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Goose use of the coastal habitats of northeastern James Bay

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Cover photo: Scaly sedge *Carex paleacea* in dense tall stands in the upper salt marshes of northeastern James Bay (M. Salathé)

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Abstract

The northeast coast of James Bay was chosen for study because of its importance as a staging area for migrating geese and because of the development of the La Grande hydroelectric complex, the main structures of which are along the La Grande River, which empties into the northeastern part of James Bay. In 1990 and 1991, use of coastal habitats by Canada Geese *Branta canadensis* and Atlantic Brant *B. bernicla hrota* was studied along the northeast coast of James Bay. Use of this coastline by other goose species is negligible. Both aerial and ground surveys were conducted to determine patterns of habitat use in spring, summer, and fall, and stomach content analysis was used to establish diet composition and food preferences.

Canada Geese used several different coastal habitats during spring and fall migration. Salt marshes, most of which occur along the mainland coast, were heavily used during both migration periods. Heath, found mainly on islands and exposed points, was also used in both periods, but especially in fall. The diet of Canada Geese in spring was characterized by a wide diversity of plants, of which scaly sedge *Carex paleacea*, needle spikerush *Eleocharis acicularis*, mare's-tails *Hippuris tetraphylla*, and marsh arrowgrass *Triglochin palustris* (all salt-marsh plants) were most important. Fewer plant species occurred in the fall diet, but *Carex*, *Eleocharis*, and other graminoids were important, as were burreeds (*Sparganium* sp., probably obtained in large part from feeding in nearby freshwater ponds) and berries (black crowberry *Empetrum nigrum* and *Vaccinium* spp., obtained from heathland). Only a few Canada Geese remained in the area during summer, most of them to moult on the heath-covered outer islands or on salt marshes.

Atlantic Brant used eelgrass *Zostera marina* meadows almost exclusively during both spring and fall migrations. Their diet in both seasons was composed almost entirely of the leaves of eelgrass. They were not present in the area during summer.

Thus, three coastal habitats (salt marsh, heath, eelgrass meadows) met the essential needs of these two goose species while they stopped off to replenish nutrient reserves on migration. Although no indication of habitat deterioration was observed in these coastal habitats, it would be desirable to ensure careful monitoring of these important habitats and to seek legal protection for key sites.

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1. Introduction

The James Bay Energy Corporation has studied the habitats of the northeast coast of James Bay since 1982. In 1989, the Canadian Wildlife Service joined the James Bay Energy Corporation in the study of those habitats and their use by waterfowl. This partnership resulted in the publication of a report describing the coastal habitats from the Au Castor River to Point Louis-XIV (Dignard et al. 1991) and the undertaking of a series of surveys and ecological observations from 1990 to 1995. This report, the second in a series, describes goose use of the coastal habitats of northeastern James Bay. An earlier report (Reed et al. 1996a) described the use of the same coastal habitats by ducks. A future report will examine waterfowl use of freshwater wetlands on the lowland coastal plain.

This area was chosen for study because of the development of hydroelectric power on the La Grande River, which flows into James Bay along its northeast coast. Development began in 1973; the resulting hydrologic changes on the coastline consisted mainly of a reduced flow of fresh water into James Bay through the Eastmain River estuary (to the south of our study area) and a major increase in flow through the La Grande River estuary (in the middle of our study area) during winter (Messier et al. 1986, 1989). Given the magnitude of the development project, there was a clear need to gain an in-depth understanding of the ecological relationships between the coastal habitats and migratory geese in that area.

Earlier studies had identified the east coast of James Bay as an important area for Canada Geese *Branta canadensis* and Atlantic Brant *B. bernicla hrota* (hereafter Brant), particularly during migration. Most of the information came from the expeditions of W.E.C. Todd (Todd 1963) and T.H. Manning (Manning 1952, 1981; Manning and Coates 1952; Manning and Macpherson 1952) and, more recently, from studies by Bourget (1973a, 1973b), Curtis and Allen (1976), Morrison and Gaston (1986), and Reed et al. (1990). That work provided a good background on the individual species present, their relative abundance, and their geographical distribution, but, with the exception of the study by Curtis and Allen (1976), gave little information on habitat use.

