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Molt migration by giant Canada geese in eastern South Dakota

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Abstract: We captured giant Canada geese (*Branta canadensis maxima*) in 7 counties in eastern South Dakota during the summer molting period, 2000–2003. We attached very high frequency (VHF) transmitters to 150 adult female geese with brood patches, and leg bands to 3,839 geese. We documented molt migrations using VHF telemetry and indirect band recovery at locations north of South Dakota. Telemetry of radio-collared female geese during the breeding season indicated that 56% of nonbreeders, 81% of unsuccessful breeders, and 19% of successful female breeders embarked on a molt migration. Five of 34 geese that underwent molt migrations moved to northeast South Dakota, and the other twenty-nine migrated north of South Dakota. Eighty-six of 647 indirect band recoveries were from north of South Dakota (46° N latitude), suggesting that the geese were molting north of South Dakota. The percentage of indirect recoveries (13%) that occurred north of 46° N latitude was significantly greater ($\chi^2_1 = 160.6$, $P < 0.001$) than northern indirect recoveries (3.5%) reported by Gleason (1997) for giant Canada geese banded in eastern South Dakota from 1955 to 1995. We believe it is likely that 50 to 60% of eastern South Dakota's population of giant Canada geese undergo molt migrations. These movements affect management strategies in nesting areas, as well as in molting areas. Any management technique, such as egg adding in nesting areas, may reduce local crop damage but increase problems in areas where geese molt. Harvest strategies for molt migrants should involve coordination with state and provincial agencies. Further studies incorporating satellite telemetry are needed to document specifically the molting locations of South Dakota geese.

Key words: *Branta canadensis maxima*, Canada geese, human–wildlife conflicts, molt migration, South Dakota

GIANT CANADA GEESE (*Branta canadensis maxima*), once considered to be near extinction, have been successfully reintroduced throughout the United States and Canada (Lee 1987, Groepper et al. 2007). Unfortunately, this successful restoration has created problems, including goose damage to lawns, golf courses, beaches, and agricultural crops (Conover and Chasko 1985, Washburn et al. 2007). In South Dakota, giant Canada geese were reintroduced in the 1960s and 1970s (Mammenga 2000). Since these reintroductions, the population of giant Canada geese has steadily risen, and the 10-year (1998–2007) average spring population estimate of giant Canada geese in eastern South Dakota was 125,000 (U.S. Fish and Wildlife Service 2007). In eastern South Dakota, the primary conflict with giant Canada geese has involved crop damage, especially in soybean (*Glycine max*) fields (Schaible et al. 2005). The extent of damage to emerging crops by flightless giant Canada geese is related to the size of the local breeding population along with the influx of molt-migrants (Flann 1999). During the molting

period, adult Canada geese are flightless while their wing feathers are being replaced. Molt migrations are summer movements of Canada geese from their nesting grounds to locations where they molt their flight feathers (Hanson 1965, Krohn and Bizeau 1979, Zicus 1981, Nichols et al. 2004). Crop damage by Canada geese can be especially high during the molting period, when geese have a higher energy demand because of feather production (Bellrose 1976). The South Dakota Department of Game, Fish, and Parks (SDDGFP) opted to control giant Canada geese through September hunting seasons that occur outside the regular season framework. The first September hunting season was instituted in 1996 and has since continued annually. Harvest estimates during the September season range from 10,000 to 50,000 giant Canada geese annually. Due to landowner complaints, SDDGFP also instituted a program in 1996 to reduce crop damage caused by giant Canada geese (Mammenga 2000). This \$250,000-per-year program is funded by a \$5 surcharge on all hunting licenses sold in South

Dakota. Landowners who file a complaint are given free access to abatement techniques (see Schaible et al. 2005) offered by SDDGFP. In some areas of eastern South Dakota, SDDGFP has used egg addling (Smith et al. 1999) to cause nest failure, thus alleviating some local crop damage problems. However, after their nests are destroyed, adult geese often leave on a molt migration.

The distance of Canada goose molt migrations range from 40 km (Martin 1964) to >2,500 km (Luukkonen et al. 2008). The longest known molt migration for a giant Canada goose nesting in South Dakota was 2,100 km from Brookings County, South Dakota, to Ferguson Lake in Nunavut Territory, Canada (Anderson 2006).

