Migratory Canada Goose Population Affiliation and Interchange Among Four National Wildlife Refuges in Tennessee and Alabama

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Abstract: Managers have assumed that migratory geese regularly interchange among wintering refuges, providing a potential to manage them as a complex. The primary purpose of our study was to determine population affiliation and magnitude of goose movements among 4 national wildlife refuges (NWR) in Tennessee and northern Alabama, thereby assessing the feasibility of this approach. Interchange and population affiliation were examined using neck collar observations from 1977–1998. Population affiliation varied among refuges, with Southern James Bay geese being most common at Wheeler NWR, and Mississippi Valley geese being most common at Reelfoot NWR. Only 5.1% of 11,039 different blue-and orange-collared geese observed at the 4 refuges were observed at more than 1 refuge during the entire study period. Less interchange occurred within individual years of the study; only 1.5% of 13,680 collared geese was observed at more than 1 refuge during a single season, and none were observed on 3 or more refuges. Most interchange occurred between the 2 closest Tennessee refuges, about 50 km apart. However, even this interchange was negligible, not exceeding 2% in any given year and was less than 3.5% throughout the 20-year period. Our findings suggest that Canada geese wintering at these refuges exhibit high site fidelity, and this fidelity should be considered when developing management strategies and setting harvest regulations.

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Four major populations of migratory Canada geese *(Branta canadensis interior)* breed around Hudson Bay and winter in the Mississippi Flyway (Fig 1): Eastern Prairie Population (EPP), Mississippi Valley Population (MVP), Southern James Bay Population (SJBP), and Tall Grass Prairie Population (TGPP; Hanson and Smith 1950, Bellrose 1976, Orr et al. 1998). Historically, Tennessee and Alabama have

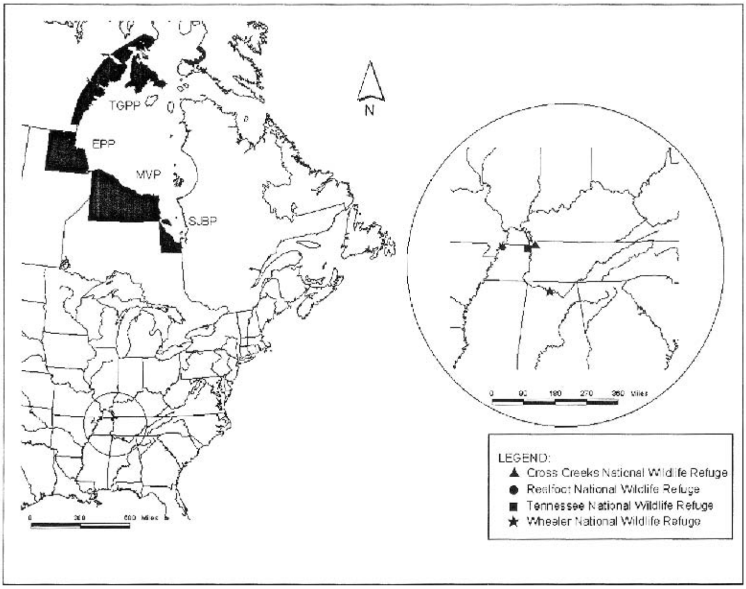

Figure 1. Location of 4 national wildlife refuges in Tennessee and north Alabama and breeding range of 4 populations of migratory Canada geese that winter there. SJBP = Southern James Bay Population, MVP = Mississippi Valley Population, EPP = Eastern Prairie Population, and TGPP = Tall Grass Population.

been 2 important states for wintering MVP and SJBP Canada geese (Orr et al. 1998, Trost et al. 1998); these states were so important for the SJBP that it was formerly known as the Tennessee Valley Population (Bellrose 1976, Samuel et al. 1991). Survey data indicate that fewer geese, especially SJBP birds, now winter in Tennessee and Alabama (J. Peterson, unpubl. waterfowl survey rep., U.S. Fish and Wildl. Serv. 2000). This apparent decline concerns waterfowl biologists and managers regarding continued persistence of these birds at traditional wintering states (Orr et al. 1998).

