due to:

1) Attrition is higher among the immatures because of their higher vulnerability, and as hunting progresses their number rapidly decreases.

2) As the surviving immatures gain experience the difference in wariness between them and adults logically would lessen.

An age ratio similar to that found in other studies was found in the kill of dusky Canada geese on the Oak Knoll Complex (Table 17). Immatures were much more vulnerable than adults to hunting early in the season. The vulnerability of the immatures gradually decreased until it reached its low near the end of the season (Figures 7, 8).

Changes in vulnerability (as shown by age ratios in the kill) on the Oak Knoll Complex were noted in all three years of the study (Figure 7). During the 1964-65 hunting season the average number of immatures per adult was 1.56; during the 1965-66 hunting season 2.57; and during the 1966-67 hunting season 3.42. I believe that this increase in vulnerability during the three year study period was directly related to the number of immature geese present on the Oak Knoll Complex and indicates an increasing percentage of immatures in the population. However, Hanson (1965) has pointed out that an increasing percentage of immatures in a goose population does not necessarily indicate a population with tolerable mortality rates and in fact may indicate excessive mortality.

There was an increase in the vulnerability of immatures between the first and second time periods in 1965 (Figure 7). The only noted difference that might account for this increase in vulnerability

Table 17. Age ratios of 4,963 dusky Canada geese from hunter bag checks on the Oak Knoll Complex.

	October 31 - November 14			November 15 - November 28		
Year	Immature	Adult	Age ratio	Immature	Adult	Age ratio
1964	201	51	3.94	273	106	2.57
1965	56	24	2.33	500	89	5.61
1966	643	83	7.74	474	80	5.58
Totals	900	158	5.69	1247	275	4.53

	November 29 - December 12			December 13 - December 26		
Year	Immature	Adult	Age ratio	Immature	Adult	Age ratio
1964	205	152	1.34	98	82	1.19
1965	299	129	2.31	170	179	0.95
1966	244	100	2.73	140	90	1.56
Totals	748	381	1.96	408	351	1.16

	December 27 - January 7		
Year	Immature	Adult	Age ratio
1964	67	130	0.51
1965	55	56	0.98
1966	86	100	0.86
Totals	208	286	0.72

