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Title: Comparative Ecology of Several Subspecies of Canada Geese During Winter in Western Oregon

Abstract approved: Robert L. Jarvis

Distribution, harvest, and foraging ecology of Canada geese (Branta canadensis) were studied from October through April, 1975-76 to 1977-78, in the Willamette Valley, Oregon. The relative abundance of Taverner's Canada geese (B. c. taverneri) increased significantly ($P < 0.01$) from ~25 percent in 1975-76, to ~50 percent in 1977-78. Distribution of subspecies was not uniform throughout the study area. Dusky Canada geese (B. c. occidentalis) comprised between 70 and 80 percent of the harvest each year on refuges. During 1977-78, the percent composition of the harvest was not significantly different on and off refuges. During 1976-77 and 1977-78, duskys were 2.8 and 2.6 times as vulnerable to harvest as Taverner's. Harvest rates and kill rates for duskys were approximately twice those for Taverner's and lesser Canada geese (B. c. parvipes) combined during the 1977-78 hunting season. Differences in vulnerability to hunting were attributed to distribution of the subspecies in relation to hunting pressure, and to differences in flocking behavior. Mean flock sizes and mean sizes of groups arriving in fields were not significantly different between subspecies, although Taverner's occurred in large groups more frequently than duskys. Taverner's used significantly ($P < 0.01$) larger fields than duskys.

Comparative Ecology of Several Subspecies of Canada Geese During Winter in Western Oregon

by

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INTRODUCTION

Early occurrence of Canada geese (*Branta canadensis*) in the Willamette Valley, Oregon, was not well documented in the literature, but dusky Canada geese (*B. c. occidentalis*) probably occurred there as early as the 1940s (Jewett 1932, Gabrielson and Jewett 1940, Gullion 1951, Chapman *et al.* 1969, Bellrose 1976). Intensive management of this flock began in the early 1960s with the acquisition and development of a refuge complex by the U. S. Fish and Wildlife Service. A management plan followed which established objectives for population size, distribution, and harvest of dusky Canada geese (1973 unpublished report of the Pacific Flyway Council). Although small numbers of other subspecies of Canada geese occurred in the Willamette Valley in winter, these were considered transient rather than resident wintering birds (Kebbe 1960, Hansen 1962, Smith 1971 unpublished report, Subspecies Composition of Wintering Canada Geese in the Mid-Willamette Valley of Oregon, Bellrose 1976). Institution of the management plan resulted in a marked increase in the size of the dusky population (from less than 20,000 during the 1950s and early 1960s to 20-25,000 during the early 1970s) and a dramatic increase in the numbers of other subspecies of Canada geese residing in the Willamette Valley in winter.

During the winter of 1975-76, observations indicated that 26 percent of the wintering flock of Canada geese were light-colored geese, and by the following winter, light geese comprised nearly 50 percent of

the wintering flock. On the basis of appearance and measurements, Jarvis (personal communications) identified the lighter-colored geese as Taverner's Canada geese (B. c. taverneri after Delacour 1954). In addition, band returns indicated the presence of geese from Cook Inlet, Alaska, which were identified as lesser Canada geese (B. c. parvipes) (Dan Timm, personal communications).

Taverner's Canada geese are suspected to nest over extensive tundra areas of Alaska (Dan Timm, personal communications). The inaccessibility of the nesting grounds and low densities of nesting geese hinder large-scale banding efforts and intensive productivity studies. The majority of the population reportedly winters in the Sacramento Valley, California, and in the Columbia Basin (Bellrose 1976). The breeding ground origin of the various wintering units is unknown.

Of major concern in the Willamette Valley was the impact of substantial numbers of other subspecies of Canada geese on the intensively managed dusky population. For example, preliminary analyses of harvest data indicated that duskys were more vulnerable to hunting than other Canada geese in western Oregon. The purpose of this study was to provide information necessary to determine whether or how to adapt the current dusky-based management plan to the changing subspecies composition of the wintering flock of Canada geese in the Willamette Valley, Oregon. My objectives were:

1. To determine the relative spatial and temporal distributions of the subspecies of Canada geese in the Willamette Valley in winter.

2. To determine the rate and characteristics of the harvest of the subspecies.

3. To compare several aspects of the foraging ecologies of the subspecies.

METHODS

Study Area

The study area was located in the Willamette Valley, between the Cascade Mountains and the Coast Range, in western Oregon. The area extended from Sauvie Island in the north to Junction City in the south (Figure 1), and was divided into 6 units similar to those of Chapman et al. (1969). Three National Wildlife Refuges (NWR's) were located within the study area: William L. Finley NWR, Ankeny NWR and Baskett Slough NWR. In addition, the area included Sauvie Island Game Management Area (Sauvie Island GMA), operated by the Oregon Department of Fish and Wildlife. Most of the Canada geese observed during the study were associated with one of these management areas.

Collection of Data

Distributions of subspecies were determined by observation. Location, size and subspecies composition of flocks were noted. During the 1975-76 and 1976-77 field seasons observations were not conducted on a regular basis. During the 1977-78 field season (October through April), observations were conducted weekly on the three National Wildlife Refuges and approximately every two weeks on Sauvie Island. Time spent sampling off refuges was approximately proportional to the number of geese present in each part of the study area, although the infrequency of censuses and the mobility of geese prevented truly representative sampling. Results of periodic aerial surveys were consulted to ensure that no large concentrations of geese were overlooked during ground