Three national wildlife refuges (NWRs) comprise the primary terminal wintering sites of SJBP geese: Wheeler NWR (WNWR) in Alabama, and Cross Creeks NWR (CCNWR) and Tennessee NWR (TNWR) in Tennessee (Fig. 1; D. H. Orr, unpubl. mimeo., U.S. Fish and Wildl. Serv. 1990). Determination of movement, distribution, and interchange of Canada geese at and among these areas is essential to understanding recent declines and developing management strategies to counteract these population trends. Although most migratory Canada geese that winter at Reelfoot NWR (RNWR; Fig. 1) belong to the MVP and EEP, some SJBP geese also winter there, and understanding interchange of geese between RNWR and the other 3 refuges provides additional insight into these issues. Furthermore, hunters have reported Canada goose movements between RNWR and TNWR, which could affect assignment of counties in western Tennessee to MVP or SJBP flyway hunting regulations.

Refuge managers in Tennessee and Alabama have assumed that SJBP geese likely would move to other wintering refuges if habitat conditions were not satisfactory at primary refuge wintering sites. Such interchange could provide a potential to manage these refuges as a complex (i.e., food shortages at 1 refuge could be compensated by providing additional resources at other refuges). Because these refuges are so important for SJBP geese, refuge management actions may impact overall flyway status of the SJBP and influence hunting regulations throughout the Mississippi Flyway. The primary purpose of our study was to determine magnitude of goose movements among these 4 refuges, thereby assessing the feasibility of managing them as a complex, as well as providing insight in recent declines of geese wintering in these locations.

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Methods

An extensive collaring program was initiated by state and federal fish and wildlife agencies in the Mississippi Flyway in 1974 to determine affinity of migratory Canada goose populations to specific nesting, wintering, and migration sites (Rusch et al. 1990). Canada geese were captured during summer on breeding and molting areas, and during winter on NWRs and state wildlife management areas, and marked with unique alphanumerically coded neck collars to enable individual identification. Orange collars were placed on birds during summer, and blue collars were used during winter.

Soon after this program was established, a collar observation effort was initiated on NWRs, starting with arrival of migratory Canada geese and continuing on a weekly basis until spring departure. Observations were recorded on standardized flyway data sheets and sent to the Wisconsin Cooperative Research Unit (WCRU) and the U.S. Fish and Wildlife Service, Office of Migratory Bird Management in Columbia, Missouri, for inclusion in the flyway database. We obtained digital records from the WCRU of all observations of geese observed at least once on CCNWR, RNWR, TNWR, and WNWR. Observations of collared Canada geese have been conducted at the 4 refuges since 1977, but over 90% of observations used for this study occurred from 1984 to 1998 because of the low number of geese collared prior to that time.

Population affiliation of orange-collared geese was assigned by personnel of

WCRU by matching banding locations to appropriate population breeding areas. Population affiliation could not be determined for blue collared geese because mixed populations occurred at wintering refuges where they were marked. Each observation was categorized by year, designating the winter (Oct–Mar) that the observation occurred. Observations of individual geese were weighted based upon the estimated percentage of each population that was collared using weighting factors provided by personnel of WCRU. Weighted percentages of various populations were determined for each refuge for each winter between 1985–86 and 1997–98, and means were used to estimate population affiliation for each refuge. Data collected prior to 1985 were not used in this analysis because associated weighting factors were not available. Percentage SJBP, MVP, and EPP geese were compared among refuges using Analysis of Variance and Duncan's Multiple Range Test (α=0.05). Percentage data were arcsine transformed before analysis to meet model assumptions.