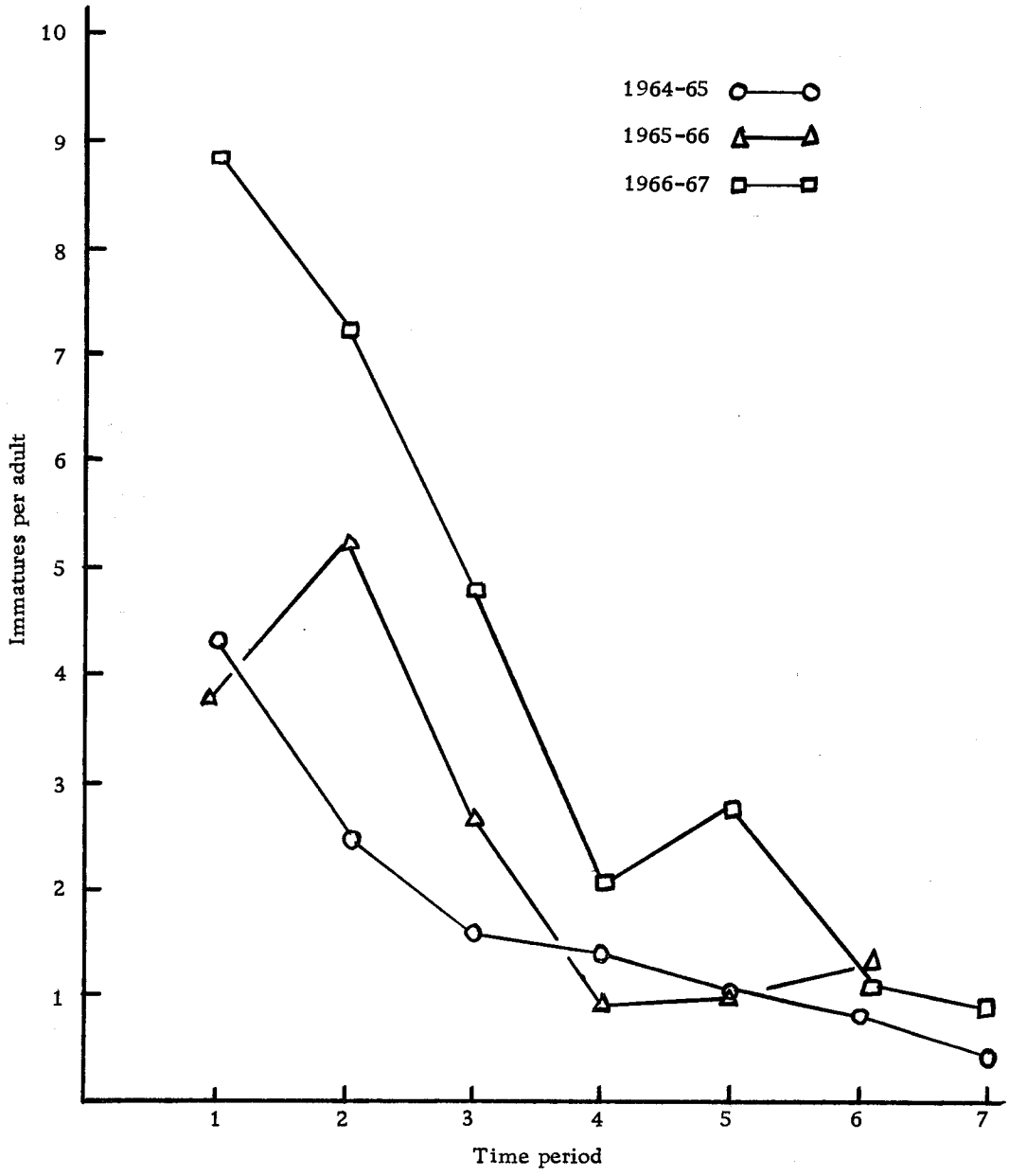

Figure 7. Number of immatures per adult killed on the Oak Knoll Complex by 10 day time periods starting with the first day of the study period.

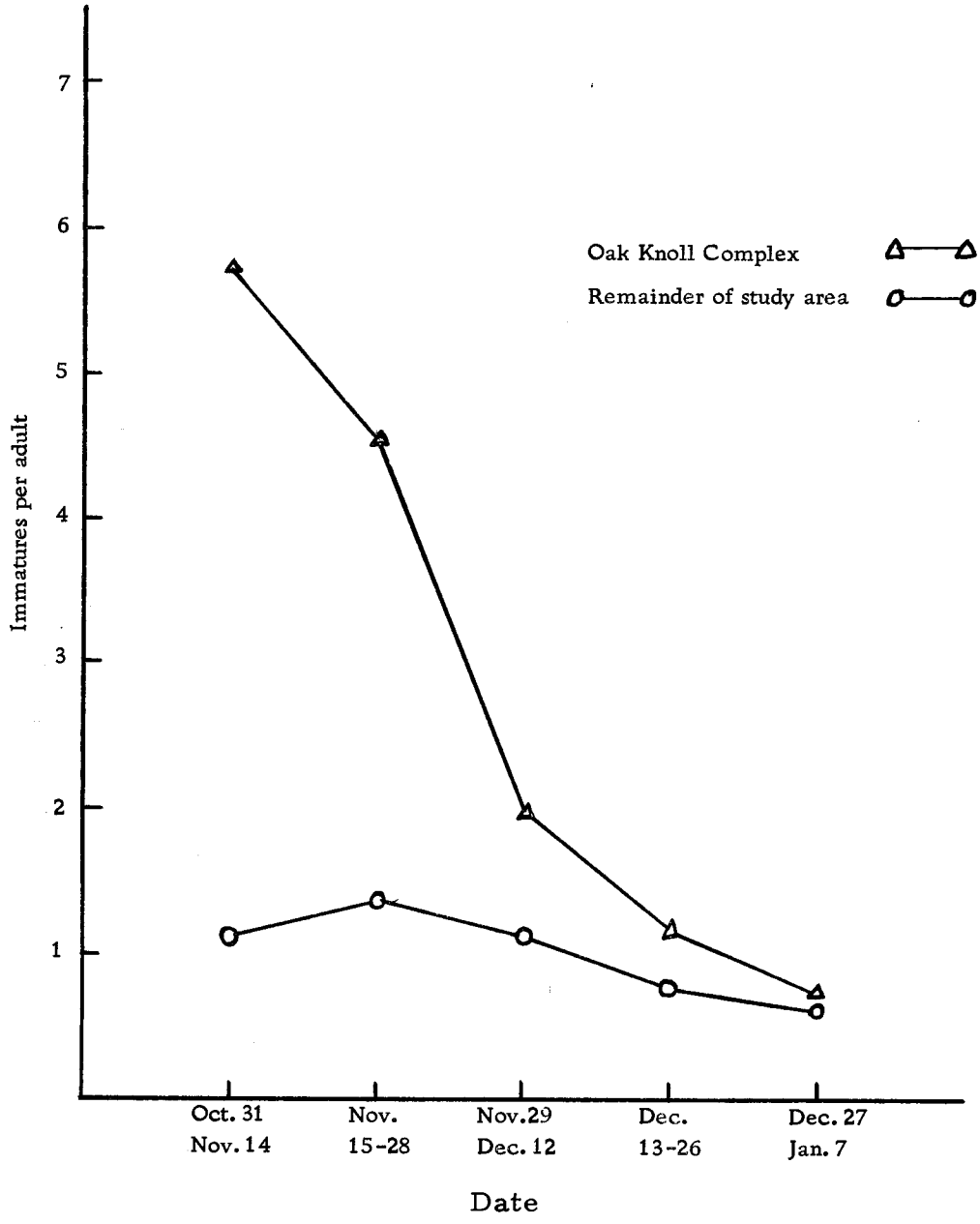

Figure 8. Comparison of the average number of immatures per adult killed on the Oak Knoll Complex with the remainder of the study area.

was that the geese were shot as they arrived on the Oak Knoll Complex. This was in marked contrast to both 1964-65, when bag checking started five days after hunting began; and 1966-67, in which the geese arrived on the Oak Knoll Complex well before hunting commenced.

