Responses of Staging Greater Snow Geese to Human Disturbance
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RESPONSES OF STAGING GREATER SNOW GEESE TO HUMAN DISTURBANCE

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Abstract: We studied the effects of human disturbance on staging in greater snow geese (*Chen caerulescens atlantica*) spring and fall in the Montmagny bird sanctuary, Québec, 1985–87. We recorded 652 disturbances (any event causing all or a part of the goose flock to take flight) in 471 hours of observation. Rate of disturbance was higher in fall (1.46/hr) than in spring (1.02/hr) ($P \leq 0.001$). The entire flock was disturbed in 20% of all cases. Mean time in flight was 56 and 76 seconds in fall and spring, respectively ($P = 0.049$). Transport-related activities particularly low-flying aircraft, caused $\geq$45% of all disturbances in spring and fall. In 40% of all cases ($P \geq 0.05$) geese stopped their feeding activities following a disturbance. Mean time to resume feeding was then 726 seconds in fall compared to 122 seconds in spring ($P \leq 0.001$). The level of disturbance that prevailed on a given day in fall ($\bar{x}$ hourly rate) influenced goose use of the sanctuary on the following day ($P \leq 0.01$). When disturbance exceeded 2.0/hour, it produced a 50% drop in the mean number of geese present in the sanctuary the next day. Low-level aircraft flights over goose sanctuaries should be strictly regulated.

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The effects of human activities on breeding (Anderson and Keith 1980, Titus and Vandruff 1981, Johnson et al. 1987) and wintering (Hume 1976, Batten 1977, Owens 1977, Tuite et al. 1983) wildfowl have been investigated. The consequence of human disturbance to staging waterfowl has recently received attention (Korschgen et al. 1985, Madsen 1985) but is still poorly documented. For instance, arctic-nesting geese may be vulnerable to disturbance during spring; disturbance could affect their activity budget, their distribution, and their ability to store fat reserves necessary for migration and breeding (Ankney and MacInnes 1978, Raveling 1979, Thomas 1983). Excessive disturbance could also disrupt pair and family bonds and induce mortality (Bartelt 1987). Hence, human disturbance may reduce the value of a staging area for geese.

Greater snow geese stop along the Saint Lawrence estuary in Québec for 5–7 weeks during spring and fall migrations between their Canadian High Arctic breeding grounds and their wintering quarters on the Atlantic coast of the United States. Although cordgrass (*Spartina* spp.) coastal marshes of the lower estuary (Gauthier et al. 1984) and adjacent agricultural fields (Bédard et al. 1986, Gauthier et al. 1988) have been used increasingly over the past decades, the brackish tidal bulrush (*Scirpus* spp.) marshes of

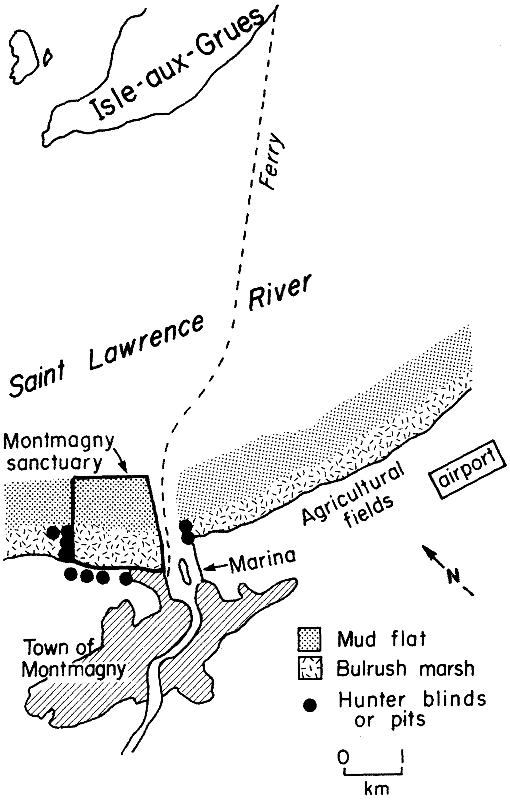

Fig. 1. Habitats and sources of disturbance for greater snow geese using the Montmagny sanctuary, Québec, 1985–87.

the upper estuary remain the most important staging area (Gauthier et al. 1984, Giroux and Bédard 1988*a*).

