DISTRIBUTION OF EASTERN PRAIRIE POPULATION CANADA GOOSE BROODS, 1977–2002: POTENTIAL INFLUENCE OF SNOW GEESE

ROBERT R. NACK, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, St. Paul, MN 55108, USA

DAVID E. ANDERSEN, U.S. Geological Survey, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, St. Paul, MN 55108, USA

Abstract: In 2001 and 2002, we conducted aerial surveys to compare indices of Eastern Prairie Population (EPP) Canada goose (*Branta canadensis interior*) brood distribution and abundance near Cape Churchill, Manitoba with those obtained in 1977 and 1978 by Didiuk (1979). Since the late 1970s, many of the coastal salt marsh areas used for brood-rearing have been degraded as a result of increased foraging pressure from locally breeding and migrating light geese (snow geese [*Chen caerulescens*] and Ross's geese [*C. rossii*]), and the density of nesting Canada geese has declined. The mean Canada goose brood density across the entire survey area in 2001–2002 was not different from 1977–1978, but the mean brood density increased significantly in the southern portion of the survey area. In 2002, the mean snow goose brood density was higher than the mean Canada goose brood density, with higher densities of snow geese in northern coastal flats/beach ridge areas and higher densities of Canada geese in southern coastal flats/beach ridge areas. The mean number of Canada goose broods observed on 15 traditional brood-rearing areas decreased between 1977 and 2002, while the mean number of snow goose broods observed increased. The distribution of Canada goose broods appears to have shifted, possibly in response to reduced food availability, direct interactions with snow geese on brood-rearing areas, or both. Loss and degradation of brood-rearing habitat may be a factor in the decline in nest density of Canada geese and has implications for EPP management.

Key words: *Branta canadensis*, brood, Canada geese, *Chen caerulescens*, Eastern Prairie Population, Manitoba, snow geese.

The density of EPP Canada geese nesting near Cape Churchill, Manitoba declined by a factor of approximately 4.5 from 1976–1979 ($\bar{x}$ = 38.7 nests/km^2) to 1993–1996 ($\bar{x}$ = 8.5 nests/km^2; Walter 1999), and has remained low since 1996 (D. E. Andersen, unpublished data). Trends in breeding population estimates derived from annual EPP aerial breeding ground surveys indicated that decreases in nest density appeared to be restricted to the vicinity of Cape Churchill (Humburg et al. 2000). A number of hypotheses have been suggested for this decline in nest density including: investigator disturbance at nest sites, dispersal of breeding females to new nesting areas, a shift in brood-rearing areas and subsequent use of new areas by first-time breeders, increased arctic fox (*Alopex lagopus*) predation, and inter-specific competition with lesser snow geese (Walter 1999). Walter (1999) evaluated these hypotheses in light of existing information, and concluded that arctic fox predation and direct and indirect competition with snow geese on brood-rearing areas were the most likely causes for observed declines in nest density.

Since the late 1960s, numbers of Mid-continent Population (MCP) lesser snow geese have increased 3-fold and salt marsh habitats along the western coast of Hudson Bay have been degraded (Abraham et al. 1996, Abraham and Jefferies 1997). Snow geese from the nesting colony at La Perouse Bay, Manitoba (Fig. 1) use traditional EPP brood-rearing areas in salt marsh habitat near Cape Churchill upon arrival in the spring through the end of the brood-rearing period in mid-August. Salt marshes are also used as spring and fall staging areas for geese that nest farther north and molt migrant giant Canada geese (*B. c. maxima*) in the summer months. Coastal brood-rearing areas near Cape Churchill have experienced degradation as a result of intense foraging pressure by large numbers of locally breeding and migrating geese (Abraham et al. 1996, Abraham and Jefferies 1997, Walter 1999, Sammler 2001).

Didiuk (1979) studied the brood movements and distribution of nesting EPP Canada geese prior to the presence of nesting lesser snow geese on the study area and intense foraging pressure by light geese on coastal