Interchange was defined as geese observed on 2 or more refuges during a given season (within year interchange) or during different seasons (between year interchange). To determine if geese from a specific refuge exhibited differential fidelity to 1 or more of the other refuges, percentage interchange was compared for all pairwise refuge combinations (e.g., CCNWR/RNWR, CCNWR/TNWR, et.). We tested the null hypotheses that percentage interchange did not differ among the 4 refuges and that percentage interchange did not differ among pairwise refuge combinations using Chi-square analysis (α=0.05). Chi-square analysis was chosen because we compared observation frequencies among different refuges, consequently weighted data were not used for this analysis. It was necessary for us to assume collar observations used to estimate percentage interchange were independent for the resulting test statistic to be unbiased. This assumption was reasonable inasmuch as each goose was only counted once in the between year interchange analysis and once per year in the within year interchange analysis. Also, no expected cell frequencies for our Chi-square tests had counts $<$5, meeting another assumption of the analysis.

Results

Population Affiliation

Population affiliation varied among the 4 refuges (Fig 2). A higher percentage of SJBP geese and a lower percentage of MVP and EPP geese were observed at WNWR than at RNWR (F=6.2–26.4; df=3, 48; $P<0.01$). Population affiliation of geese did not differ between CCNWR and TNWR, which were intermediate between the other 2 refuges (Fig. 2). Less than 0.4% TGPP geese occurred on any refuge.

Between Year Interchange

We observed 11,039 different blue- and orange-collared geese at the 4 refuges during the entire study period (1977–1998). Of these, 94.9% (N=10,474) were observed at only 1 of the refuges during all years of study (Table 1). Geese observed at RNWR were least often observed at the other 3 refuges (5.4% of 3,605 RNWR

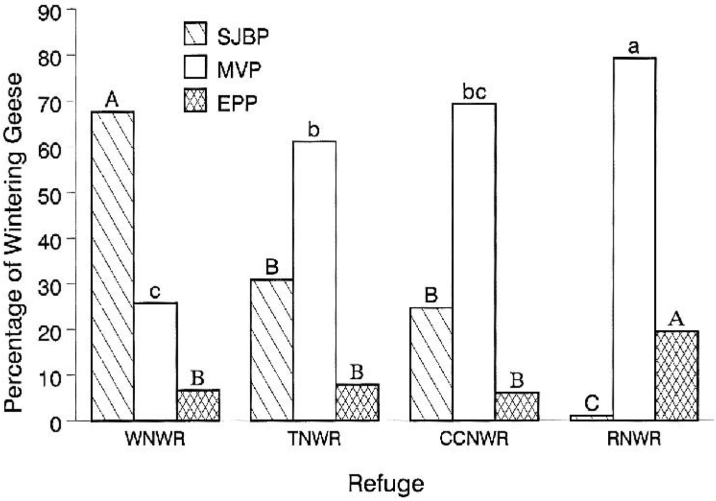

Figure 2. Mean percentage of geese of 3 migratory populations observed during winter on 4 refuges in Tennessee and North Alabama during 1985–1998. SJBP = Southern James Bay Population, MVP = Mississippi Valley Population, EPP = Eastern Prairie Population, and TGPP = Tall Grass Prairie Population; CCNWR = Cross Creeks NWR, RNWR = Reelfoot NWR, TNWR = Tennessee NWR, and WNWR = Wheeler NWR. Mean percentages of various populations differed ($P < 0.05$) among refuges with different letters of the same case and font above the frequency bars.

Table 1. Number of neck-collared Canada geese observed in different years on 4 national wildlife refuges in Tennessee and Alabama by population affiliation, 1977–1998. No geese were observed for refuge combinations not listed.