Choice of a staging site by the birds in this part of the river is influenced by the abundance of three-square bulrush (*Scirpus americanus*) (Giroux and Bédard 1988*a*), its location relative to neighboring sites, its area and accessibility to geese under high hunting pressure (Giroux and Bédard 1986), and tradition and site fidelity (C. Maisonneuve, Univ. Laval, and J. Bédard, unpubl. data). Human disturbance may also influence the distribution of geese. We identify the causes of disturbance to greater snow geese during their spring and fall stopovers and investigate the effects of disturbance on activities and distribution of geese.

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STUDY AREA

Our study was conducted in the Montmagny bird sanctuary (47°00'N, 70°35'W), 70 km east of Québec City along the south shore of the Saint Lawrence River in Québec (Fig. 1). Established in 1969, this no hunting area was especially important in fall when roughly 10% of the greater snow goose flock migrating through the estuary used it (C. Maisonneuve and J. Bédard, unpubl. data). The 3 vegetation zones within the 147-ha sanctuary were a 15-ha uppermost, narrow (20–100 m wide) zone of alternate-flowered spartina (*Spartina pectinata*) and scaly sedge (*Carex paleacea*) (e.g., the upper marsh), a 72-ha middle level zone 200–1,000 m wide (e.g., the lower marsh), dominated by three-square bulrush and an unvegetated 60-ha mudflat. The lower marsh was heavily used by geese that extracted rhizomes of three-square bulrush that accounted for ≥55% of their marsh diet (Giroux and Bédard 1988*b;* J. Bédard, unpubl. data). In spring, ≥50 and ≤0.6% of the daily time-budget of snow geese using bulrush marshes was devoted to feeding and flying, respectively (Gauthier et al. 1988). These activities accounted for 36 and 2%, respectively, in fall (J. F. Giroux, Univ. Laval, and J. Bédard, unpubl. data).

The Montmagny sanctuary was surrounded by intensive agricultural and urban activities (Fig. 1). There was a small airport, 3 km east of the sanctuary. A small-craft marina was located on the eastern edge of the sanctuary and a ferry boat, linking Montmagny and Isle-aux-Grues, left the river mouth on a tidal schedule. During fall, hunting pressure was high as hunters used blinds or pits along firing lines in the lower marsh and in adjacent agricultural fields (Giroux and Bédard 1986).

METHODS

We made observations during fall 1985, 1986 and spring 1986, 1987, from 3 elevated blinds and various temporary vantage points on shore. Two to 4 observers watched geese during daylight hours under all tide conditions in fall and during low tides in spring. During spring high tides, geese moved to adjacent agricultural fields to feed (Bédard et al. 1986, Gauthier et al. 1988). The number of geese in the sanctuary was established at the beginning of each observation period. When slightly disturbed, snow geese stretch their neck, may give alarm call(s), and may exhibit flight intention movements. We recorded only moderate to strong disturbance that caused a part or all of the observed flock to take flight. Natural flights of geese are easily distinguished from those caused by disturbance because in the latter case, all the geese take-off simultaneously. Only the latter were considered in this study.

For each disturbance, we noted the time of day, the percent of the lower marsh flooded by tide, the cause of the disturbance, the proportion of the flock taking flight (20, 21–40, 41–60, 61–80, and >80%), the time spent in flight, location where the geese landed, and the post-disturbance activity (feeding or roosting and/or preening) of most of the disturbed geese. Whenever disturbed geese resumed feeding immediately after a disturbance, we noted if they used the same site within the sanctuary (marsh sections based on landscape features). Whenever disturbed geese stopped feeding after a disturbance, we recorded the time it took for the first geese to resume feeding (not considered at high tides in fall).

The cause of a disturbance was classified as man-related, natural, or unidentified. Man-related disturbance was subdivided as hunting activities (gun shots, movements of hunters to or from their pits, and movements to retrieve shot birds), non-hunting activities (passage of humans [e.g., birdwatchers or photographers] in or near the sanctuary), agricultural or urban activities related to the presence or rapid passage of cars, trucks or agricultural implements, and transport activities related to aircraft (e.g., planes, helicopters) overflights, passage of the ferry boat, and passage of small yachts or motorboats. Natural causes related predator or predator-like disturbance (e.g., the slow wingbeat flight of large birds such as herons [*Ardea herodias*]).

All statistical analyses were conducted following Zar (1974). In certain circumstances to satisfy the assumptions of the Chi-square test (Zar 1974:49), the results of 2 cells were pooled. The acceptable level of statistical significance was established at 5%.

