FALL AND WINTER DISTRIBUTION OF CANADA GEESE IN THE MISSISSIPPI FLYWAY

MICHAEL D. SAMUEL, U.S. Fish and Wildlife Service, National Wildlife Health Research Center, 6006 Schroeder Road, Madison, WI 53711
DONALD H. RUSCH, Wisconsin Cooperative Wildlife Research Unit, 211 Russell Labs, 1630 Linden Drive, University of Wisconsin, Madison, WI 53706
KENNETH F. ABRAHAM, Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, Lakehead University Campus, 955 Oliver Road, Thunder Bay, ON P7B 5E1, Canada
MURRAY M. GILLESPIE, Department of Natural Resources, 1495 St. James Street, P.O. Box 14, Winnipeg, MB R3H 0W9, Canada
J. PAUL PREVETT, Ontario Ministry of Natural Resources, P.O. Box 5483, London, ON N6A 4L6, Canada
GEORGE W. SWENSON, Department of Wildlife Ecology, 226 Russell Labs, 1630 Linden Drive, University of Wisconsin, Madison, WI 53706

Abstract: Canada geese (Branta canadensis) from northern Manitoba and northern Ontario were marked with leg bands and neck bands and observed throughout the Mississippi flyway from 1978 to 1989. We used observations of neck-banded geese within each state to determine the relative fall/winter distribution of the Eastern Prairie Population (EPP) and the Mississippi Valley Population (MVP). Mississippi Valley geese were affiliated with states east of the Mississippi River; EPP geese were affiliated with states west of the Mississippi River. However, we found geographic differences in population distribution within several states. Significant annual changes in distribution also occurred in most states. Management of Mississippi flyway geese should consider the differences in both population dynamics and spatial and temporal distributions of MVP and EPP geese in determining state and flyway harvest objectives.

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Three major populations of interior Canada geese (B. c. interior) wintered in the Mississippi flyway before the increase in giant Canada geese (B. c. maxima) populations: the MVP (Hanson and Smith 1950), the EPP (Vaught and Kirsch 1966), and the Tennessee Valley Population (Bellrose 1976). Hanson and Smith (1950) and Reeves et al. (1968) described the geographic distribution of the MVP from leg-band recoveries. This description was subsequently refined by Craven and Rusch (1983) from observations of birds neckbanded on the Hudson Bay coast and by Tacha et al. (1988) from birds radio-marked in Wisconsin and Illinois. Mississippi Valley geese nest along the Hudson Bay coast and interior lowlands of northern Ontario, migrate through the central portion of the Mississippi flyway, and winter predominantly in southern Illinois, Kentucky, and Tennessee.

The range of the EPP lies west of the MVP. Breeding range of the EPP interior subspecies encompasses the Hudson Bay lowlands of northeastern Manitoba, particularly along the Hudson Bay coast and interior lowlands of northeastern Manitoba (Vaught and Kirsch 1966; Malecki et al. 1980, 1981). The major migration and wintering range of EPP geese is along the western border of the Mississippi flyway (Craven and Rusch 1983) west of the Mississippi River.

Populations of Canada geese in the Mississippi flyway historically have been described on the basis of wintering locale (Tacha et al. 1988). However, determining population origins based on breeding-ground areas is important because recent population management has recognized that breeding-ground conditions play an important role in determining fall flights and subsequent harvest regulations. In addition, these breeding populations overlap on the migration and wintering ranges, especially in states south of 38°N latitude; however, some overlap also exists in Wisconsin, Minnesota, Iowa, Missouri, and Illinois.

Winter population distributions of Canada geese previously were identified by leg-band recovery data. However, the ability to detect annual variation in wintering distributions (Crissey 1955) from leg-band recoveries is limited because they only measure population distribution during the hunting season (Crissey 1955, Anderson and Henny 1972), and they may be influenced by geographic differences in hunter reporting rates (Hickey 1951, Crissey 1955, Nichols and Hines 1987:33). Neck bands applied to geese on breeding areas provide the potential...
for better determination of the fall/winter affiliation of these breeding populations. Observations of neck-banded geese can provide increased information on annual variation in population distribution and on population distribution in areas without hunting.

Aquatic biologists have long recognized that many fisheries may consist of a heterogeneous mix of smaller units with different productivities (Ricker 1958, Hilborn 1985). Two important consequences have been identified when several populations are harvested by a common management (Ricker 1958, Paulik et al. 1967). First, individual populations can be harvested at suboptimal rates. And second, populations with lower productivities may be overharvested. In general, the greater the differences in productivity and size of the populations, the more important it becomes to carefully evaluate the management strategy for each population (Paulik et al. 1967). However, this concept of population management has received little consideration in wildlife management perhaps due to the difficulty of identifying individual populations (Krebs 1978.146).