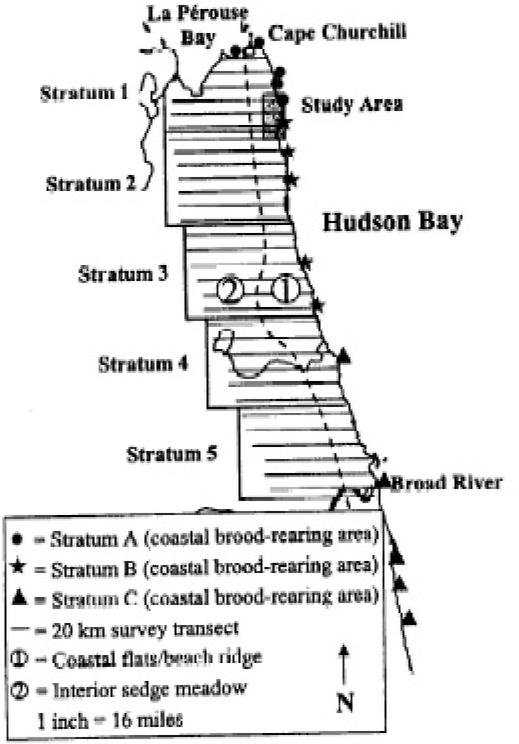

Fig. 1. Aerial transects surveyed to estimate Canada goose brood densities in 2001–2002 and coastal brood-rearing areas surveyed in 2002.

salt marsh habitat near Cape Churchill. His aerial surveys revealed 15 distinct brood-rearing areas distributed along the western coast of Hudson Bay from Cape Churchill to 16 km south of the mouth of the Broad River (92°47.5'W 58°7.5'N; Fig. 1). These coastal areas were used extensively by Canada geese during brood rearing and were characterized by lush stands of salt-tolerant sedges (*Carex* spp.) and grasses (predominantly *Puccinellia phyraganodes*).

Information on the effects of increasing light goose population size on other species is largely lacking (Ankney 1996, Abraham and Jefferies 1997). Prior to 2001, ≤2 snow goose nests were located annually during nest searches on the study area. In 2001 and 2002, 55 and 6 snow goose nests were located during nest searches, respectively (D. E. Andersen, unpublished data). Observations of Canada geese using traditional EPP brood-rearing areas have decreased, while observations of snow goose broods have steadily increased (Walter 1999, Sammler 2001).

We repeated aerial brood surveys conducted by Didiuk (1979) in 1977 and 1978 to assess the potential impacts of light geese on EPP Canada geese at Cape Churchill. The objectives of our study were to (1) identify areas that currently support high densities of Canada goose broods, (2) relate Canada goose brood densities to the distribution of snow goose broods, and (3) compare Canada goose brood distribution between periods of high (this study) and low snow goose abundance (Didiuk 1979).

STUDY AREA

The Cape Churchill (Nestor One) study area (48 km^2) is located 8 km south of Cape Churchill and within 5 km of the Hudson Bay coastline in northern Manitoba (Allen 1996, Fig. 1). The study area is approximately 15 km southeast of the La Perouse Bay snow goose colony and lies within the Hudson Bay Lowland region. The region is characterized by low relief, continuous permafrost, poor drainage, numerous relict beach ridges, coastal marshes, and coastal tundra vegetation (Wellein and Lumsden 1964, Walter 1999). Major habitat types include coastal salt marsh, beach ridge/sedge meadow, and interior sedge meadow (Didiuk 1979). Foraging geese intensively use the salt marsh habitat during the brood-rearing and migration periods. Beach ridge/sedge meadow habitat consists of freshwater sedge meadows and lakes between sand and gravel beach ridges. Interior sedge meadow habitats consist of numerous shallow water bodies and lowland areas dominated by sedges and grasses (Didiuk and Rusch 1998).

METHODS

Aerial Brood Transect Survey

East/west transect surveys were conducted between Cape Churchill and the mouth of the Broad River (Fig. 1). Transects were spaced at 2.4 km intervals and extended 20 km inland from the coast of Hudson Bay ($n = 31$). The survey area was divided into 5 strata, each covering 14.5 km of Hudson Bay coastline. We also identified 2 distinct habitat types within the survey area. The coastal flats/beach ridge habitat extended approximately 5 km inland from the coast of Hudson Bay. The interior sedge meadow area bordered the coastal flats/beach ridge habitat on the west and extended another 15 km inland to the tree line (Fig. 1). Aerial survey transects were established following the methods described by Didiuk (1979).