Refuge observations[a]	Orange-collared geese[b]				Blue-collared geese	Totals
	SJBP	MVP	EPP	Others		
T only	593	155	43	24	3,183	3,998
R only	36	535	325	22	2,494	3,412
W only	656	36	18	25	913	1,648
C only	121	51	13	2	1,229	1,416
C, T	47	9	0	0	127	183
R, T	18	56	2	0	62	138
T, W	61	2	0	0	75	138
C, W	15	0	0	1	30	46
C, R	1	3	2	0	31	37
R, W	4	2	1	0	10	17
C, T, W	1	0	0	0	4	5
C, R, T	0	0	0	0	1	1
Totals	1,553	849	404	74	8,159	11,039

a. C = Cross Creeks NWR, R = Reelfoot NWR, T = Tennessee NWR, W = Wheeler NWR; T only were geese observed only at TNWR; C, T were observed at both CCNWR and TNWR; C, T, W were observed at CCNWR, TNWR,and WNWR; etc.
b. SJBP = Southern James Bay Population; MVP = Mississippi Valley Population; EPP = Eastern Prairie Population; others include the following populations: Akimiski Island Giants, Kewatin District, Manitoba Giants, Northwest Territories, Tall Grass Prairie, and unknown.

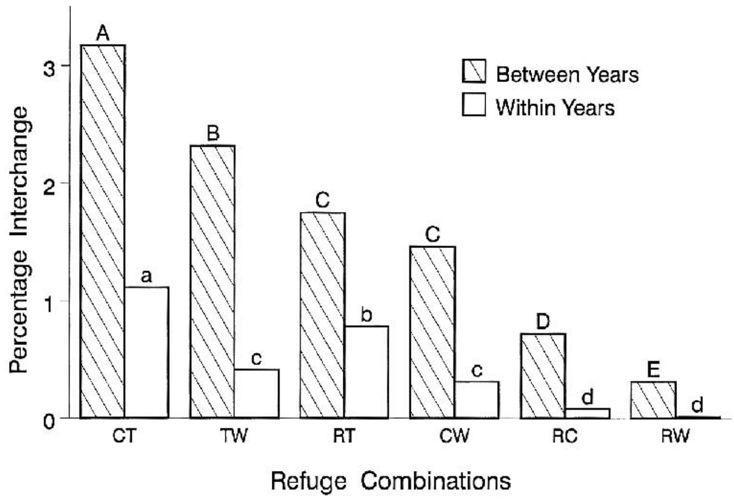

Figure 3. Percentage of geese observed on both refuges of each 2-refuge combination in Tennessee and North Alabama during 1977–1998. Between-year interchange represents geese that changed refuges in different years, and within-year interchange represents birds that changed wintering sites in the same year. C = Cross Creeks NWR, R = Reelfoot NWR, T = Tennessee NWR, and W = Wheeler NWR. Percentage interchange differed ($P < 0.05$) among refuge combinations (i.e., frequency bars) with different letters of the same case.

geese; χ^2=59.9–166.1, df=1, P<0.01), and geese observed at CCNWR were most often observed elsewhere (16.1% of 1,688 CCNWR geese χ^2=18.9–166.1, df=1, P<0.01). Percentage of geese observed at TNWR and elsewhere (10.4% of 4,463 geese) did not differ from the percentage observed at WNWR and 1 of the other refuges (11.1% of 1,854 geese; χ^2=0.7, df=1, P=0.42). Only 5 geese were observed at 3 different refuges (Table 1), and none were observed at all 4 refuges.

Percentage interchange among various combinations of refuges between multiple years varied from 0.3% of total geese observed at RNWR and WNWR to 3.2% at CCNWR and TNWR (χ^2=180.5, df=5, P<0.01; Fig. 3). In general, geese at RNWR were less often observed at the other refuges, especially CCNWR and WNWR. Among the other 3 refuges, CCNWR geese interchanged less frequently with WNWR geese than either did with TNWR geese (Fig. 3).

Within Year Interchange

Less interchange occurred within individual years. Only 1.5% of 13,680 collared geese was observed at more than 1 refuge during a single season, and none were observed on 3 or more refuges (Table 2). Geese observed at CCNWR were observed most often at 1 of the other refuges within a single year (4.8% of 2,054 CCNWR geese; χ^2=5.3–45.9, df=1, P=0.02–<0.01), and geese observed at RNWR and

Table 2. Number of neck-collared Canada geese observed in the same year on 4 national wildlife refuges in Tennessee and Alabama by population affiliation, 1977–1998. No geese were observed for refuge combinations not listed.