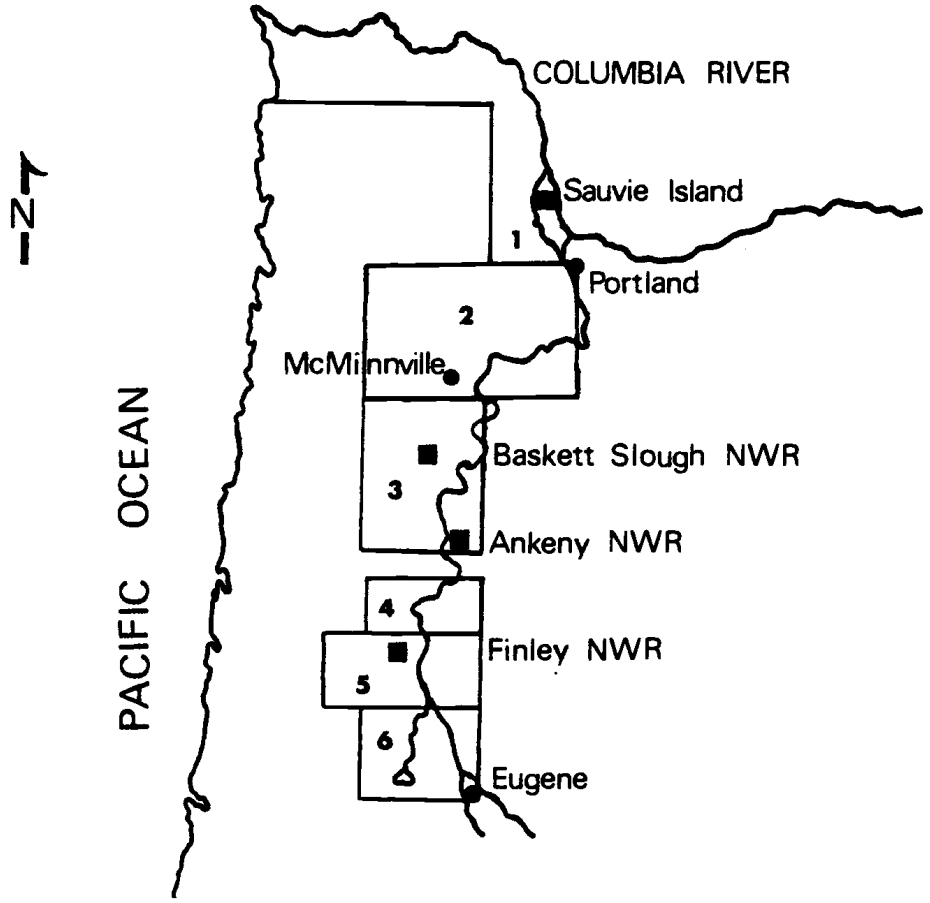

Figure 1. The study area in the Willamette Valley of western Oregon, with delineation of units 1 through 6 and locations of refuges.

surveys. I assumed there were no significant differences in observability among the subspecies.

Data on age and sex ratios and subspecies composition of the harvest on refuges were obtained at refuge checkstands. Age of geese was determined by the notched tail feather technique (Hanson 1962); thus both adult and yearling geese were treated as "adults" in my analyses. Sex was determined by cloacal examination. Measurements taken included culmen, diagonal tarsus (Dill and Lee 1970), flattened wing and central

tail feather. Checkstand personnel received instruction prior to the start of the hunting season to standardize measurement techniuqes. During the 1976-77 hunting season, color of the breast of geese harvested was characterized as light, medium or charcoal gray. During the 1977-78 season, a chart of six numbered colors was used to quantitatively describe breast color.

Characteristics of the harvest off refuges in 1977-78 were determined with the aid of a parts-survey questionnaire sent to hunters who indicated on an Oregon Department of Fish and Wildlife survey that they shot at least one goose during the 1976-77 hunting season. Date and location of the hunt, the full set of tail feathers and several breast feathers from each goose harvested were requested. In addition, private hunt clubs at varying distances from Baskett Slough NWR each received 20 questionnaire envelopes for breast and tail feathers from geese harvested during the middle two weeks of the 1977-78 hunting season. A reference collection of breast feathers was compiled from geese of known subspecies. Feathers received from the surveys were then compared with those in the reference collection to determine subspecies. Taverner's and lesser Canada geese could not be distinguished by this technique and so were combined in analysis of the data.

Harvest rates, kill rates, and estimates of numbers present in midwinter were derived from distribution and harvest data (for calculations see Appendix A). "Harvest rate" and "kill rate" were defined as in Anderson and Burnham (1976).

Aspects of foraging ecology investigated during the 1977-78 field season included:

1. Size and subspecies composition of feeding flocks.
2. Size and subspecies composition of groups arriving in fields.
3. Size of fields used.
4. Distance of fields from nearest refuge or concentration area.

Items 1 and 2 were determined by observation. Size of fields and distance from nearest refuge or concentration area were determined with maps, aerial photographs, and a planimeter.

Analysis of Data

Distribution and harvest data were analyzed by refuge, by unit, and by county. "Southern Willamette Valley" referred to the portion of the study area south of McMinnville, Oregon (Figure 1). Relative abundances of the subspecies were compared between areas or units of time by Chi-square tests of independence (Dixon and Massey 1969). The significance of differences between means of variables associated with foraging ecology was determined with the Student's t-test (Sokal and Rohlf 1969). Regression analysis was used to test for a relationship between subspecies composition of feeding flocks and distance from refuges. Data from the 1975-76 and 1976-77 field seasons were incorporated where comparable analyses were feasible.

RESULTS

Identification of Subspecies

At least six subspecies of Canada geese, according to the classification of Delacour (1954), occurred in the Willamette Valley during my study. In decreasing order of reported abundance, subspecies present included: B. c. occidentalis (Baird), B. c. taverneri Delacour, B. c. parvipes (Cassin), B. c. minima Ridgway, B. c. fulva Delacour, and B. c. moffitti Aldrich. The latter three occurred in such small numbers or were so easily identifiable that they caused no detectable influence on the data (Delacour 1954, Hansen 1962, Chapman et al. 1969, Bellrose 1976, John Annear personal communications).

Size and coloration were the criteria I used to distinguish among dusky, Taverner's, and lesser Canada geese. My ability to distinguish among subspecies was adversely affected by direct sunlight, which produced high contrasts of light and shadow. Fortunately, the climate of the Willamette Valley in winter is such that direct sunlight seldom posed a problem.