In 2001 and 2002, a fixed-wing aircraft (Partenavia PN-68 Observer) was used to conduct brood surveys. We flew surveys 30-45 m above ground level at approximately 160 km/hr, depending on wind speed and direction. In 2001, 2 observers (opposite sides) recorded Canada geese observed with and without broods within a 200 m strip on each side of the air craft. Observations were categorized by 1-minute intervals. In 2002, 1 observer recorded Canada geese and a second observer recorded snow geese observed with and without broods, within 200 m of 1 side of the aircraft. Adults were considered to have broods if they (1) were observed with goslings, (2) were observed in a group that contained goslings, or (3) exhibited behavior indicative of brood presence (e.g., mouth open, flared wings, flightless, or hiding). The number of broods in a group of adult birds with goslings was calculated by dividing the total number of adults by 2 (assuming each pair had a brood). Brood numbers were rounded up if an odd number of adults was present in a group with goslings (e.g., 5 adults = 3 broods). Adults were considered to be without broods if they were observed (1) on water without goslings, (2) flying, or (3) in a group without goslings. Criteria used to identify and count geese with broods were consistent with those used by Didiuk (1979). Brood aggregation increased throughout the brood-rearing period and was assumed to increase the detectability of broods on survey transects (Didiuk 1979). Therefore, we also calculated the proportion of broods observed in groups. A visibility correction factor for undetected broods was not used by Didiuk (1979) or in this study.

Median hatch dates on the Cape Churchill study area were used to determine timing of aerial surveys in 1977-1978 and in 2001-2002. We used a combination of egg floatation (Westerkov 1950, Walter and Rusch 1998) and candling techniques (Weller 1956) to estimate nest age and hatch dates (28-day incubation period) for all nests located during standardized nest searches on the study area.

Coastal Brood-rearing Area Survey

In 2002, 15 traditional brood-rearing areas identified by Didiuk (1979) were surveyed by helicopter (Bell 206 Jet Ranger) during the brood-rearing period (Fig. 1). The survey was initiated at the eastern side of La Perouse Bay and followed the coastline to approximately 16 km south of the mouth of the Broad River (89 km total). Coastal brood-rearing areas were identified on 1:50,000 topographical maps of the Hudson Bay coastline (Fig. 1). Brood-rearing areas were divided into 3 strata (A-C, each with 5 areas) from north to south along the coast of Hudson Bay. Two observers were used to count both Canada geese and snow geese with and without broods. We used the same criteria to identify and count broods as during aerial brood transect surveys. Survey data were compared to similar surveys conducted in 1977 and 1978 (Didiuk 1979).

Data Analysis

Brood density estimates from survey transects were calculated by dividing the total number of broods observed on each transect by the area surveyed (transect length [km] x strip width [0.2 km]). Average brood densities among transects in each stratum (1-5) or habitat type (coastal flats/beach ridge and interior sedge meadow) were used for statistical analysis. Differences in brood densities among strata and between habitat types were analyzed using 2-way analysis of variance (ANOVA) and Tukey's highly significant difference (HSD) *post hoc* test for multiple comparisons was used to identify significant differences. For all statistical tests used, we considered P-values < 0.05 to indicate significance, and used P-values < 0.10 to identify trends.

Strata 1 and 2 include the Cape Churchill study area and historically had the highest brood densities in the survey area (Didiuk 1979). Data were compared between 2001-2002 and 1977-1978 at 3 levels: strata 1-5, strata 1-2, and strata 3-5. Data collected 12 days post-median hatch in 1977 and 1978 were used in comparisons with data collected 19 and 12 days post-median hatch in 2001 and 2002, respectively. We report differences between mean density values (MD) ± 95% confidence intervals (CI) for comparisons between 2001-2002 and 1977-1978. Significant differences were noted if 95% CI around the mean difference did not include 0 (Steidl et al. 1997, Anderson et al. 2001).

Coastal brood-rearing area surveys were flown 4 times in 1977 (17, 24, 34, and 46 days post-median hatch), once in 1978 (10 days post-median hatch), and twice in 2002 (5 and 36 days post-median hatch). When possible, the mean number of broods observed in each coastal brood-rearing area was used for statistical comparison. In some cases, uncontrollable circumstances prevented all areas from being flown an equal number of times. For example, in 1978, only the 7 northern areas were surveyed due to late spring phenology and poor gosling production. We report differences between mean brood counts (MD) ± 95% CI to compare 2002 with 1977 and 1978.

RESULTS

Aerial Brood Transect Survey

Canada goose brood densities were not significantly different among strata ($F_{4,57} = 1.47$, $P = 0.22$) or between coastal flats/beach ridge and interior habitat types ($F_{1,60} = 1.53$, $P = 0.22$; Table 1) in 2001-2002. However, significant habitat type x stratum interaction terms suggested an increase in brood densities in coastal flats/beach ridge habitat in strata 3-5 ($F_{4,52} = 4.10$, $P = 0.01$).