Immatures are less vulnerable to hunting in areas other than on the Oak Knoll Complex. An average of all age data collected in areas other than the Oak Knoll Complex indicated that immatures and adults were killed in nearly equal numbers (Table 15). A comparison of the average immature vulnerability during the three year study period on the Oak Knoll Complex and in the remainder of the study area is shown in Figure 8.

Relative Recovery Rate. Age ratios in the kill do not usually reflect the actual age composition of a population of geese. A relative recovery rate is a measure of the vulnerability of one age group over another and can be used to estimate the age composition of a population of geese.

A relative recovery rate is derived from banding data and is calculated by dividing the percent of banded immature geese shot and reported the first year after banding by the percent of banded adult geese shot and reported the first year after banding. No bandint was done on the dusky Canada goose breeding ground in 1964,

however, the banding program was resumed in 1965 and 1966. Only 434 dusky Canada geese were banded in 1965 and 338 in 1966. The number of direct band recoveries from the Oak Knoll Complex in 1965-66 and 1966-67 was small and for this reason banding data for these two years was averaged to obtain a relative recovery rate (Table 18).

Nearly all of the bands from dusky Canada geese shot on the Oak Knoll Complex were examined. By using the direct band recoveries from the Oak Knoll Complex, an average relative recovery rate of 3.81 was calculated. By multiplying the subadults and adults by 3.81, an estimate of the actual sex and age composition of the pre-season population was calculated (Table 20).

Estimated Size and Sex and Age Composition of the Dusky Canada Goose Population

Population Sizes

The post-season population estimates were obtained from the Oregon mid-winter inventory (primarily an aerial inventory, but some ground counts were also made). Pre-season population estimates were calculated by adding the estimated goose kill in the study area to the post-season population estimates.

Goose kill that occurred north of the Rickreall-McMinnville Unit was not included in pre-season population estimates. There

Table 18. Numbers of dusky Canada geese banded on the breeding ground, number bands recovered on the Oak Knoll Complex, 1965-67, and the calculation of the relative recovery rate.

Category	1965-66		1966-67		Totals	
	Immature	Adult	Immature	Adult	Immature	Adult
Number banded	198	236	244	94	442	330
Number recovered first year	21	5	25	4	46	9
Direct recovery rate	10.61	2.12	10.25	4.26	10.41	2.73
Relative recovery rate	$\frac{10.61}{2.12} = 5.00$		$\frac{10.25}{4.26} = 2.41$		$\frac{10.41}{2.73} = 3.81$	

were no data available on the total dusky Canada goose kill in the area north of the Rickreall-McMinnville Unit during the three year study period. However, Henny (1967) estimated the dusky Canada goose kill on the Sauvie's Island Unit in 1965 was approximately 292. Geese killed between the breeding ground and Oregon were not considered part of the Oregon pre-season population. The mid-winter inventory included geese on the Sauvie's Island Unit because the geese fly back and forth between the Sauvie's Island and Rickreall-McMinnville Units. No allowances were made for natural mortality during the hunting season which I assumed to be negligible.

Table 19 shows the mid-winter inventories, the total dusky Canada goose kill on the study area and the calculated pre-season populations during the three year study period.

Table 19. The mid-winter inventory, total goose kill and the Oregon pre-season dusky Canada goose population during the three year study period.

	Year		
	1964	1965	1966
Mid-winter Inventory*	14,085	17,842	17,837
Total Goose Kill in Study Area*	4,218	5,031	4,944
Pre-season Population*	18,303	22,873	22,781

* Includes a small undetermined percentage of B. c. fulva.

Population Sex and Age Composition

The 1964 mid-winter inventory indicated that the dusky Canada goose population wintering in the Willamette Valley was lower than in either 1965 or 1966 (Table 19). The lower population size in 1964 can be attributed to fewer immature geese in the population, probably as a result of poor production of young during the breeding season of 1964 (Table 20).

In March 1964 a severe earthquake raised the Copper River delta of Alaska by approximately six feet. Shepherd (1965) reported that considerable physical damage was apparent on the Copper River delta following the earthquake. Shepherd stated that:

> Large ground fissures crisscrossed the flats draining ponds and diverting water courses. Huge blocks of unstable silts bordering the sloughs had slumped and filled many sloughs above the present water level. Portions of sloughs which were never dry even on a minus tide were exposed and many have become completely dry.