We documented the migration and wintering distribution of neck-banded Canada geese from northern Manitoba and Ontario during 1978–87. We assessed the degree of annual variation (within states) and the spatial variation (between states) in distribution. We tested the hypothesis that the distribution and affiliation of MVP and EPP geese are temporally constant. We also assessed the overlap in MVP and EPP geese during the fall and winter.

This analysis could not have been completed without the numerous federal and state managers and biologists who regularly observed geese in the Mississippi flyway. Many other individuals contributed to the intensive banding effort in Canada. R. E. Trost, N. T. Weiss, T. J. Moser, and R. J. Malecki provided helpful suggestions for improving the manuscript. Work on our project was initiated while the senior author was employed at the Department of Wildlife Ecology, University of Wisconsin.

METHODS

Canada geese were captured along the coasts of Hudson Bay and James Bay in Manitoba and Ontario from 1976 through 1988. Helicopter-drive trapping (Timm and Bromley 1976) was the primary technique for capturing flightless geese. All geese were legbanded and classified by age and sex. Many adults and some older goslings also were fitted with orange plastic, individually coded neck bands (Craven 1979). For our purposes, EPP geese (Craven and Rusch 1983) were those birds marked in Manitoba north or west of York Factory (57°N, 92°10'W). Mississippi Valley geese were those birds marked in Manitoba south or east of York Factory and in Ontario east to the James Bay coast and south to approximately the Attawapiskat River (52°50'N, 82°10'W), located west of Akimiski Island. Our southern boundary for MVP geese was slightly north and west of the boundary used by Tacha et al. (1988).

We obtained observations of Canada geese on major goose concentration areas (Samuel et al. 1986) in the Mississippi flyway during September–April 1978–79 through 1988–89. Observers recorded individual band-code, location and activity of geese, and estimated numbers of geese with and without neck bands. State, federal, and university biologists made observations during the biological year (1 Jun–30 May) 1978–88. We summarized these observations to obtain the number of individual MVP (\(N_M\)) and EPP (\(N_E\)) geese observed within each state or at a particular area.

We used observation data in open population capture-recapture models (Jolly 1965, Seber 1965, Pollock et al. 1990) following Brownie and Robson (1983) to estimate the number of geese marked in previous years that were alive and retained neck bands. The number of geese marked during the breeding season was added to the estimated number of marked survivors from previous bandings to obtain an estimated total number of marked geese available for observation during the fall and winter for the MVP (\(N_M\)) and EPP (\(N_E\)).

Population Distribution

Two measures of the spatial and temporal distributions of MVP and EPP geese were analyzed. We estimated the relative population distribution of breeding-ground geese in each state during each year. The percentage of MVP geese in each state was estimated by

\[
\hat{P}_{DM} = \frac{(O_M/N_M)W_M}{(O_M/N_E)W_E + (O_M/N_M)W_M} \times 100,
\]

where \(W_M\) = the proportion of MVP geese in the previous winter count and \(W_E\) = the proportion of EPP geese in the previous winter.
count. The proportions of geese were based on the estimated number of MVP and EPP geese wintering in the Mississippi flyway (K. Gamble, Waterfowl Harvest and Population Survey Data, U.S. Fish Wildl. Serv., Columbia, Mo., 1990). The percentage of EPP geese in each state was estimated by

$$\hat{P}_{DE} = 100 - \hat{P}_{DM}.$$ 

The relative population distribution provides an index of the relative abundance of MVP and EPP geese. This index depends upon the relative number of birds in each population and the proportion of neck-banded geese observed from each population. For example, a larger MVP population distribution for a state reflects the combination of MVP population level and MVP affiliation compared to the EPP. Use of the population distribution information for management is limited because the MVP has increased to population levels 2-4 times higher than the EPP, and both populations have experienced considerable annual fluctuation.

Population Affiliation

The percentage of MVP geese affiliated with each state was estimated by

$$\hat{P}_{AM} = \frac{O_M/N_M}{O_M/N_M + O_E/N_E} \times 100,$$

and the percentage of EPP geese by

$$\hat{P}_{AE} = 100 - \hat{P}_{AM}.$$ 

Population affiliation is based only on observations of neck-banded birds and is independent of the number of geese in either population and temporal fluctuations in population levels. This per capita measure provides an index to the relative importance of each population within a state. For example, states with high MVP affiliation would expect larger increases in goose populations by increasing MVP geese, rather than EPP geese. Affiliation provides a prediction of the relative population distributions if MVP and EPP geese were managed at similar population levels.