In 2002, the mean snow goose brood density across the entire survey area was higher than the mean Canada goose brood density (Table 2). This trend was also observed in strata 1-2, strata 3-5, coastal habitat, and interior habitat (Table 2). Statistically significant habitat type x stratum interaction terms indicated the

Table 1. Phenology, survey timing, and Canada goose brood densities (broods/km², SE) determined from aerial brood transect surveys flown near Cape Churchill, Manitoba in 1977–1978 and 2001–2002.

	1977	1978	2001	2002
Spring phenology	Early	Late	Early	Late
Median hatch date	14 Jun	1 Jul	18 Jun	4 Jul
Survey timing[a]	12	12	19	12
Strata 1–5	1.01 (0.21)	0.49 (0.08)	0.83 (0.17)	1.06 (0.23)
Strata 1–2	1.39 (0.47)	0.41 (0.11)	0.32 (0.12)	1.18 (0.42)
Strata 3–5	0.74 (0.13)	0.55 (0.11)	1.21 (0.25)	0.92 (0.27)
Interior habitat			0.77 (0.19)	0.79 (0.32)
Coastal habitat			1.05 (0.42)	1.35 (0.37)

[a] Days post-median hatch date.

Table 2. Mean densities (broods/km²) of snow and Canada goose broods near Cape Churchill, Manitoba in 2002.[a]

Area	Snow geese	SE	Canada geese	SE	Mean difference (± 95% CI)
Strata 1–5	28.36	5.34	1.06	0.23	27.31 ± 10.92
Strata 1–2	51.22	9.18	1.18	0.42	50.04 ± 20.22
Strata 3–5	11.86	2.35	0.97	0.27	10.89 ± 5.81
Coastal	45.52	7.02	1.35	0.37	44.18 ± 14.27
Inland	18.03	5.73	0.79	0.32	17.24 ± 11.80

[a] Aerial survey flown 12 days post-median hatch (median hatch = 4 July 2002).

Table 3. Snow goose brood densities (broods/km²) from aerial surveys conducted in 1977, 1978, and 2002 near Cape Churchill, Manitoba.

	1977		1978		2002	
Area	Density	SE	Density	SE	Density	SE
Strata 1–5	0.77	0.52	1.99	1.05	28.36	5.34
Strata 1–2	1.83	1.21	4.77	2.39	51.22	9.18
Strata 3–5	0.01	0.01	0.00	0.00	11.86	2.35

highest densities of snow geese were in coastal flats/ beach ridge areas in stratum 2 ($F_{4,32}$ = 3.20, P = 0.02).

Coastal Brood-rearing Area Survey

Surveys of 15 traditional Canada goose coastal brood-rearing areas were flown on 9 July 2002 and repeated on 9 August 2002. The mean number of broods observed between July and August surveys remained similar for Canada geese (MD = 0.57 ± 3.76) and snow geese (MD = -27.60 ± 45.05). The mean number of snow goose broods was higher than the mean number of Canada goose broods during both July (MD = 53.43 ± 59.86) and August (MD = 27.97 ± 21.51) surveys. The mean number of snow goose broods was highly variable because >200 broods were counted on some areas and 0 on others. An inverse relationship existed between Canada goose and snow goose broods on traditional brood-rearing areas. The mean number of Canada goose broods was highest in stratum C ($F_{2,12}$ = 2.43, P = 0.13) and the mean number of snow goose broods was significantly higher in stratum B than in strata A and C ($F_{2,12}$ = 5.78, P = 0.02; Table 3).

Current Versus Historical Brood Distribution

Spring phenology was similar between 1977-1978 and 2001-2002, with early and late years in each time period (Table 1). The proportion of broods observed in groups (>1 pair) during aerial brood transect surveys in 2001-2002 (0.64) was significantly higher than in 1977-1978 (0.32; χ^2_4 = 20.40, P < 0.001), even though

Table 4. Number of Canada and snow goose broods counted on 15 traditional Canada goose brood-rearing areas near Cape Churchill, Manitoba in 1977 and 2002.