Many wildlife studies related to resource exploitation have focused on comparing the size of postdevelopment populations with those present prior to development. We did not take this approach for a variety of reasons, including 1) the incompleteness of certain earlier population assessments and 2) anticipated difficulties in conducting complete and systematic surveys (costs and, especially, restrictions on aerial and ground survey work during the peak months of waterfowl migration). Furthermore, it was felt that any changes in numbers of geese would be difficult to link to events occurring in James Bay rather than to events occurring elsewhere along their lengthy migratory routes or on the wintering grounds.

Our approach was based on the premise that any eventual impacts from development would result from changes in habitats. We therefore focused primarily on identifying habitats used by the two different species of geese and showing how these habitats fulfilled their ecological requirements during various stages of their life cycles (Benoit et al. 1996). This was facilitated by the existence of a detailed habitat map (Dignard et al. 1991), which allowed us to associate any goose observation with a specific habitat. By using a combination of field techniques (surveys, behavioural observations, stomach content analyses), we sought to gain a more comprehensive understanding of how the ecological requirements of the two goose species (Canada Goose and Brant) were being met by the array of coastal habitats in the area. This richer ecological data base should allow more meaningful evaluations of the importance of various wetlands or wetland complexes, leading to more rational decisions regarding the protection and management of waterfowl populations in James Bay and elsewhere.

2. Study area

In 1990, we focused on one sector, the Bay of Many Islands, because of its wide range of habitats, representative of the entire northeast coast. Subsequently, the study area was extended to include Dead Duck Bay and an area near Point Attikuan (Fig. 1).

The following brief description of the coastal habitats summarizes the work of Dignard et al. (1991), to which readers are referred for detailed descriptions and a map of the habitats as well as a list of plant species. The northeast coast of James Bay is highly sinuous, punctuated by numerous bays, points, and peninsulas and fringed by numerous islands, islets, and reefs. There is a frequent alternation between flat, gradually sloping shorelines and rockier, hilly shores, but overall the area is low, with little relief. Vast expanses of open boreal forest are found immediately inland along the lowland plain, but the forest along the coast itself is dominated by white spruce *Picea glauca*, owing to the intensity and frequency of marine fog. In the Bay of Many Islands, vast stretches of mud/sand tidal flats are found on the shore of the mainland. Salt marshes often occur inshore from these flats, showing zonation into a low salt marsh immediately above the tidal flats and a high salt marsh. In protected bays along the coast and inshore from the islands, where the substrate, slope, and salinity are favourable, subtidal meadows or beds (the terms meadow and bed are used synonymously throughout this report) of eelgrass *Zostera marina* occur (Lalumière et al. 1994). These eelgrass meadows can be subdivided into those that are dense (≥50% vegetative cover) and continuous and those that are sparse (<50% cover) and discontinuous. Medium-sized and large islands are often covered by heath, with lichens, ericaceous shrubs, or black crowberry *Empetrum nigrum* dominating, and usually dotted with small ponds. A narrow strip of boulder-strewn shoreline fringed with sea lime-grass *Elymus mollis* or scaly sedge *Carex paleacea* is often found around the edges of these islands or along certain sections of the mainland coast. In a few areas, salt ponds are found near the upper limits of the tidal flats. Islets and reefs generally have little vegetation.

The habitats to the south, in Dead Duck Bay, have similar profiles and floristic characteristics. Point Attikuan, to the north, has less extensive mud/sand tidal flats and marshes; eelgrass beds and large expanses of heath are present.

3. Methods

3.1 Data collection

During each of the two years of the study, we made several visits to the study area in spring, summer, and fall (Table 1). Aerial surveys were restricted to the period between the beginning of June and the middle of August to avoid disturbance during the Crees' traditional spring and fall waterfowl hunts (Reed 1991).

For this study, data collected from 16 May to 13 June were considered to relate to the spring migration period, those from 25 June to 14 August to the breeding and moulting period, and those from 10 September to 1 October to the fall migration period. The middle period was further divided into the nesting and premoult period (25 June to 4 July) and the brood-rearing and moulting period (30 July to 14 August). The choice of these dates is somewhat arbitrary because of intra- and interspecific differences in the phenology of migratory and reproductive activities, but the dates chosen generally demarcate periods when most species were migrating, breeding, or moulting.