There are different theories to explain the occurrence of molt migrations, but the ecological advantages of such movements remain largely unknown. Sterling and Dzubin (1967) and Zicus (1981) stated that molt migrations are innate and suggested that the adaptive significance of molt migrations may be increased survival probability among individuals. Krohn and Bizeau (1979) reported that non-nesting molt migrant geese had higher survival rates than nesting geese banded in the same region, possibly because of their avoiding stress associated with territorial and family defense. However, molt migrants had lower survival compared to birds that remained resident on breeding areas in southern Michigan (Luukkonen et al. 2008). Salomonsen (1968) hypothesized that molt migration by nonbreeding geese was an endeavor to avoid competition with geese remaining on breeding grounds.

Most geese that molt migrate are subadults, nonbreeders, and failed breeders (Salomonsen 1968, Sterling and Dzubin 1967), but some successful nesters molt migrate after losing or abandoning their broods (Krohn and Bizeau 1979, Zicus 1981, Lawrence et al. 1998a). Using marked individuals, Zicus (1981) found that 50–60% of the entire spring population left Wisconsin on a molt migration; Lawrence et al. (1998a) reported a similar percentage in Illinois. However, based on seasonal change in population size, Nichols et al. (2004) estimated that only 21–31% of Canada geese molt migrated out of New Jersey.

Increasing giant Canada goose populations

have resulted in more molt migrants on northern nesting and brood-rearing areas, potentially increasing competition for food sources between populations of Canada geese (Abraham et al. 1999). This increase in molt migration also complicates management and surveys of some Arctic and subarctic nesting Canada goose populations (Abraham et al. 1999) and could have negative effects on northern habitats (Hill et al. 2003).

Previous banding data from 1980 to 1995 suggested that giant Canada geese from South Dakota were making short molt migrations restricted to the northeastern part of the state (P. Mammenga, SDDGFP, personal communication). Gleason (1997) reported that only 63 of 1,787 indirect recoveries occurred in North Dakota or Canada from 16,433 Canada geese banded during the summer in eastern South Dakota between 1955 and 1995. Other researchers reported capturing molting Canada geese in Canada that were banded in South Dakota (Sterling and Dzubin 1967, Abraham et al. 1999). However, evidence of long-distance molt migrations from leg-banded geese recovered north of South Dakota have greatly increased in recent years (Anderson 2006), suggesting that long-distance movements may be more common than previously thought. Understanding implications of molt migrations on population dynamics, as well as on problems, such as crop damage, is important to management of giant Canada geese in South Dakota, as well as other northern states and Canada. Knowing the geographic and temporal distribution and magnitude of South Dakota's molt migrants not only fills an important life history void, but may affect harvest management strategies. The objective of this study was to document and describe the magnitude of molt migration, departure and return dates, reproductive status, and direction of potential molting areas of giant Canada geese from eastern South Dakota.

Study area and methods

This study was conducted in Brookings, Clark, Codington, Day, Hamlin, Kingsbury, and Lake counties in eastern South Dakota (Figure 1). These counties are in the Coteau des Prairies physiographic region (Gab 1979). The large numbers of wetlands in the area are used

extensively by breeding and staging waterfowl and provide excellent nesting habitat for the increasing population of giant Canada geese (U.S. Fish and Wildlife Service 2007). Native vegetation of the area is tall grass prairie that gives way to the northern mixed-grass prairie to the west. However, because of the study area's agricultural productivity and level topography, most of the tall grass prairie has now been replaced by agricultural crops, primarily corn, soybeans, and wheat (Hogan and Fouberg 1998).

We captured Canada geese (molting adults, subadults, and goslings) during their summer flightless period (June 23, 2000–July 11, 2003). We captured geese by driving them into a trap (Cooch 1953) that we erected in a bay with a gradual shoreline. We banded all trapped geese with standard U.S. Fish and Wildlife Service aluminum leg bands. We used plumage characteristics and cloacal examinations to determine age and sex of geese (Hanson 1965). Subadults and adults were sexed and classified as after-hatch-year (AHY) geese, while goslings were not sexed and were classified as local (L) geese. We recorded leg band numbers of previously banded geese, and then we released the geese. All activities involving handling the geese were given approval by the South Dakota State University Institutional Animal Care and Use Committee (approval number 00-E004).