The effects of the earthquake on the production of young in 1964 may have been compounded by a very late spring. Shepherd (1967) stated that the late spring in 1964 was responsible for reduced clutch sizes, late nesting, poor brood survival, and nest initiation at irregular intervals. Shepherd's study of the breeding ground together with the calculated 29.9 percent immatures in the population further support the probability of poor production during the 1964

Table 20. Sex and age composition of the Oregon pre-season population based on the sex and age ratio of the geese killed on the Oak Knoll Complex and a relative recovery rate of 3.81.

	1964		1965		1966	
	Number	Percent	Number	Percent	Number	Percent
Immature female	2,691	14.7	4,255	18.6	5,399	23.7
Immature male	2,636	14.4	4,963	21.7	5,376	23.6
Total immatures	5,327	29.1	9,218	40.3	10,775	47.3
Subadult female	2,965	16.2	1,898	8.3	1,504	6.6
Subadult male	1,720	9.4	1,281	5.6	1,617	7.1
Total subadults	4,685	25.6	3,179	13.9	3,121	13.7
Adult female	3,551	19.4	4,529	19.8	3,714	16.3
Adult male	4,740	25.9	5,947	26.0	5,171	22.7
Total adults	8,291	45.3	10,476	45.8	8,885	39.0
Total Oregon* Pre-season population	18,303	100.0	22,873	100.0	22,781	100.0

*Less mortality that occurred prior to arrival in the study area.

breeding season (Table 20).

Shepherd (1965) reported that nesting densities based on his sample area may have been higher than in previous years, and that a much higher percentage of immatures was in the population than Table 20 suggests. However, Shepherd (1967) stated:

> A possible source of error in our counts is that too few of the purely adult molter flocks are being surveyed thus providing low estimates. Regardless, I think that the age ratios in the kill may be more representative of the population as long as you are correcting them for differences in vulnerability.

The estimated sex and age composition of the 1964 pre-season population is presented in Table 20.

The number of immatures produced in 1965 was greater than in 1964 (Table 20). Shepherd (1965) found that on the average 1.5 more eggs per clutch were produced in 1965 than in 1964. However, he found that nest success was approximately 30 percent lower in 1965. The percentage of immatures produced in 1965 was slightly below the production level necessary for the population to maintain a stable age distribution under the average mortality rates of approximately 45 percent (Henny 1967). The percentage of subadults in the 1965 pre-season population was substantially lower than the percentage of subadults in the 1964 pre-season population. The percentage of adults was nearly the same in both 1965 and 1964 (Table 20).

The 1966 pre-season population was estimated to contain slightly more immatures and slightly fewer subadults and adults than the 1965 pre-season population (Table 20). The average percentage of immatures in the 1965 and 1966 pre-season population approximates the average percentage of immatures necessary to replace subadult and adult losses to hunting with the average mortality rate of approximately 45 percent calculated by Henny (1967).

Males and females of the same age class while on the wintering ground were assumed to have the same vulnerability. However, wide fluctuations in the number of subadult males killed on the Oak Knoll Complex indicated that there may have been differences in subadult vulnerability. Since no birds were banded as subadults, the adult and subadult classes were grouped and adjusted with the 3.81 relative recovery rate (Table 18).

Banding data analyzed by Henny (1967) indicated that the percentage of subadults in the population in 1965 and 1966 may have been slightly higher than Table 20 suggests. However, his analysis further indicated that in order to maintain a stable condition the population must be composed of 40 to 50 percent immature geese. Henny's figures of 40 to 50 percent agree very well with the data presented in Table 20.

Productivity of the Oregon Pre-season Population

Immature dusky Canada geese wintering in the Willamette Valley represent part of the production of the previous breeding season. To calculate the productivity rate it was necessary to know only the sex and age composition of the pre-season population and the nest success. It was assumed that all females attempted to breed at two years of age (in their third spring of life).

Productivity 1964

The 1964 Oregon pre-season population was calculated to contain 5,327 immatures and 3,551 adult females (Table 20). Shepherd (1965) found that the nest success on the breeding ground in 1964 was 82.4 percent. His criterion for a successful nest was a nest in which one or more eggs hatched. By multiplying the number of adult females (3,551) by the nest success (82.4) the number of successful nests was calculated to be 2,926. By dividing the number of immatures (5,327) by the number of successful nests (2,926) the productivity rate for 1964 was calculated to be 1.82 (Table 21).

Productivity 1965

The 1965 Oregon pre-season population was calculated to contain 9,218 immatures and 4,529 adult females (Table 20). Shepherd

(1966b) reported a nest success of 62.9 percent during the 1965 breeding season. By multiplying the number of adult females (4,529) by the nest success percentage (62.9) the number of successful nests was calculated to be 2,849. By dividing the number of immatures (9,218) by the number of successful nests (2,849) the productivity rate for 1965 was calculated to be 3.24 (Table 21).