Refuge observations[a]	Orange-collared geese[b]				Blue-collared geese	Totals
	SJBP	MVP	EPP	Others		
T only	872	215	48	26	3,712	4,873
R only	42	666	399	22	3,114	4,243
W only	936	47	22	34	1,366	2,405
C only	179	66	15	4	1,691	1,955
C, T	30	9	0	0	41	80
R, T	16	52	0	0	5	73
T, W	15	2	0	0	14	31
C, W	8	0	0	0	6	14
C, R	0	2	1	0	2	5
R, W	0	0	0	0	1	1
Totals	2,098	1,059	485	86	9,952	13,680

a. C = Cross Creeks NWR, R = Reelfoot NWR, T = Tennessee NWR, W = Wheeler NWR; T only were geese observed only at TNWR; C, T were observed at both CCNWR and TNWR; C, T, W were observed at CCNWR, TNWR,and WNWR; etc.
b. SJBP = Southern James Bay Population; MVP = Mississippi Valley Population; EPP = Eastern Prairie Population; others include the following populations: Akimiski Island Giants, Kewatin District, Manitoba Giants, Northwest Territories, Tall Grass Prairie, and unknown.

WNWR were observed least often elsewhere (χ^2=17.2–45.9, df=1, P<0.01). Percentage of geese observed at RNWR and elsewhere in the same year (1.8% of 4,322 geese) did not differ from percentage observed at WNWR and 1 of the other refuges (1.9% of 2,451 geese; χ^2=0.2, df=1, P=0.89). An intermediate amount of within year interchange occurred for geese observed at TNWR (3.6% of 5,057 geese), less than the amount for CCNWR (χ^2=5.3, df=1, P=0.02), but more than the amount at RNWR (χ^2=28.0, df=1, P<0.01) or WNWR (χ^2=17.3, df=1, P<0.01).

Percentage interchange among various refuges was low within a given year, varying from <0.1% to 1.1% of total geese observed on those refuges (χ^2=132.3, df=5, P<0.01; Fig. 3). In general, the same patterns of minimal interchange occurred within years as between years, except fewer geese interchanged between TNWR and WNWR within years. Within year interchange between RNWR and refuges excepting TNWR were almost nonexistent (Fig. 3).

Discussion

Use of traditional sites has been considered the primary factor influencing winter distribution of migratory Canada geese (Hanson and Smith 1950; Crissey 1968; Raveling 1978, 1979). Although some researchers have suggested that management should be directed at the level of subflocks, as distinguished by clearly defined breeding and wintering locations (Crissey 1968, Raveling 1969, Kennedy and Arthur

1974), other studies have indicated that such groups are only loose aggregations that regularly interchange between key wintering sites (Trost et al. 1981; Anderson and Joyner 1985; Tacha et al. 1988, 1991). Based on the latter studies and anecdotal observations, we expected to detect a high level of interchange of migratory Canada geese among the 4 wintering refuges in Alabama and Tennessee; however, such interchange was minimal. Most interchange occurred between the 2 closest Tennessee refuges (CCNWR and TNWR), about 50 km apart. However, even this interchange was negligible, not exceeding 2% in any given year and less than 3.5% throughout the entire 20-year period.

This lack of interchange at terminal wintering sites perhaps indicates strong area fidelity at the southernmost latitudes of migration. Some refuges in southern Illinois serve primarily as wintering destinations for MVP geese, whereas others appear to be staging areas for early migrants that winter elsewhere (Tacha et al. 1998). Radio-marked geese that wintered at destinations sites exhibited little interchange with other refuges, but geese that primarily wintered at staging sites frequently interchanged with other refuges (up to 69% of marked geese; Tacha et al. 1998). Similarly, fidelity to specific wintering sites differed between 2 regions in Maryland (Rhodes et al. 1998). The low amount of interchange detected in our study may indicate that the 4 Tennessee and Alabama refuges are wintering destination sites, similar to Horseshoe Lake in southern Illinois and Blackwater NWR in Maryland. Southernmost refuges, such as the 4 addressed in this study, are the terminal wintering sites in a migration corridor; and it is not surprising that interchange among these areas differs from that exhibited farther north.