3.1.1 Aerial surveys

Aerial surveys were conducted in a Bell 206 L helicopter, flying at a speed of 50–100 km/h and at an altitude of approximately 50 m, depending on the topography and type of habitat. An observer in the front lefthand seat acted as navigator and counted and identified the birds seen on that side of the aircraft, whereas an observer in the back righthand seat counted birds on his side. Usually an additional observer in the rear lefthand seat assisted the observer in the front. Data were recorded on standard forms by the navigator or the observer in the left rear seat. The location of geese was recorded on a 1:50 000-scale map.

Three types of aerial surveys were conducted. In 1990, an 87-km transect following the coastline of the Bay of Many Islands and passing over some of the islands was flown on 6 and 28 June and on 3 August (Fig. 2). This survey provided an initial assessment of the use of broad groupings of habitats by geese in late spring and in summer. On 4 and 6 August 1990, four quadrats, each 25 km^2 (5 × 5 km), were thoroughly surveyed (Fig. 2); their locations were selected arbitrarily to reflect an inland to

Figure 1
The northeast coast of James Bay, showing the location of sectors surveyed in 1990 and 1991 and the location of hunting territories where Canada Geese were collected in 1990

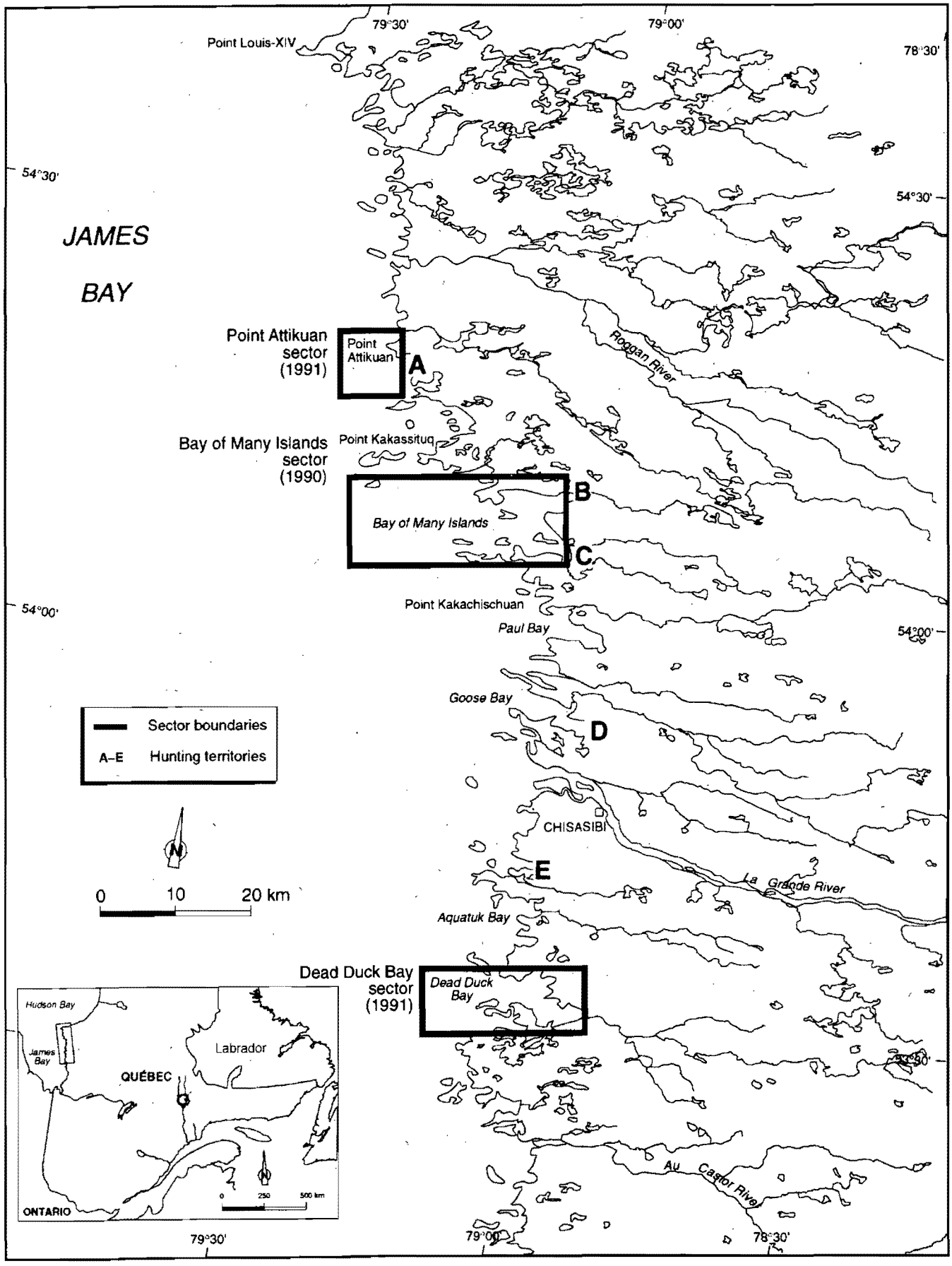


Table 1
Schedule of field activities on the northeast coast of James Bay in 1990 and 1991

Year	Periods	Field activities: Behavioural observations	Aerial surveys	Collection of goose stomachs	Goose droppings counts
1990	May			√	
	4–13 June	√	√	√	
	25 June – 4 July	√	√		
	30 July – 8 August	√	√		
	20 September – 1 October	√			
	September			√	
1991	16–22 May	√			√
	25 June – 2 July	√			√
	5–14 August		√		
	10–16 September	√			

offshore gradient in habitat conditions in the Bay of Many Islands.

A third survey was carried out between 8 and 13 August 1991, covering 44 quadrats, each 4 km^2 (2 × 2 km). The quadrats were systematically distributed among three sectors (Point Attikuan, Bay of Many Islands, and Dead Duck Bay) (Fig. 3), allowing evaluation of both population densities and habitat use by geese in late summer. The data were stratified by sector with the aim of increasing the accuracy of population estimates (see Rutherford and Hayes 1976).

3.1.2 Behavioural observations