We attached very high frequency (VHF) transmitters (total weight, 60 g; Advanced Telemetry Systems, Inc., Isanti, Minn.) to black neck collars made of Rowmark® plastic (7cm wide × 16.5 cm long; Spinner Plastics, Springfield, Ill.). We attached the transmitter collars to 5 to 10 adult breeding females (as evidenced by a brood patch) at each capture site. Although capture sites consisted primarily of family groups, the possibility of attaching neck collars to adult females that themselves had migrated from states farther south did exist. VHF transmitters transmitted continuously (pulse rate of 50 ppm and pulse width of 20 ms) at frequencies between 150 and 151 MHz. VHF transmitters were designed with an antenna (21 cm) that protruded from the top, rear of the collar at a 45° angle and ran down the bird's back. Transmitters had a guaranteed battery life of 300 days, but some lasted much longer. Based on field testing before and after



Figure 1. Study area in eastern South Dakota where giant Canada geese were captured and radio-collared, 2001–2003.

deployment, VHF units had an effective ground and aerial range of approximately 3.2 and 32 km, respectively.

During spring 2001–2004, we monitored the reproductive status of radio-marked female geese that returned to the same areas in years following their capture. We located radio-collared females using a 4-element null-peak antenna system mounted on a pickup truck. We located the geese weekly from the time they arrived in March until July 1. We classified the geese as nonbreeders, unsuccessful nesters, and successful nesters. Nonbreeders were females not known to have had a nesting attempt, while unsuccessful nesters attempted nesting but failed to hatch at least 1 gosling; successful nesters hatched at least 1 gosling (Klett et al. 1986). We determined nest success by both examining the nests for eggshell characteristics that indicated a successful hatch and observing goslings with successful females. We used a χ^2 test to compare by reproductive status and year the proportion of radio-collared females that left on a molt migration. We pooled the data across years for analysis.

When geese departed from their nesting area, presumably on a molt migration, we attempted to find their molting location using aerial telemetry. During 2001 to 2004, we searched for specific molting locations of radio-marked

females from a Cessna 172 fixed-wing aircraft with a directional 4-element yagi antenna mounted on each wing strut (Gilmer et al. 1981). The area we searched encompassed all of eastern South Dakota from Interstate 90 to the North Dakota line, southeast North Dakota east of Highway 281 and south of Interstate 94, and 45 km into western Minnesota from the northern South Dakota border south to Interstate 90 (Figure 2). The receiver scanned through all selected frequencies and cycled to successive frequencies every 4 seconds. Aerial searches were designed to cover as much area as possible based on the effective ranges of the VHF transmitters. From early June to October, bi-weekly aerial searches for individual geese started at the goose's last location. If the goose was not located, we flew 25-km transects over the coverage area. In

November and December, we used a ground vehicle to monitor geese in the 7-county area. We marked locations of molt migrants on maps made in ArcView® 3.2 GIS software and recorded Universal Transverse Mercator (UTM) coordinates. If geese were not located, we assumed they had migrated to areas farther north. It is possible that some of the collars quit functioning and that these geese were still in the study area. However, we found that all 44 transmitters on geese that stayed in the study area remained transmitting until November.

We estimated departure dates for radio-marked geese that made molt migrations by taking the midpoint of the last date we located a goose near the wetland where it was captured