Distinguishing between Taverner's and lessers was difficult, although at close range a faint barred pattern not present on Taverner's could be observed on the sides of lessers. The substantial number of banded lessers in the Cook Inlet population helped to identify these geese in sizable concentrations. In addition, the relatively small number of lessers present in the valley (2,000-3,000) and their affinity for particular areas in the vicinity of Baskett Slough NWR, also somewhat alleviated the problem of distinguishing them from taverneri.

When sunlight or distance from a flock hindered accurate classification of subspecies, geese were often classified only as dusky or "other" (light-colored geese, undistinguished, Taverner's and lessers combined).

In general, size and color differences among the subspecies provided an adequate basis for classification in the field. The differences were discernable to inexperienced observers, at least to the extent that "dark" (dusky) and "light" (Taverner's and lessers) geese could be separated.

Distribution

The relative abundances of the subspecies of Canada geese observed during winter in the Willamette Valley changed significantly ($P < 0.01$) from 1975-76 to 1977-78 (Table 1). While dusky Canada geese comprised 74 percent of the geese observed in 1975-76, by 1977-78 only 50 percent were duskys.

Subspecies composition was significantly different ($P < 0.005$) among refuges in the southern Willamette Valley during all three years (Table 2). In 1976-77 subspecies composition did not differ significantly between Sauvie Island and Ankeny NWR, where the highest proportions of Taverner's occurred. Ankeny NWR also exhibited the greatest change in subspecies composition among years: an increase from 41 percent Taverner's in 1975-76 to approximately 65 percent Taverner's during the following 2 years. A significant ($P < 0.005$) increase in the relative abundance of duskys occurred on Baskett Slough NWR from 1975-76 to 1976-77; from 1976-77 to 1977-78, the decrease in percent duskys at Baskett Slough NWR was slight but significant at the 0.025 level. The

Table 1. Relative abundance of dusky Canada geese in the Willamette Valley, Oregon, 1975-76 to 1977-78.

	1975-76	1976-77	1977-78
Number of observations	120	120	548
Number of geese observed	50,860	70,890	228,370
Percent dusky Canada geese	73.9	54.3	50.0

Table 2. Percent subspecies composition of Canada geese on refuges and on Sauvie Island, 1975-76 through 1977-78.

		1975-76 (%)	1976-77 (%)	1977-78 (%)
Baskett Slough NWR	Duskys	43.8	56.6	55.3
	Light geese[1]	16.7	3.3	8.3
	Taverner's	39.5	35.6	33.6
	Lessers	0.0	4.5	2.8
Ankeny NWR	Duskys	58.7	33.1	32.9
	Light geese[1]	0.0	0.0	1.1
	Taverner's	41.3	64.4	65.7
	Lessers	0.0	2.4	0.2
Finley NWR	Duskys	89.3	83.1	71.9
	Light geese[1]	Tr	1.4	2.7
	Taverner's	10.7	14.8	24.9
	Lessers	0.0	0.1	0.5
Sauvie Island	Duskys	no data	32.8	39.4
	Light geese[1]		2.7	0.2
	Taverner's		64.6	60.4
	Lessers		0.0	0.0

[1]Light geese referred to Taverner's and lessers, undistinguished.

relative abundance of duskys was consistently highest at Finley NWR, although percent duskys decreased significantly ($P < 0.005$) on that refuge from 1975 to 1978.

Subspecies composition was significantly different ($P < 0.005$) on from off refuges within units (Table 3), except at Finley NWR during 1975-76. Relative abundance of duskys differed on and off refuges during and after the hunting season; for each southern Willamette Valley refuge for which data were available, the highest relative abundance of duskys occurred off refuges after the hunting season (Table 3).

Monthly changes in percent subspecies composition were significant at the 0.005 level. Duskys arrived earlier than Taverner's in 1977 (Figure 2), but departure patterns of the subspecies were less clear. Data from 1975-76 and 1976-77 were too scant to compare with 1977-78.

Subspecies composition was analyzed by unit and by county for purposes of comparison with previous studies and state reports. Results

Table 3. Percent of geese observed which were duskys on and off refuges, during and after hunting season, 1975-76 and 1977-78.[1]

	Baskett Slough NWR		Ankeny NWR		Finley NWR	
	On	Off	On	Off	On	Off
1975-76						
During hunting	41.3	64.0	69.0	8.2	88.6	90.6
After hunting	53.3	74.8	38.6	-	97.0	-
Total	43.8	68.7	58.7	8.2	89.3	90.6
1977-78						
During hunting	50.1	29.4	31.2	-	71.2	62.3
After hunting	63.6	67.7	38.6	53.3	73.8	87.0
Total	55.3	43.3	32.9	53.3	71.9	74.7

[1]No data were collected after the hunting season during 1976-77.

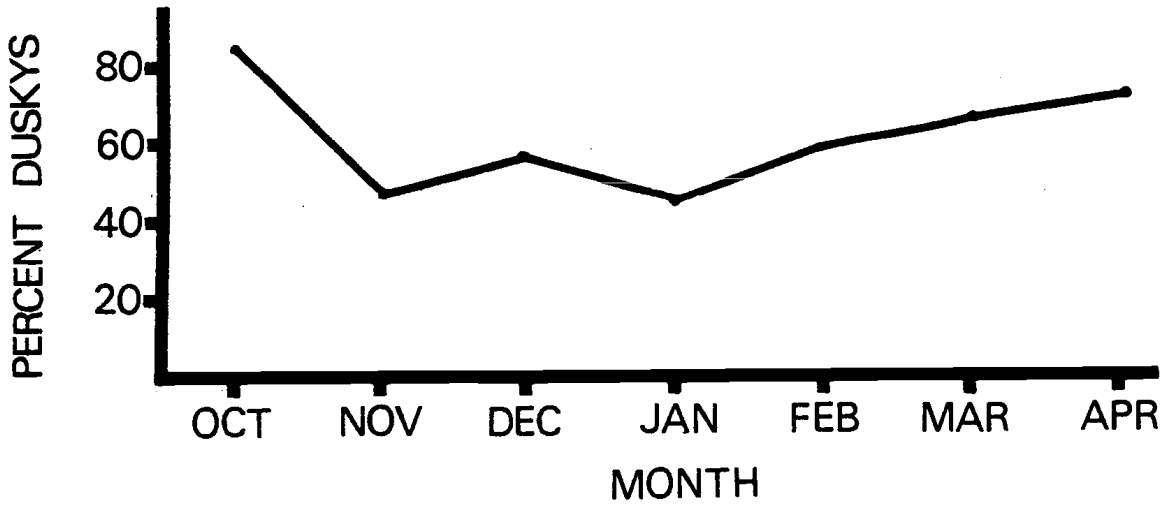

Figure 2. Observed relative abundance (percent) of dusky Canada geese, October through April, 1977-78, in the Willamette Valley.

reflected, for the most part, the patterns which emerged in the analysis based on refuges. Unit 3 included both Ankeny and Baskett Slough NWR's, and thus exhibited relative abundances of subspecies intermediate between those observed on the two refuges.