		Stratum[a]							
		A		B		C		A-C	
Year	Species	Mean	SE	Mean	SE	Mean	SE	Mean	SE
1977	Snow geese	5.40	4.69	0.50	0.50	0.20	0.20	2.02	1.56
	Canada geese	13.80	1.24	15.50	5.15	10.20	2.06	13.07	2.13
2002	Snow geese	15.80	5.04	111.50	39.44	10.40	10.15	45.93	17.74
	Canada geese	2.00	1.14	2.80	1.16	8.40	3.52	4.40	1.41

[a] Coastal brood-rearing areas are divided into strata A, B, and C from north to south.

surveys were flown at approximately the same time relative to the median hatch date (Table 1). The mean Canada goose brood density across the entire survey area in 2001 and 2002 was not different than in 1977 and 1978 (MD = 0.20 ± 0.56). The mean Canada goose brood density in 2001-2002 in strata 1-2 was similar to 1977-1978 (MD = -0.16 ± 0.69), but in strata 3-5, the mean brood density was significantly higher than in 1977-1978 (MD = 0.45 ± 0.39, Table 1). In 2002, the mean density of snow goose broods across the entire survey area (strata 1-5), strata 1-2, and strata 3-5 was considerably higher than in 1977 and 1978 (Table 4).

The mean number of Canada goose broods observed on 15 traditional EPP brood-rearing areas in 2002 was lower than the mean number of broods observed in 1977 (MD = -8.67 ± 6.19; Table 3) and to a lesser extent on 7 areas surveyed in 1978 (MD = -2.43 ± 3.24). In 2002, the mean number of Canada goose broods was lower in stratum A (MD = -11.60 ± 3.69), stratum B (MD = -2.78 ± 17.58), and stratum C (MD = -1.63 ± 13.57) than in 1977 (Table 3). This change in use of brood-rearing areas by Canada geese paralleled a decline in nest density on the core study area (portions of strata A and B) between 1977 (33 nests/km^2) and 2002 (6 nests/km^2) (D. E. Andersen, unpublished data). In 2002, the mean number of snow goose broods was higher than the mean number of Canada goose broods (MD = 41.54 ± 38.86); however, in 1977-1978, numbers of Canada goose broods exceeded snow goose broods (MD = 8.91 ± 3.97; Table 3) on coastal brood-rearing areas.

DISCUSSION

In 2001-2002, aerial transect surveys revealed the highest densities of Canada goose broods were in coastal flats/beach ridge habitat in strata 3-5, south of areas (strata 1 and 2) that traditionally had highest brood densities (Didiuk 1979). These southern areas (strata 3-5) experienced a significant increase in use by Canada goose broods compared to 1977-1978. A higher proportion of broods observed in groups suggests that broods were more easily detected in 2001-2002; however, brood densities over the entire survey area remained similar to 1977-1978. High variation in brood density estimates in 2001-2002 and 1977-1978 resulted from observations of large groups of aggregated broods in interior sedge meadow survey areas (Didiuk 1979).

Data from 15 coastal brood-rearing areas surveyed in 2002 were compared with data from 1977. Spring phenology was "early" in 1977 and "late" in 2002; however, brood density estimates across the entire survey area were similar between years (2002: $\bar{x}$ = 1.06, SE = 0.23; 1977: $\bar{x}$ = 1.01, SE = 0.21). Brood density estimates were unusually high for a late year in 2002; however, the 2002 EPP breeding grounds survey also reported a higher number of breeding birds and nesting effort than in recent years (D. D. Humburg, Missouri Department of Conservation, unpublished data). The number of Canada goose broods decreased significantly on northern coastal brood-rearing areas (stratum A) between 1977 and 2002, with no subsequent increase in broods on other southern coastal brood-rearing areas.

Since 1977-1978, Canada goose brood densities have increased in strata 3-5 (transect surveys) and decreased on coastal brood-rearing areas. These data suggest that Canada goose broods have increased their use of freshwater sedge meadows adjacent immediately inland from to southern coastal salt marshes. In 1976-1978, 20 of 21 (95%) radio-marked Canada goose females nesting in beach ridge/sedge meadow habitat moved their broods to salt marsh habitat (Didiuk 1979). In 2000-2002, only 5 of 27 (19%) Canada geese nesting in beach ridge/sedge meadow habitat made initial movements to those traditional brood-rearing areas and 26 of 40 (65%) of all radio-collared female geese with broods used freshwater sedge meadow habitat for the entire brood-rearing period (R. R. Nack, unpublished data).

