Movements and Wintering Locales of Atlantic Flyway Canada Geese

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Abstract: A "home range" analysis using 23,285 observations of 6,036 neck-banded Canada geese (*Branta canadensis*) seen from 16 October to 28 February 1984–87, identified wintering concentration areas within the Atlantic Flyway. Biweekly sampling of 4 cohorts affiliated with these concentration areas during the last 2 weeks of January revealed that >90% of the geese wintering in the Chesapeake Bay and western Pennsylvania regions arrived in these areas by early October. Most geese (>90%) sampled in central New York appeared by early November, while 90% of the sample of birds wintering in North Carolina were not present until early December. Fifteen to 25% of the North Carolina sample was observed in the Chesapeake region prior to their arrival in North Carolina.

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Atlantic Flyway Canada geese have experienced a number of population and distribution changes over the past few decades that are of concern to state and federal wildlife managers. These changes include a decline in the number of birds wintering in the southern portion of the flyway (Hankla and Rudolph 1967, Trost and Malecki 1985), a northward expansion and redistribution of geese on the winter range (Malecki et al. 1988), and an overall decline in the goose population (1989 U.S. Dep. Int., Fish and Wildl. Serv. Midwinter Survey, unpubl. rep.). Management actions to reverse these trends primarily involve manipulation of harvest regulations to influence survival (Hestbeck and Malecki 1989*a*). Success of these actions depends upon defining biologically meaningful cohorts or groups of geese and the ability to relate fall migration movements and timing of each cohort's arrival at its winter terminus to local and regional hunting seasons.

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Cohorts of animals may be defined in many ways. Ideally, cohorts are defined using aspects of the animal's ecology and not artificial criteria. However, delineating biologically based groupings over large geographical areas is difficult. Therefore, previous investigators have used state or regional boundaries to define cohorts of Canada geese on a flyway-wide basis (e.g., Malecki and Trost 1986, Hestbeck and Malecki 1989*a*, *b*). Our objectives were to use observations of neck-banded Canada geese to define biologically based wintering cohorts (i.e., groups of geese wintering in the same area) in the Atlantic Flyway and to follow the fall migration movements of these cohorts to their winter termini. We then relate these movements and chronology to local and regional hunting seasons.

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Methods

From 1983 to 1987, Canada geese were uniquely marked with yellow-black or orange-white neck-bands and standard USFWS legbands in New York, New Jersey, Pennsylvania, Maryland, Delaware, Virginia, North Carolina, and South Carolina. Geese on the Ungava, Hudson, and James bays in northern Canada were also marked. From 1 October to 28 February 1984–1987, paid observers traveled automobile routes through the states where banding occurred and recorded the location of each observed neck-banded goose to the nearest 10-minute degree block. Within each state, the routes traveled by observers were similar among years. Each state was surveyed every 1 to 3 weeks and within a state survey effort was consistent among years.

We used 23,285 neck-band observations of 6,036 individual Canada geese to define discrete goose wintering or concentration areas (referred to as "reference areas") using program HOME RANGE (Ackerman et al. 1988). HOME RANGE uses a harmonic-mean analysis to delineate areas of high animal use by comparing the number of observations in a cell (i.e., a 10-minute degree block) to the number that would be expected if observations were distributed uniformly. This method is used frequently by ecologists to identify core or high-use areas, such as foraging or den sites, within individual home ranges (Dixon and Chapman 1980, Samuel et al. 1985, Ackerman et al. 1988). In this study, we used HOME RANGE in a similar fashion. In our analysis, we assumed that observations of individual geese within the flyway were analogous to locations of an individual within its home range. Our reference areas are thus analogous to the core use areas of individuals. Because program HOME RANGE is based on observations of individual geese, it provides

an objective, eco-geographical basis for defining wintering goose concentration areas.

To determine which regions of the flyway migrating geese used consistently, we defined reference areas for each 2-week period between 16 October and 28 February 1984–1987, (9 periods/yr, $N = 36$) using HOME RANGE. Only rarely ($\leq 1\%$) were birds observed in more than 1 10-minute block during a sampling period; in these instances both sightings were used. Reference area boundaries were delineated by connecting degree blocks of latitude and longitude that were either fully or partially contained in HOME RANGE's average core use area ellipse.