Harvest

Refuges

Identification of subspecies. In kill samples I relied on color, weight and standard measurements to classify geese. As in field observations, duskys in kill samples were usually easy to distinguish from the other subspecies. Taverner's and lessers were sometimes difficult to separate due to their similarity in color and considerable overlap of measurements (Delacour 1954, Johnson et al. 1979). In some cases I used a discriminant function (Simpson and Jarvis in preparation) to classify problematic individuals. Most geese not actually examined by

me were identified by inspection of age, sex, weight and measurements recorded at checkstands.

Subspecies composition. The total harvest of Canada geese on southern Willamette Valley refuges varied from 1200 (1976-77) to 950 (1977-78). The proportion of the harvest comprised of duskys decreased from 77 percent in 1975-76 to a low of 71 percent in 1976-77 when the harvest was highest, then increased to 75 percent in 1977-78 (Table 4). Differences between years were significant ($P < 0.025$). For each refuge except Baskett Slough NWR, differences between years in subspecies composition of the harvest were significant ($P < 0.025$). Subspecies composition of the harvest was different between refuges each year ($P < 0.005$), except between Baskett Slough and Finley NWR's in 1975-76. On Sauvie Island GMA duskys comprised 73 percent of the harvest in 1976-77, and 80 percent in 1977-78, but the difference between years was not significant ($P > 0.05$). No data were collected on Sauvie Island during the 1975-76 hunting season, and data from 1976-77 and 1977-78 represented only a sample of the total harvest on Sauvie Island GMA.

The greatest change in subspecies composition of the harvest occurred on Ankeny NWR, where the percent duskys in the harvest decreased from 61 percent in 1975-76 to 39 percent in 1977-78 (Table 4). The greatest proportion of duskys in the harvest occurred on Finley NWR during all three years.

Age and sex ratios. During the 1975-76 hunting season, age ratios in the harvest were 0.75 and 0.90 immatures per adult for duskys and Taverner's, respectively (Table 5). During the last two years of the

Table 4. Percent subspecies composition of the harvest of Canada geese on southern Willamette Valley refuges and Sauvie Island GMA, 1975-76 through 1977-78.

		1975-76		1976-77		1977-78	
		Number	Percent	Number	Percent	Number	Percent
Baskett	Duskys	384	77.1	470	72.9	227	73.5
Slough	Taverner's	114	22.9	115	17.8	57	18.4
NWR	Lessers	-	-	60	9.3	25	8.1
Ankeny	Duskys	92	61.3	56	45.2	55	38.7
NWR	Taverner's	58	38.7	57	46.0	86	60.7
	Lessers	-	-	11	8.8	1	0.7
Finley	Duskys	390	81.9	333	75.3	424	86.7
NWR	Taverner's	86	18.1	94	21.3	50	10.2
	Lessers	-	-	15	3.4	15	3.1
Subtotal	Duskys	866	77.0	859	70.9	706	75.1
(NWR's)	Taverner's	258	23.0	266	22.0	193	20.5
	Lessers	-	-	86	7.1	41	4.4
Sauvie	Duskys	no data		326	73.3	131	79.9
Island	Taverner's			87	19.5	25	15.2
GMA	Lessers			32	7.2	8	4.9

Table 5. Age and sex ratios of Canada geese harvested on refuges in western Oregon, 1975-76 through 1977-78.

Willamette Valley NWR's		Number Harvested	Immatures per Adult	Males per Female (Adults)
1975-76	Duskys	866	0.75	1.54
	Taverner's	258	0.90	0.94
1976-77	Duskys	859	0.95	1.06
	Taverner's	266	0.88	0.76
	Lessers	86	0.91	1.20
1977-78	Duskys	706	1.22	1.19
	Taverner's	193	0.86	0.82
	Lessers	41	0.71	2.00
Sauvie Island GMA				
1976-77	Duskys	326	0.88	0.73
	Taverner's	87	1.23	0.86
	Lessers	32	0.78	1.00
1977-78	Duskys	131	1.47	1.04
	Taverner's	25	1.50	1.00
	Lessers	8	0.60	0.00

study the age ratio of Taverner's harvested on refuges including Sauvie Island GMA decreased slightly to approximately 0.87 immatures per adult. The age ratio for duskys in the harvest increased slightly in 1976-77, and exceeded 1.2 for the 1977-78 hunting season (Table 5). Lesser Canada geese were harvested at the rate of 0.91 and 0.71 immatures per adult during the 1976-77 and 1977-78 hunting seasons, respectively, on refuges including Sauvie Island GMA. Percent adults in the weekly harvest on refuges increased after the fourth week of the season, and decreased during the last weeks of the season during 1976-77 and 1977-78 (Figure 3).

Sex ratios (males:females) of adult duskys harvested on southern Willamette Valley refuges exceeded 1.0 during all three years of the study (Table 5). The sex ratio for adult Taverner's reached 1.0 only during the 1977-78 hunting season on Sauvie Island GMA.

Off Refuges

Identification of subspecies. Comparison of breast feathers with the reference collection to identify subspecies resulted in ~15 percent error when tested on a known sample taken from geese harvested on refuges, with duskys being misidentified twice as frequently as Taverner's and lessers combined. However, because this information was used only to compute relative abundances in the harvest, equal numbers of geese misclassified in each direction cancelled each other and resulted in only a 5.2 percent error.