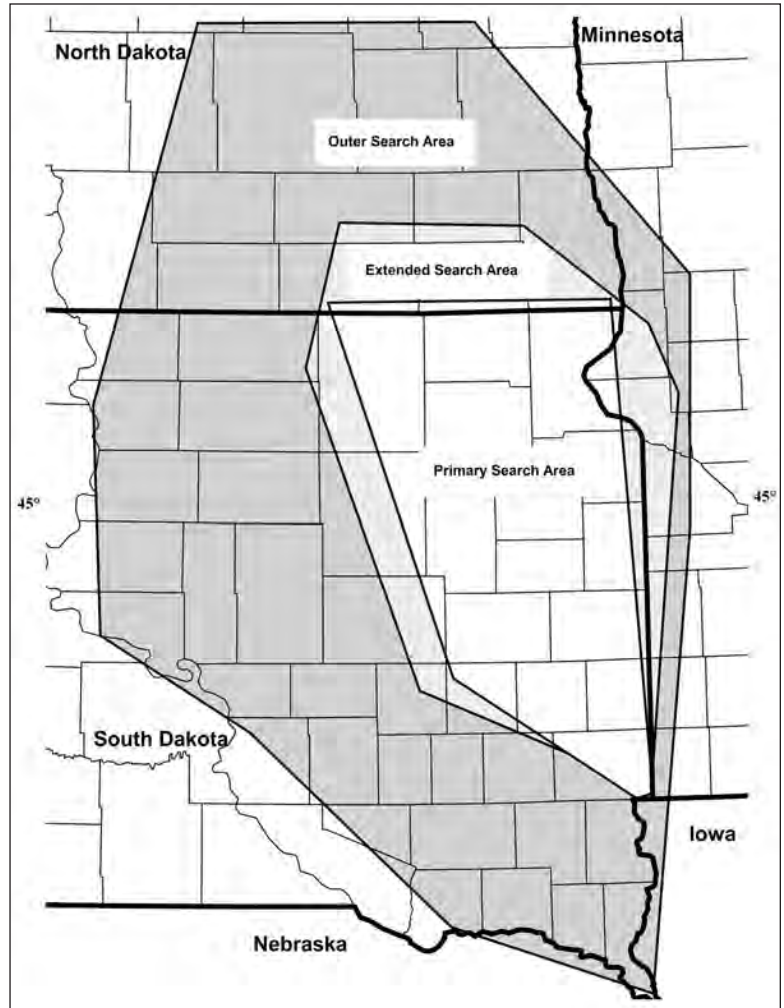


Figure 2. Aerial search areas for locating radio-collared geese using aerial telemetry in eastern South Dakota, 2001–2003. We searched the primary search area weekly, the extended search area every 2–3 weeks, and the outer search area 2–3 times.

and the first date we could not locate it. If radio-marked geese returned from a molt migration later that fall, we recorded return dates as the first date a goose was located near the wetland where it had been found that spring.

We obtained leg-band recoveries from geese that we banded during this study through March 2005 (U.S. Geological Survey Bird Banding Laboratory, Laurel, Md.). We defined a direct recovery as a banded bird killed or found dead during the first hunting season following banding and an indirect recovery as a banded bird killed or found dead during any hunting season following the first hunting season after banding. We examined indirect recoveries only from north of South Dakota

Table 1. Fate of adult female giant Canada geese fitted with radio-transmitters on neck collars during their first year after capture in eastern South Dakota, 2001–2004.

Year captured	Number with neck collars	Number shot during fall	Number relocated following spring	Number not relocated
2001	44	14	24	6
2002	48	16	29	3
2003	29	8	18	3
2004	22	10	7	5
Total	143	48	78	17

(46° N latitude) because Canada geese from eastern South Dakota have been documented making northward post-molt movements (Anderson 2006). Thus, direct recoveries may indicate northward post-molt movements and not a molt migration. It is possible that some indirect recoveries were also from post-molt movements, but because of the wide disparity in distances between post-molt movements and molt migrations (Anderson 2006), many indirect recoveries were probably from geese that had molt migrated. We compared indirect recoveries with those reported by Gleason (1997). We used ArcView® 3.2 GIS software to plot indirect recoveries.

Results

We caught and leg-banded 3,839 geese (752 AHY males, 864 AHY females, and 2,323 L) at 25 sites during the summers of 2000–2003. Of these, we also fitted 150 adult females with radio collars. Over the 5-year analysis period, we received 648 direct recoveries and 645 indirect recoveries from leg-banded geese. Indirect recoveries included 221 birds banded as adults and 424 banded as locals. There were no immediate deaths of geese fitted with neck collars, but not all transmitters could be used for analysis. We excluded 7 geese fitted with neck collars because of injury, death, or transmitter malfunction. VHF transmitters performed well during all 4 years, with only 3 transmitters malfunctioning prior to geese making their first fall migration southward. There was no other evidence of transmitters malfunctioning throughout the first fall after deployment, and no missing geese with nonfunctional transmitters were ever shot by hunters. Three

VHF transmitters started to expire during late spring of the second year at the end of their expected battery life, but most transmitters continued working throughout the second fall after deployment.

We radio-collared 150 adult females over 3 field seasons. We were able to monitor the reproductive status of 78 geese that we located during the year after they were collared (Table 1). Hunters shot and killed 48 of the neck-collared geese during the first fall after being marked. The other 24 geese either were killed and unrecovered, did not return to the area, or the transmitters quit functioning.