Productivity 1966

The 1966 Oregon pre-season population was calculated to contain 10,775 immatures and 3,714 adult females (Table 20). Hansen (1962) showed that the nest success on the Copper River delta in a normal year was 87.4 percent. Shepherd (1965) found the nest success in 1964 to be 82.4 percent. Hilliker (1967) reported that the nest success on the delta was better than average, but that they had not collected any nest success data as such. For this reason, Hansen's (1962) figure of 87.4 was used as an estimate of nest success. By multiplying the number of adult females (3,714) by the nest success figure (87.4) the number of adult females nesting successfully was calculated to be 3,246. By dividing the number of immatures (10,775) by the number of successful nests (3,246) the productivity rate for 1966 was estimated to be 3.32 (Table 21).

Table 21. Number of adult females, nest success percentage, successful nests, immatures produced and the calculated productivity rate of the Oregon pre-season population.

	Number of adult females	Nest success percentage	Successful nests	Immatures produced	Productivity rate
1964	3,551	82.4*	2,926	5,327	1.82
1965	4,529	62.9*	2,849	9,218	3.24
1966	3,714	87.4**	3,246	10,775	3.32

*From data collected on the breeding ground by Peter E. K. Shepherd, Alaska Department of Fish and Game.

**Estimate taken from Hansen (1962) and information supplied by Hiliker (1967).

Projected Population Trends

The status of the dusky Canada goose population from 1964 through 1966 has been discussed. However, of particular concern are population trends in the future.

The sex and age composition and size of the 1966 Oregon pre-season population is presented in Table 20. By applying average mortality rates for each age group (Henny 1967) to this population, the sex and age composition of the 1966 post-season population can be calculated. Future population sizes can be predicted by applying the percent nest success and productivity rate to the number of subadult and adult females in the post-season populations.

The 1966 pre-season population was used as a base from which to project future population sizes from 1967 through 1971 in the manner previously described (Table 22). A theoretical maximum and minimum productivity were used in calculating population levels. The maximum productivity for the population was calculated by assuming that 50 percent of the subadult and all adult females attempt to nest, that the nest success was 85 percent and the productivity rate was 3.40. Henny (1967) showed that a productivity greater than the theoretical maximum would be unlikely based on brood counts and nest success.

The minimum productivity was calculated by assuming 50

Table 22. The projected Oregon pre-season dusky Canada goose population 1967-1971.

	1966*	1967		1968		1969		1970		1971	
		Max. **	Min. +	Max. **	Min.+	Max. **	Min. +	Max. **	Min. +	Max. **	Min. +
Immature Female	5,399	4,035	1,659	4,234	1,677	4,239	1,496	4,109	1,191	4,049	977
Immature Male	5,376	4,035	1,659	4,234	1,677	4,239	1,496	4,109	1,191	4,049	977
Total Immature	10,775	8,070	3,318	8,468	3,354	8,478	2,992	8,218	2,382	8,098	1,954
Subadult Female	1,504	2,322	2,322	1,735	713	1,821	721	1,823	643	1,768	511
Subadult Male	1,617	2,312	2,312	1,735	713	1,821	721	1,823	643	1,768	511
Total Subadult	3,121	4,634	4,634	3,470	1,426	3,642	1,442	3,646	1,286	3,537	1,022
Adult Female	3,714	3,370	3,370	3,659	3,659	3,479	2,837	3,416	2,306	3,276	1,910
Adult Male	5,171	4,392	4,392	4,320	4,320	3,911	3,269	3,698	2,678	3,560	2,153
Total Adult	8,885	7,762	7,762	7,979	7,979	7,390	6,106	7,114	4,984	6,836	4,063
Total Oregon Preseason Population***	22,781	21,847	15,714	19,917	12,759	19,510	10,540	18,978	8,652	18,470	7,039

* From Table 20.

** Calculated assuming 50 percent of the subadult and all adult females attempt to nest, a nest success of 85 percent, a productivity rate of 3.40 and the average mortality rates for each age group calculated by Henny (1967).

\+ Calculated assuming 50 percent of the subadult and all adult females attempt to nest, a nest success of 62.9 percent, a productivity rate of 1.82 and the average mortality rates for each age group calculated by Henny (1967).

*** Less mortality that occurred prior to arrival in the study area.

percent of the subadult and all adult females attempt to nest, that the nest success was 62.9 percent and that the productivity rate was 1.82. This estimate of nest success and productivity rate were chosen because they represent the lowest combination of nest success and productivity possible from the data in Table 21. There are many combinations of nest success and productivity rate that are above and below the lowest possible combination in Table 21. However, based on studies conducted by Shepherd (1965) on the breeding ground, lower combinations seem unlikely. Maximum and minimum population levels presented in Figure 9 probably bracket the population levels for the next five years providing mortality rates remain the same.

The population could decrease 18 percent in five years with the theoretical maximum productivity; with the theoretical minimum productivity the population could decrease as much as 69 percent in five years. In making these population projections I assume that the mortality rates will not change as population levels decline; however, this is highly unlikely because with a decrease in immatures in the population adult mortality rates will probably increase.

Henny (1967) pointed out that immature mortality rates were increasing in recent years. It seems apparent that unless changes are made to alter mortality rates a population decline will occur. The population was stable in 1965 and 1966 at about 23,000 geese.