Subspecies composition and age ratios. Responses were received from 33 of 200 hunters sampled. Breast feathers and tail feathers of

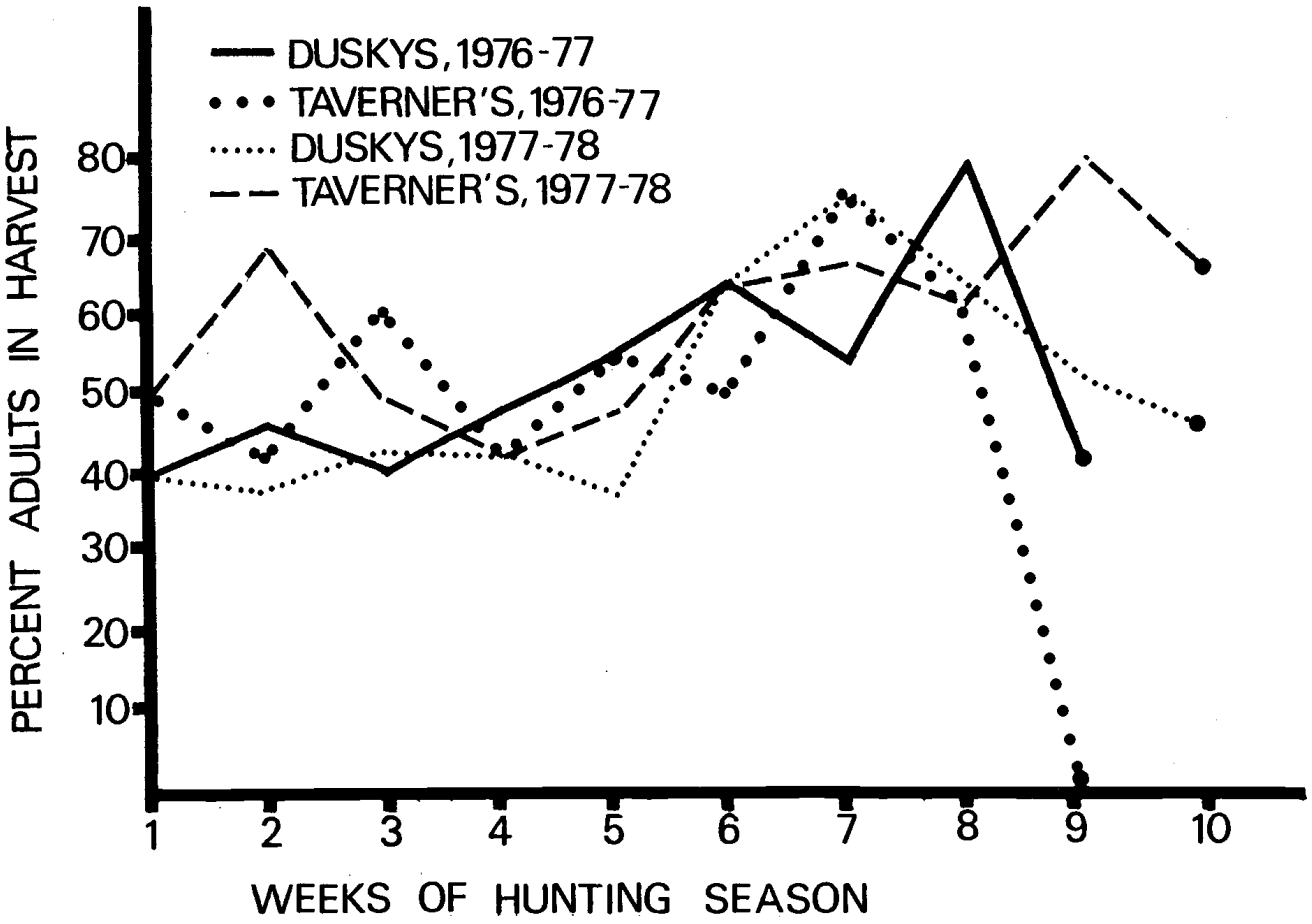

Figure 3. Percent adults in the harvest of dusky and Taverner's Canada geese on Willamette Valley refuges 1976-77 and 1977-78.

Table 6. Percent subspecies composition and age ratios of the harvest of Canada geese off refuges in the Willamette Valley, 1977-78.

	Duskys			Taverner's and Lessers		
	Number	Percent	Im/Ad	Number	Percent	Im/Ad
Random	54	68.3	1.57	25	31.7	0.92
Clubs	42	73.7	1.00	15	26.3	0.87
Total	96	70.6	1.29	40	29.4	0.90

79 Canada geese harvested within the study area were received; 68.3 percent of the 79 were duskys (Table 6). Age ratios in the sample were 1.57 immatures per adult for duskys and 0.92 immatures per adult for Taverner's and lessers.

In a sample collected at five hunt clubs in Unit 3, 73.7 percent of 57 geese harvested were duskys (Table 6). Subspecies composition of the samples differed among clubs; the highest proportion of duskys (88.2 percent) occurred on a club approximately 17 km north of Baskett Slough NWR, while only 50.0 percent were duskys in a sample taken 5.8 km north of the refuge. Age ratios (immatures per adult) were 1.0 for duskys and 0.87 for Taverner's and lessers.

Although a lower proportion of duskys occurred in the harvest off refuges, the subspecies composition of the total combined harvest off refuges (random and club surveys) was not significantly different from subspecies composition of the harvest on refuges. Age ratios in the total combined harvest off refuges were 1.29 immatures per adult for duskys and 0.90 immatures per adult for Taverner's and lessers. Percent adults in the harvest increased steadily throughout the season for both subspecies. The combined harvest off refuges in Unit 3 contained nearly

the same proportion of duskys (72.6 percent) as did the harvest on Baskett Slough NWR (73.5 percent).