To establish ecological links between geese and their habitats, eight sites, each with a variety of habitats, were selected for behavioural observations at the start of fieldwork in 1990 (Fig. 2). At three sites (S02, S03, S11), repeated scans were performed every 30 or 45 minutes over six- or 12-hour periods. At the other five sites (S01, S05–S08), a single instantaneous scan was carried out during each observation session (Table 2).

During each count, the location of all groups of geese observed was plotted on an acetate sheet overlaying a 1:10 000 colour aerial photograph of the site; thus, the behaviour observed could be associated with a specific habitat. Simultaneously, the number of individuals in each group and their behaviour were recorded. The categories of behavioural activity used in our observations included feeding, resting, flying, preening, vigilance, and social interaction. The repeated scans were used to examine habitat use in relation to time of day and tidal level. An electronic planimeter was used to measure the area of each habitat at each site.

3.1.3 Diet of Canada Geese and Brant

In May 1990, Cree hunters in five different hunting territories spread along the coastline of the study area (Fig. 1) collected esophagi and gizzards from 309 Canada Geese shot during the traditional spring hunt. Although most hunting was concentrated in coastal habitats, some of the harvested geese could have been taken in freshwater wetlands short distances inland from the coast. In October 1990, an additional 19 digestive tracts were collected in one of the hunting territories (Bay of Many Islands). Each digestive tract was sealed in a plastic bag and frozen as soon as possible. In 1990–1991, esophagi and gizzards were collected from 31 Brant in early June in the Bay of Many Islands and from 42 Brant in late September – early October at the same location and at Point Attikuan.

3.1.4 Goose dropping counts

Goose droppings were counted in 0.5 × 20.0 m transects to document utilization of heathland by Canada Geese in spring. Three such transects were established at each of two island sites and at one mainland location in the Bay of Many Islands on 18–19 May 1991 (Fig. 2). At the time of the establishment of the three transects, a visual evaluation of the plant cover was made for each one, and the goose droppings present were counted and removed. A second dropping count was made a month later, on 26 June 1991.