Next spring, all females were in territorial nesting pairs, but we observed that twenty-five of them did not attempt to nest. These nonbreeders were paired and remained in the same areas from shortly after arrival in spring until mid- to late May. Unsuccessful nesters remained on the wetland near their failed nests until mid- to late May. After mid-May, nonbreeders and unsuccessful nesters left their territorial areas to join nonterritorial flocks. We observed some successful nesters that lost their broods joining these nonterritorial, gregarious flocks prior to departure. Family groups of successful nesters joined together and formed their own flocks, which were generally separate from the other geese without goslings.

The proportion of female geese, by reproductive status, making molt migrations (i.e., birds that were not located in the study area in mid-summer and were therefore assumed to have migrated) was similar among years ($\chi^2_2 = 3.23$, $P = 0.20$; Table 2). The proportion of both unsuccessful nesters (13 of 16; $\chi^2_1 = 18.47$, $P < 0.001$) and nonbreeders

Table 2. Number of adult female Canada geese ($n = 34$) that participated in molt migration by reproductive status out of 77 radio-collared geese captured in eastern South Dakota 2001–2004.

Year	Female goose reproductive status			
	Nonbreeder	Unsuccessful	Successful	Total
2001	2 of 5	3 of 5	1 of 14	6 of 24
2002	4 of 9	5 of 6	5 of 14	14 of 29
2003	5 of 8	2 of 2	1 of 8	8 of 18
2004	3 of 3	3 of 3	0	6 of 6
Total	14 of 25 (56%)	13 of 16 (81%)	7 of 36 (20%)	34 of 77 (44%)

(14 of 25; $\chi^2_1 = 9.16$, $P < 0.002$) that made molt migrations was significantly higher than that of successful nesters (7 of 37). Overall, 47% of all radio-collared females made a molt migration (Table 2).

The earliest departure date that geese left on a molt migration was May 16, and the latest was June 16, with 91% departing by June 10. Of the 34 molt migrants, we located the molting locations of only 5 geese in northeast South Dakota, including Long Lake in Codington County (1 goose), Bitter Lake in Day County (2 geese), and Sand Lake National Wildlife Refuge in Brown County (2 geese). None of the remaining 29 radio-collared geese was located in our search area, and we assumed that they made molt migrations farther north.

The earliest return date for radio-collared geese that made a molt migration was July 20, and the other 11 geese returned between October 1 and November 28. We found only 12 of the 34 geese returned during the same fall from molt migrations during 2001–2004. An additional 8 geese were not present at their breeding sites during the fall, but upon their return the following spring they had functional collars. We recovered 6 of the 34 radio-collared geese that were shot north of South Dakota. For example, 1 goose departed on a molt migration on June 3, 2004, and was shot in Corning, Saskatchewan, on October 20, 2004. We were unable to locate the remaining eight of 34 radio-collared geese again. Indirect band recoveries from north of 46° N latitude (86 of 647) illustrate a broad distribution of geese that were killed

by hunters: north of the South Dakota breeding area from North Dakota (51.2% of recoveries), Manitoba (27.9%), Saskatchewan (16.3%), and Minnesota (4.7%; Figure 3). The percentage of indirect recoveries (13.3%) north of 46° N latitude was significantly greater ($\chi^2_1 = 160.6$, $P < 0.001$) than northern indirect recoveries (3.5%) reported by Gleason (1997) for giant Canada geese banded in eastern South Dakota from 1955 to 1995. However, during the time period of 1955 to 1995 there was no September hunting season in North Dakota or Canada. Gleason (1997) reported the highest number of band returns in October. A band recovery was reported from as far north as The Pas, Manitoba (53.6° N latitude), approximately 1,075 km north of its banding site. Indirect recoveries were documented in North Dakota and Canadian provinces from all 7 capture counties, indicating that molt migration occurs throughout the eastern South Dakota study area. Of indirect recoveries from north of South Dakota, we banded 71 L geese; 8 geese were AHY males, and 7 were AHY females. These indirect recoveries occurred from September 1 until as late as November 3 (Table 3).