Cohorts of migrant Canada geese in each reference area were identified for each year from 1984 to 1987, using observations of individual geese seen during the last 2 weeks of January. We used this period because Canada geese use traditional wintering areas (Raveling 1978, Trost and Malecki 1985) and the probability of geese moving between reference areas at this time should be low (Raveling 1969). If, however, a goose was observed in more than 1 reference area during this time, it was eliminated from the analysis.

If a cohort constructed using data from the last 2 weeks of January contained <50 individuals, we pooled the data for the entire month of January and used these merged data as the cohort. Cohorts containing <50 geese after pooling were subjectively eliminated because, after initial data analysis, we could not be confident that the patterns observed did not result from the effects of small sample size.

Within-year movements of individual geese in each cohort were followed by determining the degree block of observation for each goose observed during each 2-week sampling period. We examined trends in north-south goose distributions relative to assigned reference areas using the sign test (Zar 1974). Two-week periods were used in our analysis because they provided a balance between maximizing sample sizes (i.e., the number of geese observed) and minimizing the number of geese observed in >1 reference area. We also estimated the percentage of neck-banded birds observed in their assigned reference area for each 2-week period.

Results and Discussion

Between 1984–87, a mean of $1{,}825 \pm 242$ (SD) observations of individual geese were used to define areas of high use for each 2-week sampling period. The number of areas per sample period ranged between 2 and 7, and 6 areas were used consistently by migrating geese (Fig. 1). These reference areas corresponded closely with and enclosed the major concentration areas of Atlantic Flyway Canada geese as described by Addy and Heyland (1968), Hankla and Rudolph (1967), and Bellrose (1978:147). Because of the similarity of results, we feel confident that our reference areas reflect biologically meaningful groupings and that the delineated regions represent sites of high fall-winter use by Canada geese. Although further testing is necessary, these results also suggest that program HOME RANGE may provide an objective, biologically based approach for defining high use areas for other species or populations distributed over large geographical regions.

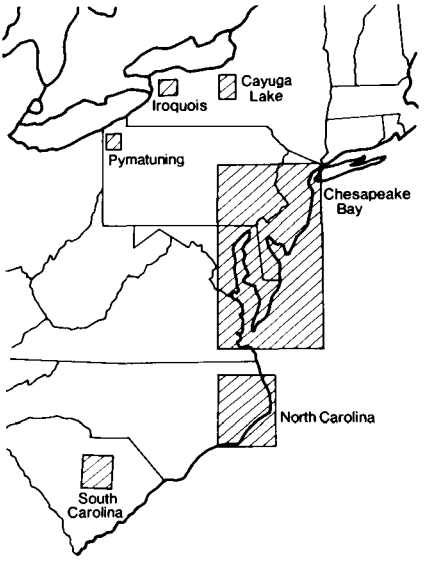

Figure 1. Location of the 6 Canada goose reference areas definded by program HOME RANGE.

The number of neck-banded geese observed in reference areas during late January varied within and between years (Table 1). Because the Iroquois and the South Carolina cohorts contained <50 geese after the January data were pooled, these cohorts were eliminated from further analysis.

The number and percentage of Canada geese observed in all reference areas generally increased through time, reflecting the movement of geese into the flyway (Table 2). Over 90% of the Pymatuning and Chesapeake, Cayuga Lake, and North Carolina cohorts were observed in these areas by early October, early November and early December, respectively (Table 2).

Table 1. The number of neck-banded Canada geese in each cohort for all reference areas. Data for the Cayuga Lake, Pymatuning, Chesapeake Bay, and North Carolina cohorts are the number of geese observed in each reference area during the last 2 weeks of January, 1984 to 1987. Data for the Iroquois and South Carolina cohorts are the number observed in those reference areas during the entire month of January, 1984 to 1987.

	Year				
Cohort	1984	1985	1986	1987	Total
Cayuga Lake	170	288	354	417	1,229
Iroquois	2	16	39	8	65
Pymatuning	108	121	73	70	372
Chesapeake Bay	874	1,061	1,572	1,485	4,992
North Carolina	54	55	84	213	406
South Carolina	30	47	48	32	157

Table 2. The total number (*N*) of Canada geese observed from each reference cohort during 2-week sample periods, 1984 to 1987, and the average percentage (%±1 SD) of these geese observed within their reference area during that period.