3.2 Data analyses

3.2.1 Aerial surveys

3.2.1.1 Transect (1990)

Aerial transect surveys were divided into 1-km segments using the Universal Transverse Mercator (UTM) grid. Because of the patchiness of the habitat and the difficulty of associating a given bird (often seen in flight) with a specific habitat, we recognized groupings of two adjacent habitats, which we refer to as "macrohabitats." The four macrohabitats recognized (marsh–tidal flat, eelgrass bed–tidal flat, heath–tidal flat, and open water) are described in Table 3 and in Reed et al. (1996a).

Although some freshwater habitats along the mainland coast were covered during this survey, they were not included in the present analysis.

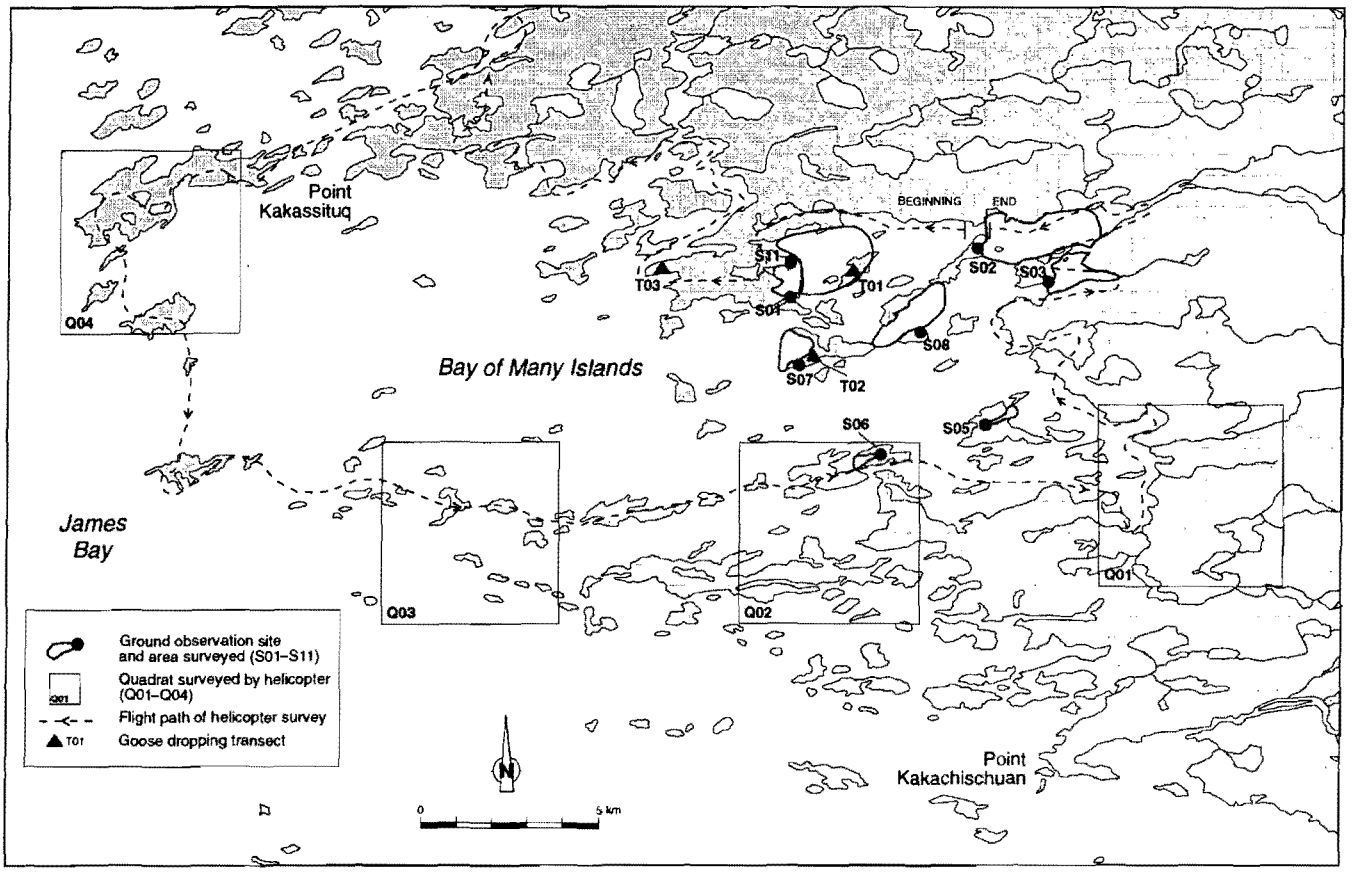
3.2.1.2 Quadrats

Aerial surveys of quadrats involved exhaustive counts of geese in all wetlands within 5 × 5 km (1990) or 2 × 2 km (1991) quadrats during the brood-rearing and moult periods (Figs. 2 and 3). The survey technique is adapted from that developed by Bordage (1987). Using the method described by Cochran (1977:91), we estimated populations from the stratified mean calculated for all the sectors. Note that some of the innermost quadrats of this survey covered some freshwater mainland habitats; thus, exceptionally in this case, freshwater habitats have been included in the analysis.

3.2.2 Behavioural observations

Data collected at ground stations were analyzed with Bonferroni's method (Byers et al. 1984) to determine whether habitats were used or avoided significantly by each species. At stations where repetitive scans were conducted over several hours, data were compiled by species according to habitat and behaviour, and bird

Figure 2
The Bay of Many Islands, showing the location of survey quadrats and transects, ground observation stations, and goose dropping transects



numbers were expressed in number of individuals per square kilometre.

3.2.3 Diet

Of the 328 Canada Goose esophagi collected, 150 from birds shot during the spring hunt and 14 from geese collected in the fall contained identifiable food items and were retained for analyses. Similarly for Brant, 27 of 31 esophagi from spring and 30 of 42 from fall were retained.

Food items found in the digestive tracts were identified to species whenever possible (otherwise to genus or family). Different plant parts (e.g., seed, leaf, stem, root) were recorded separately. Each item for each goose was oven-dried for 24 hours at 65°C and weighed. Weights below 0.05 g were rounded upward to that value for the calculation of percent dry weight.

Figure 3
Location of survey quadrats in Point Attikuan, Bay of Many Islands, and Dead Duck Bay sectors, 8–13 August 1991