Many Canada geese are known to winter farther south during harsh winter periods characterized by high levels of ice and snow cover (Craven and Rusch 1983, Humburg et al. 1985, Rusch et al. 1985). Other flocks migrate earlier to terminal wintering sites independent of severe weather, with their migration being more dependent on traditional behavior (Kennedy and Arthur 1974, Havera 1999). Such movements support Orr et al.'s (1998) hypothesis that 2 groups of geese winter on southernmost refuges, those that traditionally winter there year-after-year and those that only winter there during harsh periods, generally mid- to late winter. As an example, during the harsh winter of 2000–2001, late arriving geese more than doubled the usual wintering numbers at CCNWR, TNWR, and RNWR; but no similar spillover occurred at WNWR (D. H. Orr, unpubl. mid-winter survey rep., 2000). These observations further validate our conclusion that little movement will occur from Tennessee terminal wintering refuges to WNWR, and even severe winters appear to no longer result in late arriving geese at WNWR. Thus, the loss of traditional migrating birds cannot be replenished by interchange among southernmost refuges.

Management Implications

Our results suggest that management actions for these 4 refuges (which support up to 2/3 of migratory Canada geese surveyed in Alabama and Tennessee; Orr et al. 1998) should not be influenced by the belief that intermixing readily occurs once birds reach final wintering sites. It is important that each refuge and state ensure adequate food resources and other requirements (i.e., roosting, loafing, and sanctuary sites) for their respective wintering flocks. Clearly, these 4 refuges should not depend on each other to provide food resources for wintering Canada geese because of strong philopatry and low interchange among refuges.

Lack of refuge interchange and failure of flocks to use other refuges under adverse conditions are likely to be important traits if significant negative population impacts occur (e.g., poor breeding conditions, competition with other geese and other wildlife, shortstopping, and excessively high harvest rates). Such impacts could potentially eliminate birds from specific refuge areas because of engrained fidelity for these sites. Such a loss previously occurred at St. Marks NWR in the Florida Panhandle, where wintering migratory geese declined from peaks of 26,000 to virtually no geese in less than 20 years (Crider 1967, Hankla and Rudolph 1967, Orr et al. 1998). If the distribution and abundance of migratory Canada geese to the Southeast is to continue, we believe actions will be needed to ensure proper flyway hunting harvest rates, abundant forage and open space, adequate sanctuary, and better identification of flock migration patterns.

Wildlife biologists and managers have recently recognized that many migrating and wintering flocks of Canada geese consist of mixtures of various breeding populations and/or subspecies (Trost et al. 1980, Malecki and Trost 1986, Samuel et al. 1991, Jarvis and Bromley 1998, Orr et al. 1998, Sullivan et al. 1998). Management actions to protect certain goose stocks moving through a flyway often conflict with opportunity to harvest other populations (Rusch et al. 1998, Sullivan et al. 1998). Jarvis and Bromley (1998) discuss such mixing and suggest strategies to coordinate management for different populations. They emphasize a need for strategic plans with goals addressing the preferred mix of populations and their distribution within wintering areas. Hopefully, such strategies will consider the lack of movement between terminal wintering sites.

We recommend continued development of such flyway plans, focusing on needs to address the feasibility of better identifying and protecting those Canada goose stocks with an affinity for deep-south wintering behavior. Specific research would involve radio satellite tagging of SJBP geese and better documentation of the importance of early arriving birds in Tennessee and Alabama. The extensive neck collaring program in the Mississippi Flyway has provided a mechanism to compare population composition and interchange of geese among important wintering sites, and collar observations should be continued to assess changes in migratory Canada geese in the southern United States.

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