The highest densities of Canada goose broods were observed in coastal flats/beach ridge habitat in strata with the lowest densities of snow goose broods. Our data suggest that Canada geese shifted use of brood-rearing areas in response to reduced food availability, direct interactions with snow geese on brood-rearing areas, or both factors. Additional evidence supports an inverse relationship between densities of Canada and snow goose broods on the study area. Currently, intensive snow goose banding efforts at La Perouse Bay are concentrated in areas north of the Broad River (J. McRae, Hudson Bay Helicopters, personal communication) and EPP banding drives, formerly conducted on the study area, have shifted to coastal areas south of the Broad River and near the town of Churchill (M. Gillespie, Manitoba Conservation, personal communication).

Snow geese are highly dependent on salt marsh vegetation during the nesting and brood-rearing periods, (Bazely and Jefferies 1989, Kerbes et al. 1990, Williams et al. 1993, Gadallah and Jefferies 1995, Srivastava and Jefferies 1996, Kotanen and Jefferies 1997) and competition for limited salt marsh vegetation is likely responsible for direct movement of snow geese to the coast from nest sites following hatch (Walter 1999; R. R. Nack, personal observation). Although not obvious from coastal area surveys, the density of snow goose broods on traditional coastal Canada goose brood-rearing areas appeared to decrease throughout the brood-rearing period (R. R. Nack, personal observation). This suggests that snow geese forage on salt marsh vegetation available early in the brood-rearing period, but disperse as forage availability decreases. Coincident with increased use of traditional Canada goose brood-rearing areas by snow geese, Canada geese appear to have changed their use of brood-rearing habitats. It is likely that degradation of traditional brood-rearing areas has resulted in this change, as physical displacement of Canada geese by snow geese is unlikely and interactions between species were brief and rarely confrontational (Walter 1999; R. R. Nack, personal observation).

The degradation of salt marsh habitat and concurrent reduction in forage quality and quantity is believed to be responsible for decreased gosling survival and growth, and body size of snow geese nesting at La Perouse Bay and the McConnell River, Nunavut, Canada (Cooch et al. 1991, Aubin et al. 1993, Cooch et al. 1993, Williams et al. 1993, Gadallah and Jefferies 1995). Reduced forage availability and quality is also thought to be responsible for the reduced body size (Leafloor et al. 1998) and late summer gosling mortality of Canada geese nesting on Akimiski Island, Nunavut (Leafloor et al. 2000). Although a long-term change in body size has not been observed in breeding EPP Canada geese (Walter 1999; R. R. Nack, unpublished data), geese that remain faithful to traditional brood-rearing areas as foraging conditions decline may experience reduced fitness (e.g., reductions in gosling growth rate and survival) that could lead to a decline in recruitment and nest density.

If first-time breeders nest in areas where they were reared as goslings, and Canada goose broods are being displaced to more southerly areas, then a temporal shift in nest density toward areas south of the study area is possible and may have contributed to the observed decline in nest density on Cape Churchill ([or] the Nestor One study area). The dispersal distance for first-time breeders at Cape Churchill is unknown; however, reproductive parameters (i.e., decreased egg size, increased clutch size, increased body size) suggest Canada geese breeding on the study area are older geese (Walter 1999). Leafloor (1998) noted several instances of long distance natal dispersal (≥70 km) by breeding Canada geese that were banded as goslings. MacInnes and Lieff (1968) reported natal dispersal distances of 5 km and 10.5 km for McConnell River Canada geese; however, they felt most geese returned to nest in the same general area in subsequent years. Telemetry data from 2000–2002 indicates that 18 of 41 radio-marked Canada goose broods moved south of the study area, but remained within 15 km of the nest site (R. R. Nack, unpublished data). Humburg et al. (2000) also observed increased densities of nesting EPP Canada geese at the mouth of the Broad River, the southern boundary of our survey area.

MANAGEMENT IMPLICATIONS

The effects of increasing snow goose populations on other bird species and the localized decline in nest density of EPP Canada geese are of concern to managers. Our observations at Cape Churchill may indicate how other areas could be impacted by increased densities of breeding and foraging snow geese increased densities of breeding and foraging snow geese could impact other areas. For example, numbers of snow geese nesting at the Broad River have increased from 110 nesting pairs in 1997 to 668 nesting pairs in 2002 (D. D. Humburg, Missouri Department of Conservation, unpublished data). If the number of snow geese breeding near the mouth of the Broad River continues to increase, saline and freshwater marshes in the vicinity and south of the Broad River may be degraded, resulting in reduced use of these areas by Canada geese during the brood-rearing period. The degradation of brood-rearing habitat and competition with snow geese could continue to have an impact on EPP Canada geese and other bird species. The area over which snow geese could negatively impact Canada geese during the brood-rearing period is likely to increase.

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