Discussion

It appears that a high percentage of nonbreeding and unsuccessful adult female geese move north from eastern South Dakota on a molt migration. Most geese that had a successful nest molted in South Dakota, but 19% of them departed on a molt migration. Early research indicated that successful nesting

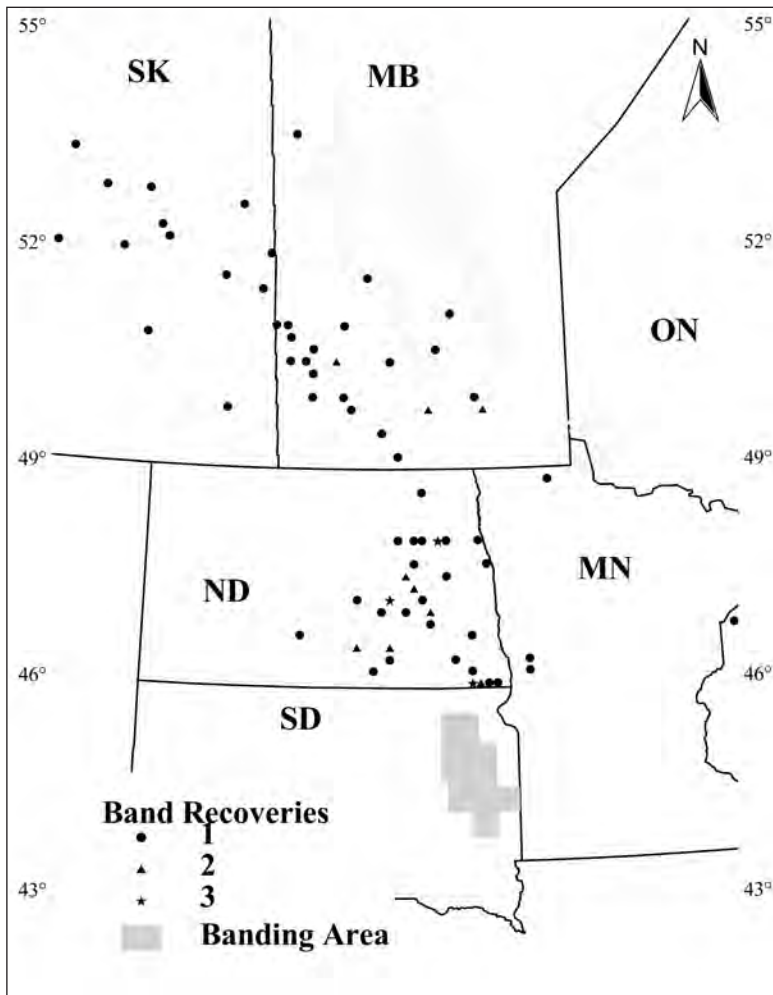


Figure 3. Indirect leg-band recoveries of giant Canada geese banded in the eastern South Dakota breeding area and that were shot or found dead north of the South Dakota–North Dakota border (46° N latitude), 2001–2004.

geese do not participate in molt migrations (Hanson 1965, Salomonsen 1968), but more recent studies have documented some successful females making molt migrations (Krohn and Bizeau 1979, Zicus 1981, Lawrence et al. 1998a). We observed 2 marked females with broods a week after hatching, but both geese subsequently left on a molt migration. These individuals may have lost their goslings to predation or gang broods. We were unable to find molting locations for most radio-collared females that made the molt migration because it was not logistically feasible to search all of North Dakota and Canada due to limitations and expenses associated with VHF telemetry. Because only five of the molt-migrant, radio-marked geese were found in the expanded

search area in South Dakota, North Dakota, or Minnesota, it is logical to assume that the other geese molted farther north. Departure dates for geese making a molt migration from eastern South Dakota were similar to those from other U.S. locations (Zicus 1981, Lawrence et al. 1998a, Mykut 2002). However, return dates for radio-marked females indicated that geese remain farther north late into the fall before returning to South Dakota. We located 12 of 20 radio-collared geese that returned by the end of October; the other 8 geese returned in November. In addition, nearly 30% of indirect recoveries from north of South Dakota occurred after October 1, providing evidence of a delayed return of some molt migrants to South Dakota (Table 3). In contrast, Luukkonen et al. (2004)

Table 3. Number of indirect recoveries of giant Canada geese banded in eastern South Dakota and shot or found dead north of it (46° N latitude) out of 3,839 banded geese and 645 indirect recoveries from 2001 to 2004.