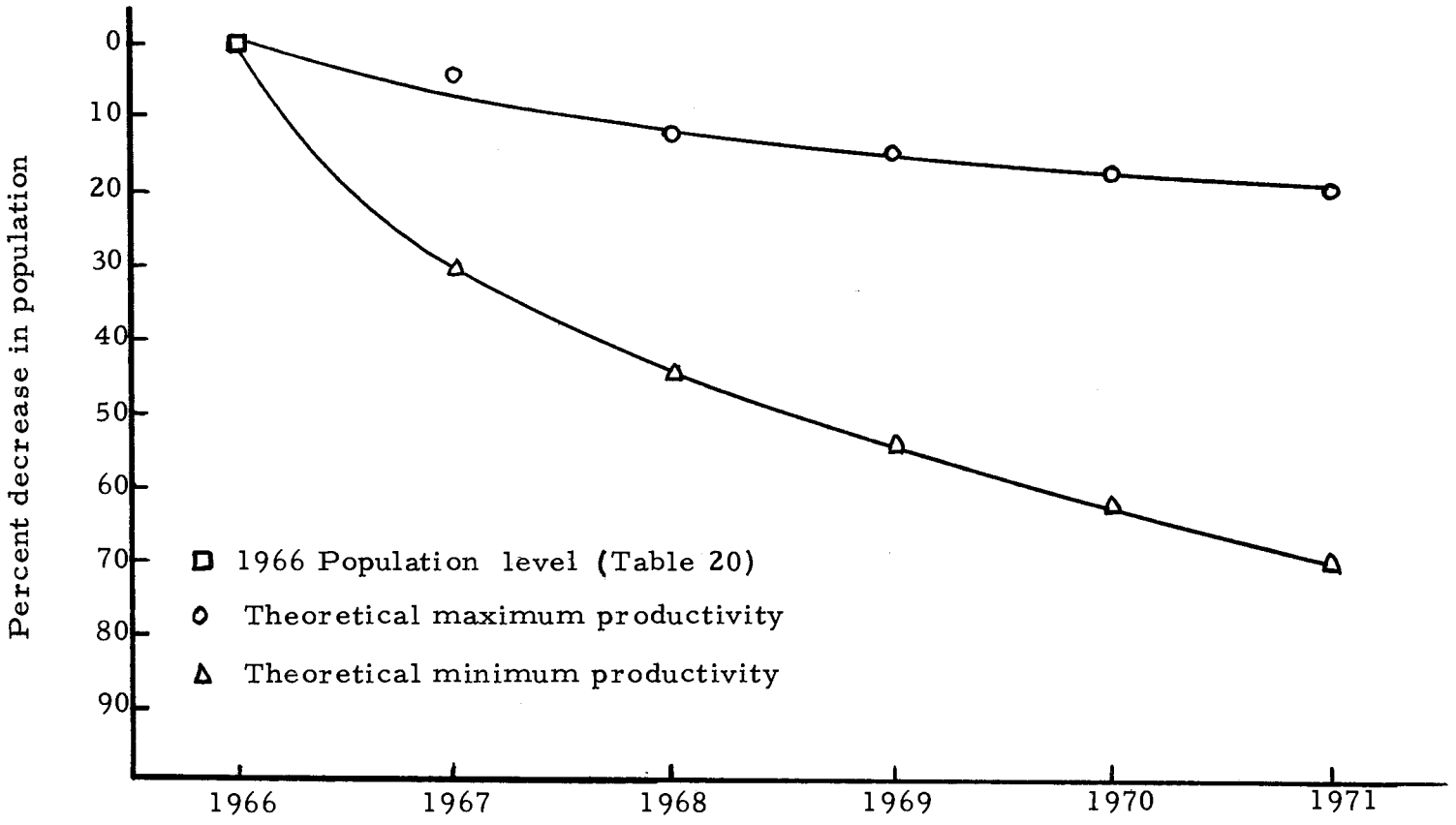

Figure 9. The projected Oregon pre-season dusky Canada goose population levels based on the average mortality rates calculated by Henny (1967) and the theoretical maximum and minimum productivity.

The percentage of adults in the population declined in 1966 (Table 20). In order to maintain a stable population in 1967 the number of immatures produced must be greater than the theoretical maximum productivity (Figure 9).

SUMMARY AND CONCLUSIONS

The dusky Canada goose is the most important goose in the Willamette Valley, Oregon, accounting for over 95 percent of the hunter goose kill. The annual kill of the dusky Canada goose in the study area was between 4,000 and 5,000 geese. From 50 to 67 percent of the total kill occurred on the Oak Knoll Complex and Fringe Unit. The hunter success on the Oak Knoll Hunt Club was over two geese per hunter day, while Henny (1967) found that in the remainder of the Willamette Valley the average hunter kills less than one goose a year.

During the three year study period the number of geese using the William L. Finley National Wildlife Refuge has increased. The geese moved to the refuge earlier in each succeeding year of the study. In 1964 and 1965 the geese arrived on the Oak Knoll Complex and then moved to the Finley Refuge. In 1966 the geese arrived on the Oak Knoll Complex and William L. Finley National Wildlife Refuge simultaneously.