RESULTS

We observed geese for 471 hours and found no difference in the length of observation/day among years for a given season ($H = 1.28$, 1 df, $P = 0.257$ in fall and $H = 0.13$, 1 df, $P = 0.717$ in spring). This represents 57 and 48 days of observation in fall and spring, respectively, for mean observation length of 302.3 ± 15.5 (SE) minutes/day in fall and 229.5 ± 21.9 minutes/day in spring. The staging period of geese in the Montmagny sanctuary was similar in both seasons and averaged 44.5 and 43.5 days in fall and spring, respectively. Snow geese arrived at Montmagny in early April and left around 20 May. In fall, the first geese reached Montmagny at the end of September and the last birds left in mid-November. Geese used the sanctuary more in fall than in spring; mean flock size was 1,737 ± 196 birds in spring compared to 7,117 ± 471 in fall for a mean total use of 50,275 and 291,910 goose-days, respectively. The overall use was comparable in both years in fall; in spring, the sanctuary received lower use in 1987 than in 1986.

No difference was noted in disturbance rates between years of observation for a given season ($t = -1.17$, 55 df, $P = 0.248$ in fall and $t = -1.28$, 46 df, $P = 0.208$ in spring) ($n = 653$ disturbances), so data were pooled for subsequent analyses. The mean disturbance rate was significantly higher in fall (1.46 ± 0.11/hr) than in spring (1.02 ± 0.09/hr) ($t = 3.01$, 103 df, $P = 0.003$, $n = 105$).

Rate of disturbance was negatively correlated with the date ($r = -0.57$, $P = 0.0001$, $n = 57$) and positively correlated with the size of the flock ($r = 0.46$, $P = 0.001$, $n = 57$) using the sanctuary in fall. Date and flock size were not correlated ($r = -0.11$, $P = 0.311$, $n = 82$). Date and flock size were not correlated to disturbance rate in spring ($r = 0.19$, $P = 0.182$, $n = 48$ and $r = -0.02$, $P = 0.915$, $n = 45$, respectively). The percentage of the marsh flooded by tide affects the frequency of disturbance, in spring ($\chi^2 = 15.5$, 3 df, $P \leq 0.005$, $n = 152$) and fall ($\chi^2 = 17.9$, 4 df, $P \leq 0.005$, $n = 436$) (Fig. 2A). Moreover, the level of disturbance also varied with time of day in spring ($\chi^2 = 88.1$, 11 df, $P \leq 0.001$, $n = 166$) and fall ($\chi^2 = 203.7$, 11 df, $P \leq 0.0001$, $n = 486$) but the pattern differed between seasons ($\chi^2 = 95.2$, 11 df, $P = 0.0001$,

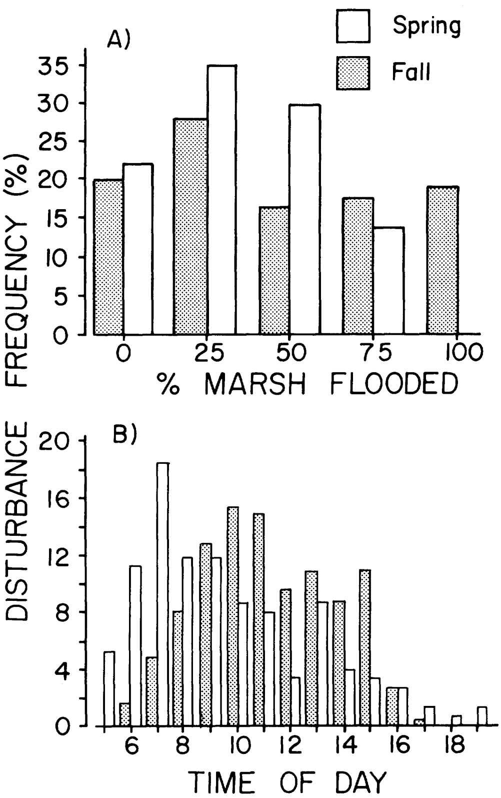

Fig. 2. Influence of tidal level (% of the marsh flooded) and time of day on disturbance frequency (%) of staging greater snow geese in the Montmagny sanctuary, Québec, fall and spring 1985–87.

$n = 652$). In spring, most disturbances occurred early during the day and in fall, most disturbances occurred between 0900 and 1600 hours (Fig. 2B).