Twelve of 19 survey responses from Sauvie Island came from private hunt clubs; these responses indicated 41.7 percent duskys in the harvest. The difference in subspecies composition of the harvest on and off the Game Management Area was significant ($P < 0.005$).

Relative Vulnerability

Relative vulnerabilities (likelihood that a member of one subspecies will be harvested compared to likelihood that a member of a second subspecies will be harvested) calculated for dusky and Taverner's Canada geese on refuges in the Willamette Valley indicated that duskys were more vulnerable to harvest than Taverner's, except on Finley NWR during the 1976-77 hunting season (Table 7). Based on subspecies composition figures for the entire study area, duskys were 2.8 times as likely to be

Table 7. Relative vulnerabilities to hunting of dusky and Taverner's Canada geese in the Willamette Valley, 1976-77 and 1977-78.

	1976-77	1977-78
Baskett Slough NWR	2.3	3.6
Ankeny NWR	1.9	1.4
Finley NWR	0.6	3.3
Subtotal NWR's	1.4	3.4
Off Refuges[1], Unit 3	no data	3.4
Total Study Area[1]	2.8	3.6

[1]Figures compare duskys to Taverner's and lessers combined.

shot as Taverner's and lessers in 1976-77, and 2.6 times as likely to be shot as Taverner's and lessers during the 1977-78 season (Table 7). Off refuges in Unit 3, relative vulnerability of duskys compared to Taverner's and lessers was slightly less than on Baskett Slough NWR, the nearest refuge, during 1977-78 (Table 7). (See Appendix A).

Harvest Rates and Kill Rates

Harvest rates (numbers harvested divided by number in fall flight) were calculated for duskys, and Taverner's and lessers combined during the 1977-78 hunting season (see Appendix A). A harvest of 12,468 duskys, or 68 percent of 18,439 Canada geese harvested in western Oregon (Smouse et al. 1978, Annual Survey of Hunters in Oregon During 1977, Survey Research Center Report, Oregon State University), divided by an estimated fall flight of 39,000 duskys (Dan Timm personal communications) resulted in a harvest rate of 32.0 percent. Adding a 20 percent crippling loss (Craighead and Stockstad 1956, Green et al. 1963, Vaught and Kirsch 1966, Chapman et al. 1969) resulted in a 38.4 percent kill rate for duskys. The number of duskys present in mid-winter, 24,038, was calculated by subtracting total hunting mortality from fall flight.

I divided the number of duskys present in mid-winter by 0.46, the percent duskys in the wintering flock (averaged from November through February and weighted by numbers of geese censused in each area surveyed), to obtain a mid-winter estimate of duskys, Taverner's and lessers totalling 52,256. I derived a mid-winter estimate of Taverner's and lessers (28,218) and added harvest (5,787) plus crippling loss to obtain an estimated fall flight for Taverner's and lessers of 35,162. The

harvest rate for Taverner's and lessers was 16.5 percent; the kill rate was 19.8 percent. The mid-winter estimate of Taverner's and lessers (28,218) constituted a 17.6 percent increase over the 1976-77 mid-winter estimate of 24,000 (Jarvis and Rodgers unpublished report to the Dusky Goose Subcommittee, Pacific Flyway Technical Meeting, March 1978).

Foraging Ecology

The mean size of flocks comprised of at least 95 percent Taverner's was larger than the mean size of flocks comprised of at least 95 percent duskys in all areas during the 1977-78 field season (Table 8), although the difference was significant ($P < 0.01$) only on Sauvie Island. The mean size of groups of duskys arriving in fields was smaller than the mean size of groups of Taverner's arriving in fields, but the difference was not significant. No significant relationship was found between subspecies composition of flocks and distance from refuges.

The mean size of fields used by duskys was significantly smaller than the mean size of fields used by Taverner's ($P < 0.01$) during 1977-78, although on refuges the difference between subspecies was not significant ($P > 0.05$). Off refuges, mean size of fields used by each subspecies was smaller than the mean size of fields used on refuges; the difference between size of fields used on and off refuges was significant only for duskys ($P < 0.05$). The smallest fields used by each subspecies off refuges were larger than the smallest fields used on refuges.

Table 8. Sizes of flocks of at least 95 percent one subspecies of Canada geese in the Willamette Valley, 1977-78.

	Sample Size (No. Flocks)	Mean Size of Flocks
Baskett Slough NWR		
Duskys	24	220.1
Taverner's	3	563.0
Ankeny NWR		
Duskys	12	138.4
Taverner's	22	536.0
Finley NWR		
Duskys	38	289.0
Taverner's	5	388.6
Sauvie Island		
Duskys	24	131.2
Taverner's	32	361.3
Off Refuges		
Duskys	30	158.9
Taverner's	5	235.2
TOTAL		
Duskys	128	202.2
Taverner's	67	420.3

DISCUSSION

Distribution

On Sauvie Island, my classification counts consistently yielded higher proportions of Taverner's than estimates made by Oregon Department of Fish and Wildlife personnel (F. Newton personal communications). Large portions of Sauvie Island GMA, primarily on Sturgeon Lake, were inaccessible by vehicle or on foot, and state personnel felt that large concentrations of duskys were being overlooked by me in those areas. In addition, large flocks (1,000 to 3,000) of Taverner's frequented the easily accessed southern portion of the island. Thus, my observed subspecies composition on Sauvie Island might have been biased toward Taverner's.

The percent subspecies composition of geese on Willamette Valley refuges from 1975 through 1978 (Table 2) did not directly indicate an increase in Taverner's for two reasons. First, the relative abundances reported in Table 2 refer only to observations made within refuge boundaries. However, the observed subspecies composition for Units 3 (Baskett Slough and Ankeny NWR's) and 5 (Finley NWR) for those years did indicate an overall increase in the relative abundance of Taverner's, as did observations conducted throughout the entire study area (Table 1).

Secondly, the observed relative abundances were not converted to actual abundances, since that would have required accurate census figures on a unit and refuge basis for each sampling period. Without accurate census figures it was impossible to draw any conclusions about

movements between refuges during winter. Monthly fluctuations in the observed subspecies composition (Figure 2) were probably due to a combination of movements of geese and sampling error.