The kill on the Oak Knoll Complex was found to be dependent on the number of hunters not the number of geese present. In the remainder of the study area the kill appeared to be dependent on the number of geese not the number of hunters. A marked decrease in the number of geese using the Rickreall-McMinnville Unit was noted

in 1966 probably because the geese moved to the Finley Refuge. As a result the total kill in the Rickreall-McMinnville Unit was substantially lower in 1966 than in either 1965 or 1964.

Movement of large numbers of geese to the Finley Refuge did not alter the kill on the Oak Knoll Complex. The kill increased in all three years of the study. This was especially noticeable in 1966 when the kill on the Oak Knoll Complex and Fringe Unit increased approximately 20 percent over 1965.

Immatures made up a disproportionately high percentage of the kill on the Oak Knoll Complex. The number of immatures in the kill increased each year of the study. This increase in the percentage of immatures in the kill may lead one to believe the population is increasing, however, the population remained stable in 1965 and 1966. Hanson (1950) stated:

> A relatively high kill of juveniles coupled with a year in which productivity is low is almost certain to place a goose population in a hazardous position.

The age composition of the 1964 pre-season population indicated the percentage of immatures was below the level necessary to maintain a stable population. The Alaskan earthquake and other factors apparently resulted in reduced production on the Copper River delta. The effect of this poor production was demonstrated when the Oregon pre-season population dropped approximately 20 percent in 1964. Hanson (1950) further stated:

> A year of low productivity in Canada geese should be of particular concern to the administrators who seek to influence the kill by hunting regulations, for the reason that the young birds bear a double responsibility. Being more vulnerable to shooting than the adults, they must contribute a disproportionate share of the kill, and, secondly, they must survive in sufficient numbers to help reproduce an equivalent of the annual loss in the breeding population.

The Oregon pre-season population was fairly stable in 1965 and 1966 at about 23,000 geese. The percentage of immatures in the population has increased in each year of the study. The percentage of adults in the population dropped in 1966 while the number of immatures in the population increased to nearly 50 percent. The percentage of subadults in the population in 1965 and 1966 remained the same, possibly indicating that the number of subadults in the 1965 population was not sufficient to replace adult losses. Hanson (1965) discussing the importance and meaning of a situation similar to that which the dusky Canada goose population seems to be approaching, stated:

> It would be reasonable to assume that a high percentage of immatures (50 to 60 percent) in a goose flock in autumn would necessarily indicate a thriving and secure population. But more than likely it may point to a population whose age structure is out of balance as a result of heavy losses from hunting or from one or more preceeding years of extremely low productivity, or a combination of both.

Henny (1967) found that approximately 50 to 65 percent of the subadult and all of the adult females must attempt to nest, and the

nest success must be between 85 and 90 percent in order to maintain a stable population. He further calculated that the probable maximum productivity rate under these conditions would be approximately 3.40. The calculated productivity rate in 1964 (1.82) fell well below Henny's (1967) figure of 3.40. In both 1965 and 1966 the calculated productivity rate was similar to Henny's maximum productivity figure.

The dusky Canada goose population is maintaining near maximum production, with an increasing percentage of immatures in the population, and the population is not increasing. This apparent inbalance in the age structure of the population has been shown to be near its maximum. It appears that unless adjustments are made to reduce mortality rates a series of poor nesting years could markedly reduce the population. The effect of one year of poor production was demonstrated in 1964 when the population size declined sharply. Shepherd (1965) has pointed out that ecological changes on the Copper River delta caused by the Alaskan earthquake may have an adverse effect on dusky Canada goose production in the future. It therefore seems reasonable that some form of protection be imposed to reduce mortality while the population is still large enough to sustain some hunting pressure.

There are two basic methods of reducing Canada goose mortality; refuges and hunting regulations. Since the development of the William L. Finley National Wildlife Refuge and its satellites, large

numbers of dusky Canada geese have moved to these refuges. However, the effect of the refuges on the total goose mortality has been negligable, primarily because of the excellent management of hunting on the Oak Knoll Complex. Whether or not the refuges will ultimately reduce the mortality on this population can only be speculated, but at present I cannot foresee this happening. The Oak Knoll Complex is growing each year with more hunt clubs proposed in the future. It has been shown that with large numbers of geese present on the refuge, the Oak Knoll Complex can still sustain a maximum harvest of geese. It appears that the refuge alone cannot adequately reduce the dusky Canada goose mortality rate and, therefore, some form of hunting restrictions appear to be necessary.