Man-related disturbances were more frequent than natural or unidentified disturbances ($\chi^2 = 458.1$, 2 df, $P \leq 0.0001$, $n = 445$ in fall and $\chi^2 = 116.2$, 2 df, $P \leq 0.0001$, $n = 151$ in spring) (Table 1). Transport activities were the most important human disturbance in both seasons ($\geq$45%) and aircraft overflights ranked first among these (Table 1). Hunting caused 27% of disturbances in fall.

The entire flock took flight in 20% of disturbances, but important differences were observed between seasons ($\chi^2 = 150.5$, 4 df, $P = 0.001$, $n = 604$) (Table 2). In fall, 49.8% of disturbances affected only 20% of the flock, and $\geq$70% of them affected $\leq$40% of the flock. In spring, however, $\geq$50% disturbances caused the entire flock to take flight (Table 2).

Disturbances affecting most members of the flock ($\geq$60%) were mainly caused by human activities related to transport, particularly in spring (Fig. 3). Disturbances related to hunting, non-hunting activities, and natural causes, affected only a small proportion ($\leq$40%) of the flock in both seasons (Fig. 3). Tide level ($\chi^2 = 20.9$, 16 df, $P = 0.187$, $n = 433$ in fall and $\chi^2 = 16.3$, 12 df, $P = 0.178$, $n = 152$ in spring) and flock size ($F = 1.11$, 4 df, $P = 0.354$, $n = 451$ in fall and $F = 2.27$, 4 df, $P = 0.070$, $n = 147$ in spring) did not influence the proportion of the flock disturbed.

Geese spent a mean of 56 ± 2.9 seconds in flight/disturbance in fall and of 77 ± 10.4 seconds in spring ($t = -1.99$, 105.9 df, $P = 0.049$, $n = 342$). Following post-disturbance flight, geese continued to feed in 59.6 and 55.4% of cases in fall and spring, respectively ($\chi^2 = 0.481$, 1 df, $P = 0.488$). When they resumed feeding, they fed on the site used immediately before disturbance 83.3 and 74.7% of the time in fall and spring, respectively. When geese stopped feeding (40.4 and 44.6% of all cases, respectively), the mean time to resume feeding/disturbance was 726.3 ± 139.1 seconds in fall compared to 122.4 ± 79.5 seconds in spring ($t = 3.77$, 307.5 df, $P = 0.0002$). Time spent in flight and time to resume feeding were not correlated ($r = 0.001$, $P = 0.988$, $n = 313$).

Time spent in flight differed between seasons and among causes of disturbance in fall ($F = 6.12$, 4 df, $P = 0.0001$, $n = 242$) but not in spring ($F = 1.90$, 4 df, $P = 0.119$, $n = 90$) (Table 1). In both seasons, geese spent more time flying after transport-related disturbances than they did after any other type of disturbance ($P \leq 0.05$). Time in flight was much longer after aircraft passage in spring ($\bar{x} = 109.7$ sec) than in fall ($\bar{x} = 65.6$ sec) ($t = -2.20$, 51.1 df, $P = 0.032$, $n = 130$) (Table 1). Hunting disturbance caused geese to take flight for about 50 seconds. Time to resume feeding was not influenced by the type of human disturbance ($F = 0.55$, 4 df, $P = 0.699$, in fall and $F = 0.08$, 4 df, $P = 0.988$ in spring) (Table 1) but was generally greater in fall than in spring and that, for most disturbance types, mainly for aircraft ($t = 2.32$, 114.9 df, $P = 0.022$). Hunting and transport-related activities caused the greatest loss of feeding time in fall ($\geq$15 min/disturbance). Ferry boats had little influence ($\leq$10%). Natural disturbances caused feeding interruption of only a few seconds (Table 1).

Only 4.0% of all cases of disturbance pro-

Table 1. Relative importance (%) of disturbance, time in flight (sec), and time to resume feeding (sec) ($\bar{x}$ ± SE) by staging greater snow geese in the Montmagny sanctuary, Québec, 1985–87.