2-week	Cayuga Lake			Pymatuning			Chesapeake			North Carolina		
Period	*N*	%	SD	*N*	%	SD	*N*	%	SD	*N*	%	SD
16–31 Oct	130	0.70	0.09	103	0.97	0.04	1116	0.92	0.09	92	0.75	0.12
1–14 Nov	294	0.80	0.08	146	0.95	0.05	956	0.93	0.04	80	0.79	0.06
15–30 Nov	391	0.98	0.04	137	0.97	0.04	1087	0.95	0.02	141	0.81	0.18
1–15 Dec	340	0.97	0.03	138	0.95	0.04	1247	0.97	0.01	136	0.86	0.09
16–31 Dec	487	0.98	0.02	147	0.99	0.02	1348	0.98	0.02	136	0.82	0.14
1–15 Jan	669	100.0	0.00	208	100.0	0.00	1491	0.99	0.01	146	0.96	0.05
16–31 Jan	1229	100.0	0.00	317	100.0	0.00	4992	100.0	0.00	406	100.0	0.00
1–14 Feb	697	100.0	0.00	129	0.97	0.05	1161	100.0	0.00	118	0.93	0.07
15–28 Feb	515	0.98	0.02	100	0.96	0.06	997	0.99	0.01	140	0.94	0.02

Prior to January, geese still outside their reference areas were observed more frequently to the north than to the south (sign test, all $X^2 \geq 46.1$, all $P \leq 0.001$). During February, no north-south pattern existed (sign test, all $X^2 \leq 0.12$, all $P > 0.05$).

Atlantic Flyway Canada geese nest in northern Canada to the east of James and Hudson bays (Addy and Heyland 1968, Bellrose 1978). These geese congregate prior to autumn migration on staging areas located along the coasts of Labrador, Newfoundland, and the Ungava, Hudson, and James bays (Addy and Heyland 1968). Peak movement from staging areas occurs during October and early November (Addy and Heyland 1968), and many geese may migrate directly to their wintering grounds (Addy and Heyland 1968, Harvey 1987). While our results support these conclusions, they suggest that Atlantic Flyway Canada geese may exhibit heterogeneous migration behaviors and that the degree of direct migration may depend upon the location within the flyway of each cohort's winter terminus.

Geese in the Pymatuning and Chesapeake cohorts appear to migrate directly from their staging to wintering areas. Over 85% of the geese in the Cayuga Lake cohort not seen in that reference area during October were observed in the degree blocks immediately surrounding that area. Therefore we suspect that these geese also migrate directly from their staging to wintering areas. Many geese wintering in North Carolina delay their arrival to this reference area, possibly because of delays in the onset of migration or to the use of "stopover" areas. For instance, 15%–25% of North Carolina geese were observed in the Chesapeake region prior to their arrival in North Carolina.

The heterogeneous pattern of fall migration movements exhibited by Atlantic Flyway Canada geese has implications for their management within the flyway. On a regional or site-specific basis, this study indicates that management actions which influence the start of state or regional harvest will affect a high percentage of the migrant geese that winter in those areas. However, geese in the southern portion of the flyway may be exposed to additional harvest because a high proportion of these birds are in northern areas, particularly the Chesapeake region, at the start of hunting seasons.

A major management objective in the Atlantic Flyway is to increase survival and numbers of southern wintering Canada geese. Significant regulatory changes have been made throughout the flyway to achieve this objective. For example, from 1984–87 the opening of the hunting season in the Chesapeake region was delayed by 2 weeks, from 15 October to 30 October, and bag limits were reduced, resulting in a decrease in overall harvest by 8% (USFWS, Office of Migratory Bird Management, unpubl. data). The Canada goose season in South Carolina has been closed since 1985 and a restriction in both season length and bag limit in the North Carolina goose season has reduced their harvest by 25% (USFWS, Office of Migratory Bird Management, unpubl. data). To date, these regulatory changes have not been successful in reversing the decline of southern wintering goose numbers (Hestbeck and Malecki 1989*a*). Other factors such as poor production from northern breeding areas and subsistence hunting in Canada, may be influencing this negative response.

Additional work with each cohort is needed to identify specific research needs and refine our ability to manage them.

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