Henny (1967) has outlined four possible methods of reducing the mortality of dusky Canada geese. These methods are: (1) the establishment of a season bag limit, (2) the establishment of a yearly quota system, (3) a reduction of the bag limit, or (4) a reduction of the length of the hunting season. The effects of establishing a season bag limit cannot be calculated. The yearly quota system has the advantage of maintaining mortality at the proportion desired, thus allowing regulation of the population size. The effect of the latter two restrictions can be calculated from the kill data collected on the Oak Knoll Complex. A reduction of the bag limit could have its greatest effect on the "Complex" because of low hunter success

throughout the remainder of the study area. A reduction in the length of the hunting season could have its greatest effect on adult mortality in areas other than the Oak Knoll Complex, because adults and immatures are killed in nearly equal numbers in these areas.

The restrictions applied to the kill data from the Oak Knoll Complex were, (1) reduction in the bag limit to two birds (reduce bag by one bird), (2) closure of the hunting season 18 days early, and (3) closure of the hunting season 25 days early. These dates were chosen because the peak of the adult kill occurred in the last three weeks of the season (Figure 5).

The effect of reducing the bag limit by one bird was calculated by subtracting the percentage of the average bi-weekly hunter success in excess of two birds from the total kill during the 1965-66 and 1966-67 hunting season during each bi-weekly period. All of the reduction occurred between 31 October and 12 December. The effect of shortening the season was calculated by subtracting all geese shot after the theoretical closing dates. Table 23 shows the effect of the changes in the season length and bag limit on the kill at the Oak Knoll Complex, during the 1965-66 and 1966-67 hunting seasons.

The manipulation of the bag limit and season closure dates caused marked differences in the age composition of the kill. A majority of the geese saved by reduction of the bag limit by one bird would be immatures (Table 23). These immature geese would not

Table 23. The calculated effect of manipulations of the season length and bag limit on the dusky Canada geese killed on the Oak Knoll Complex 1965-66 and 1966-67.

	Reduce bag limit to two geese			Shorten season 18 days			Shorten season 25 days		
	Percent reduction in kill			Percent reduction in kill			Percent reduction in kill		
	Adult*	Immature	Total	Adult*	Immature	Total	Adult*	Immature	Total
1965	12.8	22.9	19.8	28.7	12.7	17.6	49.3	20.8	29.5
1966	13.3	21.5	19.7	33.9	9.7	15.1	42.5	15.4	21.5
Average	13.1	22.0	19.7	31.2	10.9	16.2	45.9	17.6	25.0

*Includes subadults.

become part of the productive element of the population for at least two years. However, the effect of closing the season early would markedly reduce the subadult and adult kill because a majority of the harvest of these age groups occurred near the end of the hunting season (Figure 5, Table 23).

It should be pointed out that a late opening of the hunting season will have little or no effect on dusky Canada goose mortality in the Willamette Valley because these geese do not usually arrive before early November.

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APPENDIX

CANADA GOOSE TAIL—FEATHER COLLECTION ENVELOPE

Hunters: You can help the Oregon State University's Dept. of Fisheries and Wildlife to conduct a study of the PRODUCTIVITY of geese in Oregon. We need tail feathers from each Canada goose you kill this season. From these we can tell whether it was hatched this past summer or was an older bird. The proportion of young in the kill tells us how good a "crop" of birds was produced.

PLEASE

1. Pull all the tail feathers.
2. Place these feathers in envelope.
3. Use ONE ENVELOPE for each bird.
4. Continue collecting tail feathers for the entire season.
5. If no provision is made for collecting envelopes at your place of hunting, PLEASE MAIL. No postage is required.

PLEASE COMPLETE

County _____

Nearest town _____

Date Shot _____

If banded list number _____

Name _____

Address _____

PLEASE LEAVE BLANK

Cloacal Exam.			**Tail Exam.**
Ad.	M.	F.	Ad.
Sub. Ad.	M.	F.	Imm.
Imm.	M.	F.	Unk.
Unk.	M.	F.	
			Wt.

Appendix 1. Information side of the self-addressed stamped tail feather envelope used during the Random Hunter Survey.

Appendix 2. Letter accompanying envelopes for tailfeathers sent to goose hunters during the 1966-67 random hunter survey.

OREGON STATE UNIVERSITY
DEPARTMENT OF FISHERIES AND WILDLIFE

DUSKY CANADA GOOSE PRODUCTION STUDY
Corvallis, Oregon

Dear Goose Hunter:

Your name has been selected from a list of Oregon sportsmen who have indicated (in this year's mail survey of hunters, conducted by Oregon State University) that they hunt geese in the Willamette Valley.

We would appreciate your cooperation in a research project designed to learn about the production of young in these geese.

We can determine production by obtaining a collection of tailfeathers from cooperating sportsmen and identifying tailfeathers of those geese that were hatched this past spring. The number of young geese compared to the number of adult geese that you and others kill is our best estimate of the nesting success that occurred during the past breeding season.

Enclosed are a number of envelopes. Will you please place the tailfeathers from each of the geese that you or your hunting parties shoot in the separate postage-paid envelopes. Use one envelope for each goose. Mail the envelopes as soon as possible after the hunt. Please fill in the information blank on the back of the envelope before mailing. Additional envelopes may be mailed to you later in the season.

Thank you, and good hunting!

Howard M. Wight
Associate Professor of
Wildlife Ecology