	Fall (n = 436)					Spring (n = 152)				
		Time in flight		Time to resume feeding			Time in flight		Time to resume feeding	
Cause of disturbance	%	$\bar{x}$	SE	$\bar{x}$	SE	%	$\bar{x}$	SE	$\bar{x}$	SE
Human related	80.7	45.4	6.3	854.2	420.7	72.3	43.7	8.9	148.6	99.6
Urban, agricultural	7.8	32.1	5.9	103.2	65.1	6.6	31.4	8.6	68.6	39.7
Transport										
Aircraft	28.8	65.6	5.0	1,320.5	515.9	52.0	109.7	19.4	493.9	419.2
Ferry boat	10.9	49.9	13.1	26.0	11.0	9.2	60.0	0.0	60.0	0.0
Marina	3.3	67.0	9.7	1,229.9	679.1	0.6	50.0	5.9	56.9	4.4
Non-hunting activity	2.9	33.3	12.6	546.1	448.8	3.9	35.0	7.6	63.8	34.7
Hunting activity										
Gun shots	20.7	52.0	4.9	465.5	320.6					
Hunter movements	6.7	44.3	7.6	2,288.2	904.4					
Natural[a]	2.8	8.4	4.2	4.3	0.8	2.0	3.0	2.0	3.0	2.0
Unidentified	16.1	54.2	7.9	858.5	449.3	25.7	51.0	5.8	151.7	111.0

[a] Predator or predator-like disturbance.

voked immediate departure of geese from the sanctuary in fall; in spring this proportion was 36.5% (χ^2 = 92.5, 1 df, P = 0.0003). We compared the rate of disturbance observed one day with the difference recorded in flock size the next day (Table 3). In fall, flock size significantly decreased with disturbance rates (F = 2.98, 4 df, P = 0.037, n = 54); at low rates of disturbance, no change was noted in flock size the next day but when disturbance rate reached or exceeded 2.0/hour, the flock size decreased by about 50%. This decrease was not observed in spring (F = 0.72, 4 df, P = 0.588, n = 39) (Table 3).

DISCUSSION

Disturbance of greater snow geese affects their feeding activities and their subsequent use of the Montmagny sanctuary, particularly in fall. The mean disturbance rate that we recorded (1.26/hr) was higher than that observed by Owens (1977) for wintering dark-bellied brant geese (*Branta bernicla bernicla*) in England (0.68/hr) but lower than that reported by Prevett and MacInnes (1980) for wintering lesser snow geese (*Chen c. caerulescens*) in the central United States (1.4–2.6/hr). Moreover, because our study recorded only disturbances severe enough to cause geese to take flight, our data represent a minimum estimate of the effects of disturbance to staging greater snow geese.

The impact of human disturbance varies among wildfowl species (Burger 1981) and depends on their wariness and their capability of habituating to certain disturbing events. Disturbance rates were higher when there were more birds in the sanctuary. Owens (1977) observed that larger flocks of brant geese took flight at a greater distance than did smaller ones when approached by people. Madsen (1985) also observed this phenomenon in pink-footed geese (*Anser brachyrhynchus*) staging in Denmark. Disturbance behavior of a goose flock is largely determined by the individual behavior of its most nervous members because the take-off of only few birds may cause the entire flock to take flight. In our study, fall disturbance rate was negatively related to date. Decreased hunting pressure at the end of the season and/or habituation of geese to gunfire (Owens 1977) may explain this pattern. Giroux and Bédard (1988) found that goose distribution in the Montmagny sanctuary in fall was influenced by the location of hunter pits. Other studies have also shown that different bird species quickly become habituated to frequent and regular disturbing

Table 2. Extent of the disturbance (in proportion of the flock taking flight) related to the frequency of disturbance (% of the total disturbances) in staging greater snow geese in the Montmagny sanctuary, Québec, 1985–87.

% of the flock taking flight	Fall (%, n = 452)	Spring (%, n = 152)
20	49.8	17.9
40	21.8	8.6
60	12.3	9.9
80	6.6	11.2
100	9.0	52.6

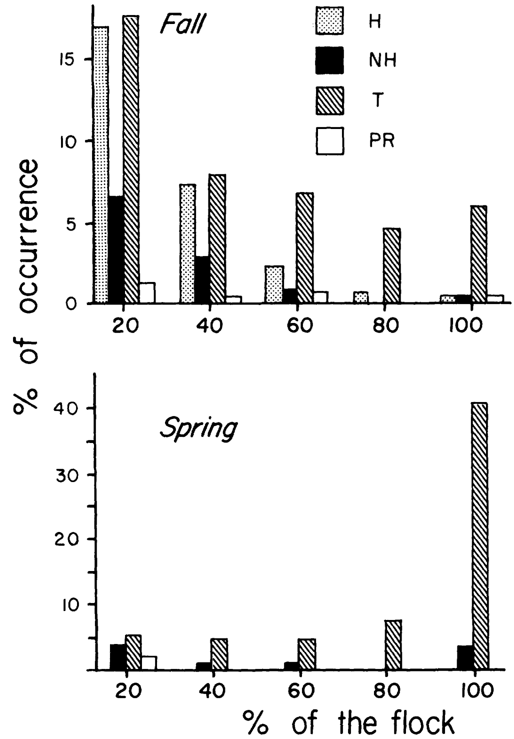

Fig. 3. Relation between the cause of disturbance and the extent of the disturbance caused to the flock (20–100%) in snow geese staging in the Montmagny sanctuary, Québec, spring and fall 1985–87. H = hunting activity, NH = non-hunting activity, T = transport and agricultural-urban activity, and PR = predator or predator-like disturbance.