Recovery Date	North Dakota	Manitoba	Saskatchewan	Minnesota	Total number (%)
Sep 1–10	15	3	4	1	23 (27)
Sep 11–20	14	3	2	1	20 (23)
Sep 21–30	4	9	3	0	16 (18)
Oct 1–10	3	5	2	1	11 (13)
Oct 11–20	2	3	2	0	7 (8)
Oct 21–30	5	1	1	1	8 (9)
Oct 31–Nov 9	1	0	0	0	1 (1)
Total	44	24	14	4	86 (100%)

reported that most molt migrants had returned to Michigan and the highest harvest rate was in September. Return dates may be related to molt migration distance, but geese also may be remaining in northern areas due to less hunting pressure or favorable weather patterns.

Indirect recoveries were broadly distributed north of South Dakota, and these data suggest that geese molted in several different areas of Canada and North Dakota. We could not identify exact locations because indirect recovery locations are not necessarily indicative of molting sites. However, these locations can provide insight regarding the direction and distance of molting areas (Krohn and Bizeau 1979). Geese that migrate to subarctic and arctic areas have a lower chance of recapture, observation, and a low probability of being recovered until they fly south into areas with more hunting pressure (Lawrence et al. 1998a, Nichols et al. 2004). Thus, many banded geese that were shot likely molted farther north than their recovery locations. For example, the most distant indirect recovery was near The Pas, Manitoba. This location is 1,000 km farther south than where a goose fitted with a Platform Transmitting Terminal flew to molt at Ferguson Lake, Nunavut Territory (Anderson 2006).

After mid-June, there were few geese unassociated with family groups on most area wetlands, indicating that many subadults had

departed the area. Since 44% of radio-collared females made a molt migration and subadults make up the highest percentage of molt migrants (Salomonsen 1968), we believe it is likely that the proportion of geese that make a molt migration from eastern South Dakota's population of giant Canada geese was similar to the 50–60% reported elsewhere (Zicus 1981, Lawrence et al. 1998a).

Some research has indicated that survival rates for molt migrants are lower than for geese that molt on breeding areas. Lawrence et al. (1998a, b) suggested that geese making molt migrations may be subject to greater hunting mortality and possibly even natural mortality. However, Zicus (1981) suggested that molt migrants may have better survival than geese molting on the southern breeding grounds. If molt migrants have higher survival rates, then the proportion of the population that makes long-distance molt migrations may increase.

During this study, both South Dakota (since 1996) and North Dakota (since 2001) had special September Canada goose-hunting seasons and a traditional hunting season that started in early October. Anderson (2006) found that the giant Canada goose population in South Dakota has one of the lowest survival rates of any population studied. The annual survival rates for this Canada goose population were 0.52 for adults and 0.68 for locals. These low survival rates

are probably due to the high harvest mortality recorded during the September hunting season (Anderson 2006). If molt migrants remain in Canada until late fall, they avoid the September hunting season and probably suffer lower hunting mortality than geese that stay in South Dakota. If molt-migrants have a higher survival rate, it is possible that the number of giant Canada geese molt migrating north of South Dakota will increase.

Some state and federal agencies have used egg addling or nest destruction to cause nest failure of giant Canada geese (Smith et al. 1999). These management techniques may induce a molt migration, which may in turn alleviate some localized crop damage. However, those unsuccessful geese (and their mates) will molt somewhere farther north, possibly increasing crop damage in areas where they molt migrate. In effect, these management techniques may just be moving problems from 1 area to another. Molt migrants that move north may be contributing to problems in those areas, such as biasing population estimates for northern nesting subspecies, increased competition (Abraham et al. 1999), and habitat damage (Hill et al. 2003).

It appears that some giant Canada geese from eastern South Dakota that make molt migrations to North Dakota and Canada are not returning until late fall. If 50–60% of South Dakota resident Canada geese are migrating northward to molt, they are an important component of goose harvests in North Dakota and Canada. Even though these geese attempt to nest in South Dakota, they may reside within South Dakota only for a short period during the hunting season. Thus, harvest strategies for many molt migrants should involve coordination with other states, primarily North Dakota and Canadian provincial agencies.

Studies that document the survival rates of molt migrants compared to those that molt on South Dakota breeding areas are needed. It is likely that geese that fly to Canada to molt and remain there until late fall have better survival rates than those remaining in South Dakota to molt. Research on northern locations where South Dakota's geese are molting may be important to future goose management. We recommend the use of satellite telemetry in future investigations regarding molt-migrating

Canada geese to document molting locations, chronology, and magnitude (e.g., Luukkonen et al. 2008).

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