A clear pattern of distribution of the subspecies emerged: Taverner's occurred in greater numbers and proportions on Sauvie Island and near Ankeny NWR. Baskett Slough NWR supported nearly equal proportions of Taverner's and duskys as well as most of the lessers. Finley NWR remained a stronghold of the duskys. The north-south cline in proportions of Taverner's present was distorted only by the affinity of Taverner's for Ankeny NWR. Ankeny NWR was the most recently established of the federal waterfowl refuges in the Willamette Valley (1965), and prior to 1975 supported very few Canada geese during winter. Taverner's apparently took advantage of the newly available winter habitat to a greater extent than either dusky or lesser Canada geese.

Harvest

That dusky Canada geese comprised only 70 to 80 percent of the harvest in the southern Willamette Valley during this study, compared to 90 percent 10 years earlier (Chapman et al. 1969), reflected the recent decrease in relative abundance of duskys. On Sauvie Island GMA, however, I found 70 to 80 percent duskys in the harvest in comparison with Chapman et al.'s (1969) finding of 43 percent duskys. Chapman et al.'s (1969) data were collected from the entire island and vicinity, whereas the largest portion of my sample came from the Game Management Area. As was previously noted, duskys were observed on or near the Management Area much more frequently than Taverner's.

Although the trend in relative abundance of duskys and Taverner's was reflected in the harvest, the two subspecies were harvested in the proportions in which they occurred in the Willamette Valley only during the 1975-76 hunting season, when data collected were not as precise nor as complete as data gathered during the last two years of the study. During the 1976-77 and 1977-78 seasons, the relative abundance of duskys decreased but duskys continued to comprise 70 to 80 percent of the harvest. I calculated relative vulnerability to hunting as an index to the relative rates of harvest of the subspecies.

The relative vulnerability of duskys and Taverner's to hunting differed between areas (Table 7), which suggested that external factors as well as factors inherent in the two subspecies affected relative vulnerability. First, harvest rates differed among refuges, and thus probably among areas off refuges as well. For example, over 40 percent of the Canada geese in the Willamette Valley during the 1977-78 hunting season occurred at Ankeny NWR, yet kill at Ankeny NWR accounted for only 15 percent of the harvest on refuges during that season. The reverse occurred on Finley NWR, where roughly 20 percent of the geese provided over 50 percent of the harvest on refuges.

Hunting pressure differed among refuges, with Finley NWR outranking both Ankeny and Baskett Slough NWR's in number of hunters per day. According to the state survey (Smouse et al. 1978, Annual Survey of Hunters in Oregon During 1977, Survey Research Center Report, Oregon State University), hunting pressure and harvest were heaviest in the vicinity of Sauvie Island, and in Polk County (near Baskett Slough NWR). These two areas combined hosted approximately 50 percent of the hunters

and accounted for over 50 percent of the harvest of geese in western Oregon during both the 1976-77 and 1977-78 hunting seasons (Smouse et al. 1978). Furthermore, Sauvie Island GMA allowed hunting every other day throughout the season (mid-October to mid-January), whereas on federal refuges hunting was allowed only on Wednesday, Saturday and Sunday from 15 November to 15 January.

Distribution of the subspecies with respect to hunting pressure was probably an important factor in determining relative vulnerability of the subspecies to hunting over the entire study area. Further evidence of the effect of distribution on vulnerability to hunting was provided by the kill sample collected at hunt clubs in Unit 3. Subspecies composition of the samples from each club reflected the habitual distributions and preferred feeding locations of duskys, Taverner's and lessers within the unit.

Kennedy and Arthur (1974) cited refuge characteristics as responsible for different rates of harvest on subflocks of Canada geese on different refuges in southern Illinois. Size of refuges in relation to number of geese present and available food supply, availability of water, and spatial relationships between hunting areas and preferred feeding and loafing sites on refuges probably all affected harvest rates for particular refuges in the Willamette Valley.

Craighead and Stockstad (1956) found the harvest of Canada geese near two refuges in the Flathead Valley, Montana, was directly related to amount of movement of geese, and that movements of geese were related to biological drives rather than to hunting pressure or weather. Koerner et al. (1974) noted the importance of food supply, social structure of

the flock, and weather factors in determining movements of color-marked geese in Ohio. Differences between duskys and Taverner's with respect to amount of movement could have contributed to the differences in vulnerability to hunting between subspecies on any one refuge.

In a pilot study on Finley NWR (M. K. Williams 1978 unpublished report, Morning Flight Behavior of Wintering Canada Geese in the Willamette Valley, Oregon), no significant differences were found in morning flight behavior of duskys and Taverner's except in time of peak departure (duskys later than Taverner's). However, those conclusions were probably biased by the very small number of Taverner's using the area where the study was conducted (< 10 percent).

Hanson and Smith (1950) suggested decreased wariness of geese at Horseshoe Lake, Illinois, as a factor contributing to high rates of harvest there. Among possible causes of decreased wariness, those authors listed size of aggregations, and size of aggregations in relation to size of area being used (density). Owens (1977) found increased mean and maximum flushing distance with increased size of flocks of wintering brent geese (B. bernicla) in England. During my study, Taverner's were observed in larger flocks than duskys, although statistical analysis of my data did not overwhelmingly support my impressions about differences in flocking behavior based on observations.

A study of flocking behavior conducted during spring of 1977 (C. M. Taylor 1977 unpublished report, Differences in Flight Behavior Between Dusky and Taverner's Canada Geese) revealed that duskys occurred as singles or pairs more frequently than expected, while Taverner's occurred singly or in pairs less frequently than expected on Baskett

Slough and Finley NWR's. The tendency of Taverner's to form large flocks may have reduced their vulnerability to the gun in two ways: (1) large flocks would be more difficult to decoy than small ones, as is common knowledge among experienced goose hunters; (2) the possible tendency of large flocks to prefer large fields would make them more difficult to hunt (Grieb 1970).