events (Stalmaster and Newman 1978, Cooke 1980). It could be advantageous for geese to become more tolerant to disturbance in fall because when they fly, the wind can push them outside of the sanctuary and expose them to hunters. Bartelt (1987) has shown that disturbance caused separation of family members and increased hunting mortality of Canada geese (*Branta canadensis*). Therefore, the decreased response to disturbance that we observed in fall could be related to growing tolerance by snow geese.

The amplitude of the response to disturbance by geese varies depending upon its cause. Therefore, the impact of disturbance is related to its frequency and its cause. Human activities, particularly those related to transport, were the most important sources of disturbance recorded in our study. Owens (1977) observed that brant geese were particularly susceptible to disturbance by small aircraft. Disturbance by aircraft affected greater snow geese in many ways but it generally disturbed the entire flock. Time spent in flight and time to resume feeding were also greater after disturbance by aircraft than after any other type of disturbance encountered in our study. Frequently, the geese took flight before the observer could detect the presence of the aircraft generating the disturbance (L. Bélanger and J. Bédard, unpubl. data). Thus, unidentified disturbances may have included cases in which aircraft never heard by the observer were detected by the geese. The time to resume feeding after a disturbance was strikingly shorter in spring than in fall. This is probably related to the necessity to deposit fat during spring as the birds prepare for migration and breeding (Ankney and MacInnes 1978, Raveling 1979, Thomas 1983).

An extreme response of waterbirds to severe and frequent disturbance is to leave the disturbed site (Thornburg 1973, Hume 1976, Tuite et al. 1983). Geese may learn to identify the danger associated with particular sites and try to avoid them (Owens 1977, Madsen 1985). Our study indicates that disturbance of greater snow geese that are staging affects their feeding activities and their subsequent use of a staging site. Whenever greater snow geese that are staging were disturbed at a rate of ≥2.0 disturbances/hour on 1 day, their numbers at the site were lower the next day.

Table 3. Influence of the mean hourly disturbance rate (no./hr) on 1 day upon the attendance by greater snow geese in the Montmagny sanctuary, Québec, 1985–87 the following day.

		No. geese present on the day following the disturbance − no. geese present on the day of disturbance				
		Fall			Spring	
Disturbance rate	No. days of observation	$\bar{x}$	SE	n	$\bar{x}$	SE
≤0.5	11	−959.1	927.5	9	66.7	337.8
0.6–1.0	16	908.3	859.5	14	39.3	432.3
1.1–1.5	12	−716.7	590.1	9	−488.9	340.8
1.6–2.0	12	−583.3	676.8	6	−916.7	685.3
≥2.1	13	−3,575.1	1,272.5	1	−500.0	

MANAGEMENT IMPLICATIONS

The entire population of greater snow geese (350,000 birds; J. Bédard, unpubl. data) stops in Québec during fall and spring migration and stages in the Saint Lawrence River. Bulrush marshes cover only 3,750 ha and the number and total area of sanctuaries in the estuary is limited (5 totalling approx 800 ha; C. Maisonneuve and J. Bédard, unpubl. data). In fall, large numbers of snow geese are then confined at these sites because of high hunting pressure. Moreover, Giroux and Bédard (1987) showed that grazing by greater snow geese greatly lowered plant production within sanctuaries. Consequently, a reduction in feeding time due to disturbances, and a depleted food base could affect the distribution and the length of the staging period of greater snow geese along the Saint Lawrence estuary.

A primary goal in improving and maintaining the carrying capacity of staging habitats of greater snow geese should be to reduce human disturbance to ≤ 1.0/hour, particularly aircraft overflights. As geese are slow to habituate to such disturbance, aircraft flights over sanctuaries should be strictly regulated. Although further study is needed, we suggest that flights below 500 m should be prohibited as recommended by Owens (1977). The consequences of human disturbance (e.g., hunting and aircraft) on energy budget of staging geese should be investigated because these effects could be as serious as the emigration of the geese.

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