Data Analysis

We conducted a linear models analysis (Grizzle et al. 1969) separately for each state to determine differences in affiliation. The dependent variable contrasted the number of geese for each population observed in a state ($O_i$) to the number of geese not observed ($\hat{N}_i - O_i$). Independent variables analyzed were population origin (MVP vs. EPP), year of observation, and population-year interactions. Significant population-year interactions were reviewed for annual differences in affiliation with a multiple comparisons procedure for linear contrasts (Grizzle et al. 1969:498) controlled for a Type I error rate of 0.05 for each state. We conducted these multiple comparisons by pooling equivalent $\hat{P}_{AM}$ estimates and by testing for pairwise differences among all the resulting groups. We used an identical linear models analysis and multiple comparison procedure to analyze population distribution, except that the number of observed geese ($O_i$) was weighted by $2\cdot W_i$ to account for differences in population size and to provide observation rates of marked geese that were similar to the unweighted rates.

We also partitioned and analyzed the relative distributions of MVP and EPP geese at wildlife refuges (and other important goose concentration areas) with observations of breeding-ground birds in $\geq 2$ years. We calculated the mean proportions of MVP and EPP geese at each area as the weighted average of the annual distribution estimates from 1984 to 1987, with weights based on the number of neck-banded geese observed at each site and year. Isoclines of the proportion of MVP and EPP geese were estimated by using spline smoothing techniques (GCONTOUR procedure [SAS Inst., Inc. 1987]) and were displayed on a map of the Mississippi flyway.

RESULTS

Population Distribution

The estimated number of neck-banded geese present increased for both populations but varied annually (Table 1) based on banding histories, annual survival rates, and neck-band retention rates. The number of marked geese observed in each state also varied by population, year, and among states (Table 1). These counts were presumably influenced by the number of marked geese in each population, the amount of observer effort, and environmental conditions influencing the distribution of geese.

The weighted linear model analyses indicated significant ($P \leq 0.01$) population and year interactions for the population distribution of MVP and EPP geese in Arkansas, Illinois, Missouri, Tennessee, and Wisconsin. The relative abundance of MVP and EPP geese in these states
fluctuated annually. Population–year interactions were not significant in Iowa ($P \geq 0.58$), Kentucky ($P \geq 0.25$), or Minnesota ($P \geq 0.83$). All states showed significant differences ($P \leq 0.01$) between EPP and MVP population distributions.

Observations of geese in Arkansas, Iowa, Minnesota, and Tennessee were generally insufficient for analysis before 1984 (Table 1). Therefore, we analyzed only the 1984–87 trends in population distribution for these states. Arkansas had a greater proportion of EPP geese from 1984 to 1986 (Table 2), but MVP geese increased in 1987. Many EPP and few MVP geese were observed in Iowa and Minnesota, indicating a strong affiliation with EPP breeding areas. In Tennessee, more MVP than EPP geese were present in all years, but the MVP proportion increased during 1986–87.

We examined the long-term trends in population distribution for Illinois, Kentucky, Missouri, and Wisconsin (Table 2). Average distributions showed a high proportion of MVP geese in Kentucky ($\bar{x} = 95\%$), Illinois ($\bar{x} = 93\%$), and Wisconsin ($\bar{x} = 98\%$) during the 10-year period. Illinois showed 4 patterns of MVP population distribution ranging from 84 to 97% (Table 2). In contrast, Wisconsin observations followed a consistent pattern, except in 1979 (Table 2) when the proportion of MVP geese observed decreased to 70%. Observations in Missouri were predominantly of EPP geese ($\bar{x} = 86\%$) except in 1979, when the MVP constituted the major proportion (65%) of the population.

The distribution of MVP and EPP populations during 1979 exhibited an unusual pattern. The traditional MVP states of Illinois, Kentucky, and Wisconsin showed a strong decrease in relative use by MVP neck-banded geese. Conversely, the only EPP state (Mo.) with sufficient data exhibited a significant increase in the observation of MVP neck-banded geese. No other year showed a similar pattern of change in population affiliation.