Sex and Age Ratios

The sex ratios of adult duskys harvested on Willamette Valley refuges approximated those reported by Chapman et al. (1969) except during the first year of my study. The paucity of band return data on Taverner's prevented speculation on possible reasons for the lower (fewer females) sex ratios of adult Taverner's killed on refuges during my study.

Age ratios of duskys in the harvest were lower (fewer immatures) than those reported by Chapman et al. (1969), although the increase from 1975-76 to 1977-78 (Table 5) reflected an increase in percent young in the population (Bromley, personal communications). For both Taverner's and duskys, age ratios in the harvest were higher (more immatures) off than on refuges (Tables 5 and 6). Chapman et al. (1969) reported that age ratios were lower in the harvest outside the Oak Knoll Complex (which was managed very much like a refuge) than on the Complex and Fringe Unit, where over half the total harvest of duskys occurred. During my study less than 10 percent of the harvest of duskys occurred on federal refuges in Oregon, so that although distribution of the harvest in the Willamette Valley changed considerably, the variation in age

ratios in the harvest in relation to where the bulk of the harvest occurred remained the same.

If the increase in Taverner's wintering in the Willamette Valley during recent years were due to reproductive success, one would have expected very high age ratios in the harvest of Taverner's. Such was not the case (Tables 5 and 6), and during the last two years of the study age ratios of Taverner's in the harvest were lower than age ratios of duskys. It seemed unlikely that the discrepancy was due to sample sizes. However, the reliability of age ratios in the harvest as indices to percent young in goose populations was questioned by Grieb (1970), Vaught and Kirsch (1966) and others. In addition, relative vulnerability of adult and immature geese to hunting may have varied with harvest rate or with other factors affecting hunting conditions, so that (1) a direct comparison of age ratios of duskys and Taverner's in the harvest may not be a valid means of comparing percent young in the two populations, and (2) the role of reproductive success in the recent increase in Taverner's in the Willamette Valley in winter cannot be entirely discounted on the basis of low age ratios in the kill.

Foraging Ecology

I believe that differences in flocking behavior between duskys and Taverner's were more pronounced than my data indicated. Data on flock sizes contained extremely high variances in relation to sample sizes and mean values. I hoped that examination of sizes of groups arriving in fields would provide more meaningful data. However, off refuges sample sizes were small, and on refuges the short distances of flights,

the large numbers of geese, and the familiarity of geese with refuges rendered the data less meaningful. It was my feeling that a more tightly designed study of the flocking behavior of the two subspecies would detect significant differences.

One possible manifestation of the greater wariness of Taverner's (or of their tendency to form larger flocks) was their preference off refuges for large fields. Marquardt (1962) found that small Canada geese of the Tall Grass Prairie preferred to feed in large open fields with short vegetation, a fact which he related to the evolutionary ecology of the smaller tundra forms of Canada geese. Grieb (1970) noted that the smaller Short Grass Prairie Canada geese not only preferred open areas but would land on the highest point available in fields. The use by geese of larger, more open fields, and the difficulty of hunting such open terrain were suggested as possible factors contributing to lower rates of harvest for Short Grass Prairie Canada geese than for geese of the Mississippi Flyway (Hanson and Smith 1950, Grieb 1970).

The lack of a significant difference in mean size of fields used by duskys and Taverner's on refuges was probably due to the limited choices available to geese on refuges. The fact that geese of both subspecies used smaller fields on than off refuges provided evidence of the decreased wariness of geese on refuges.

CONCLUSIONS

The desirability of identifying and managing separate components of wintering aggregations of Canada geese was emphasized by Crissey (1968), and by Raveling (1969). My purpose was to provide some of the information necessary to reach that goal. I found the "unmanaged" segment of the wintering flock, the Taverner's, increasing more rapidly than the successfully managed and increasing dusky population. Thus, my study provided conclusive evidence in agreement with Raveling (1978): management regulations established with respect to one population or management unit may have very different and unforeseen effects on other populations or segments of populations of Canada geese.

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APPENDIX

APPENDIX A

Calculation of harvest rates and kill rates for dusky and for Taverner's and lesser Canada geese in western Oregon, 1977-78.

	18,439	Canada geese harvested in western Oregon (ODFW survey)
-	184	1% other subspecies in harvest, based on NWR's
=	18,255	Duskys, Taverner's and lessers harvested
x	0.683	Percent duskys in harvest, based on independent survey (Table 6)
=	12,468	Duskys harvested
÷	39,000	Duskys in fall flight (Dan Timm, personal communication)
=	0.320	HARVEST RATE for duskys

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	12,468	Duskys harvested
x	1.2	Adding 20% crippling loss
=	14,962	Duskys dead due to hunting
÷	39,000	Duskys in fall flight
=	0.384	KILL RATE for duskys

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	39,000	Duskys in fall flight
-	14,962	Duskys dead due to hunting
=	24,038	Duskys in mid-winter
÷	0.460	Percent duskys, avg. November-February, corrected for sampling
=	52,256	Duskys, Taverner's and lessers in mid-winter
-	24,038	Duskys in mid-winter
=	28,218	Taverner's and lessers in mid-winter

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	18,255	Duskys, Taverner's and lessers harvested
-	12,468	Duskys harvested
=	5,787	Taverner's and lessers harvested
x	1.2	Adding 20% crippling loss
=	6,944	Taverner's and lessers dead due to hunting
+	28,218	Taverner's and lessers in mid-winter
=	35,162	Taverner's and lessers in fall flight

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5,787 Taverner's and lessers harvested
÷ 35,162 Taverner's and lessers in fall flight

= 0.165 HARVEST RATE for Taverner's and lessers

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6,944 Taverner's and lessers dead due to hunting
÷ 35,162 Taverner's and lessers in fall flight

= 0.198 KILL RATE for Taverner's and lessers

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CALCULATION OF RELATIVE VULNERABILITY

$$\frac{\frac{\%\ \text{DUSKYS IN HARVEST}}{\%\ \text{DUSKYS PRESENT}}}{\frac{\%\ \text{TAVERNER'S IN HARVEST}}{\%\ \text{TAVERNER'S PRESENT}}}$$