No distinct geographic boundary between MVP and EPP geese is indicated, although MVP geese dominate in areas east of the Mississippi River, and EPP geese are more abundant west of the Mississippi River (Fig. 1). Some mixing occurs between the 2 populations, and more
Table 2. Relative distributions (%) of Mississippi Valley Population (MVP) and Eastern Prairie Population (EPP) geese in the Mississippi flyway, 1978–87, based on breeding ground affiliations and previous mid-winter population estimates.

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^a Weighted mean based on the number of neck-banded geese observed in each year.

^b Years within states with same letters are not statistically different (P > 0.05).
DISCUSSION

Our analysis of neck-band observations is generally consistent with the population designation and geographic distribution of MVP and EPP geese in the Mississippi flyway described from leg-band recoveries (Vaught and Arthur 1965, Reeves et al. 1968, Malecki et al. 1981). In particular, our data demonstrate that winter population distributions of MVP and EPP geese appear to have a low degree of overlap, although overlap is greater in the southern portion of the flyway. The annual distribution and affiliation of MVP and EPP geese changed significantly in states in the southern portion of the Mississippi flyway. In some states, observations of neck-banded geese were insufficient to test whether there were annual differences in affiliation or distribution. However, distribution differences in Arkansas, Illinois, Missouri, and Tennessee, combined with changes in the number of geese wintering at southern refuges (e.g., Trost et al. 1980), imply that annual variation might have occurred in other states as well. These distributions also could vary yearly depending on weather patterns and goose responses to habitat changes, hunting pressure, or other factors (Humburg et al. 1985).

Consistently small proportions (≤5%) of MVP or EPP geese in a state probably represent incidental overlap between populations. This appears to be the pattern for northern states such as Iowa, Minnesota, and Wisconsin. Greater population overlap appears in the southern states of Arkansas, Illinois, Missouri, and Tennessee. The degree of population overlap in these states depends upon the geographic location within the state and annual variations related to weather or other factors. We speculate that the lower relative proportion of MVP geese seen in Wisconsin, Illinois, and Kentucky coupled with the increase of MVP geese in Missouri during 1979 may have resulted from (1) greater mortality or loss of neck bands for MVP geese banded in 1979 (D. H. Rusch and M. D. Samuel, unpubl. data), (2) the hazing program conducted at Horicon National Wildlife Refuge which influenced the distribution of MVP geese (Rusch et al. 1985), (3) poor identification of MVP and EPP geese neckbanded before 1979, or (4) a natural deviation from the traditional distribution pattern.

MANAGEMENT IMPLICATIONS

Eastern Prairie and MVP goose flocks provide a valuable example of the importance of indi-
Table 3. Relative breeding ground affiliation of neck-banded geese observed in the Mississippi flyway, 1978–87.

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* Weighted mean based on the number of neck-banded geese observed in each year.
* Years within states with same letters are not statistically different (P > 0.05).

Individual population management in wildlife ecology. These populations have separate breeding areas, and the productivity of both populations might be influenced by different environmental conditions. Fall and winter distributions also are generally separated by the Mississippi River, although more overlap occurs in southern states. This geographic separation both justifies and facilitates separate population management, which has allowed harvest adjustments for differences in annual productivity and the establishment of distinct management objectives for each population (Anonymous, Management Strategy for Expansion and Distribution of Mississippi Valley Population Canada Goose, 1984–88, unpubl. rep., 1985; Anonymous, A Management Plan for the Eastern Prairie Population of Canada Goose, unpubl. rep., 1986). However, continued refinement of these management objectives could be made more difficult by annual variations in distribution patterns within the flyway and spatial distribution patterns within the southern states. These spatial and temporal distributions of geese have particular relevance to flyway and statewide harvest objectives, including efforts to increase goose populations south of 36°N latitude. Harvest regulations in southern states, such as Arkansas, Missouri, and Tennessee which have a mixture of birds from MVP and EPP goose populations will have a combined influence on both populations.

Although recent studies have not been able to identify discrete MVP subpopulations (Anderson and Joyner 1985; Tacha et al. 1988, 1991), distinct patterns of movement and winter distribution of MVP (Kennedy and Arthur 1974) geese could further complicate population management. In addition, we presently have little information on the size, distribution, or affiliation of giant or Tennessee Valley populations in the Mississippi flyway. Continued increases in the giant Canada goose population combined with their widespread distribution throughout the Mississippi flyway will require further refinements in goose population management. These management approaches should recognize that the relative contribution of several populations may be especially important in areas with substantial overlap. We suggest that these approaches use information on population affiliation and population levels to achieve optimum harvest levels.

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