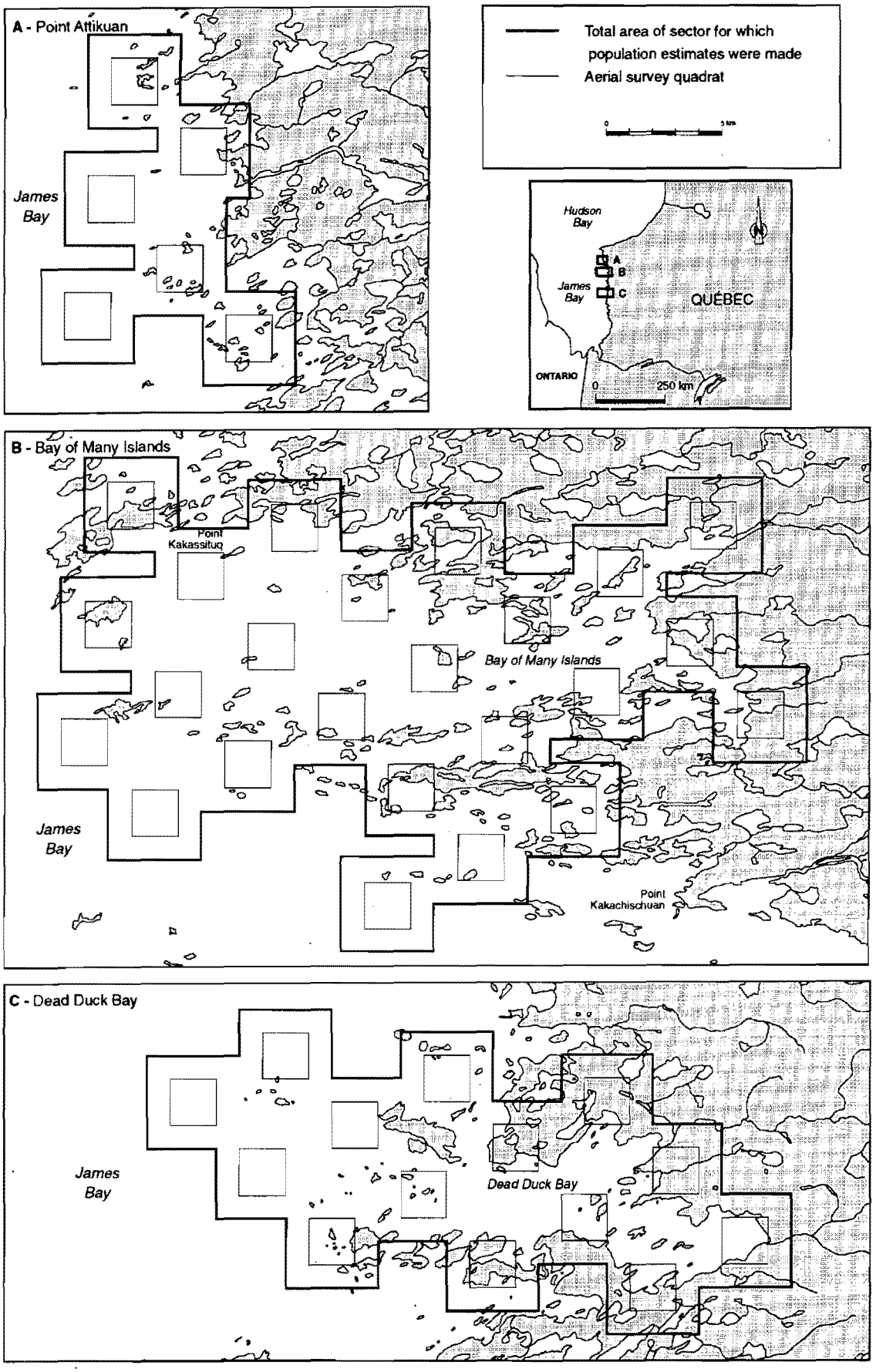


Table 2
Periods of behavioural observations at eight sites in the Bay of Many Islands in 1990 and 1991

Site	Year	Date	Observation periods[a]	No. of counts
S01	1990	6, 8, 10 June	7:15, 9:13, 15:11	3
		1 July	9:04	1
		1 August	17:24	1
		23 September	15:53	1
S02	1990	6 June	06:30–12:00	12
		8 June	15:30–21:00	13
		22 September	12:15–17:45	12
	1991	28 June	15:00–20:30	8
S03	1990	7 June	14:00–19:30	12
		11 June	08:00–13:00	11
		23 September	12:00–18:00	12
	1991	20 May	09:30–15:30	13
S05	1990	7, 9, 12 June	12:25, 11:00, 10:25	3
		30 June	12:24	1
		1 August	19:29	1
		23 September	13:50	1
S06	1990	7, 10, 12 June	11:42, 16:08, 10:53	3
		30 June	10:59	1
		1 August	18:05	1
		23 September	14:50	1
S07	1990	6, 9, 12 June	17:15, 11:58, 18:35	3
		1 July	7:25	1
		1 August	16:17	1
		23 September	16:15	1
S08	1990	8, 10, 12 June	7:39, 13:28, 7:58	3
		1 July	8:02	1
		1 August	16:45	1
		23 September	16:50	1
S11	1991	12 September	12:00–18:00	13
		13 September	07:30–12:30	11

[a] Eastern daylight saving time (EDT).

Table 3
Categories of macrohabitats used in analysis of aerial survey data

Aerial surveys		
Transect	Quadrat	Description[a]
Marsh–tidal flat	Marsh–mud/sand tidal flat	Mainly freshwater and salt marshes, mud/sand tidal flats, or a combination of the above.
Eelgrass bed–tidal flat	Eelgrass bed	Eelgrass meadows with dense or sparse cover.
	Boulder-strewn tidal flat or boulder-strewn shore fringed with vegetation	Tidal flats strewn with rocks or boulders, boulder-strewn shoreline, or rocky islets fringed with vegetation.
Heath–tidal flat	Heath	Both *Empetrum* and lichen heaths.
	Offshore island	Boulder-strewn tidal flats without shoreline or submerged vegetation, and barren rocky islands.
Open water	Open water	Areas of open water around islands.
–	Freshwater habitats	Freshwater lakes, ponds, marshes, and bogs near the coast.

[a] Adapted from Dignard et al. (1991).

4. Results

4.1 Habitat use by Canada Geese

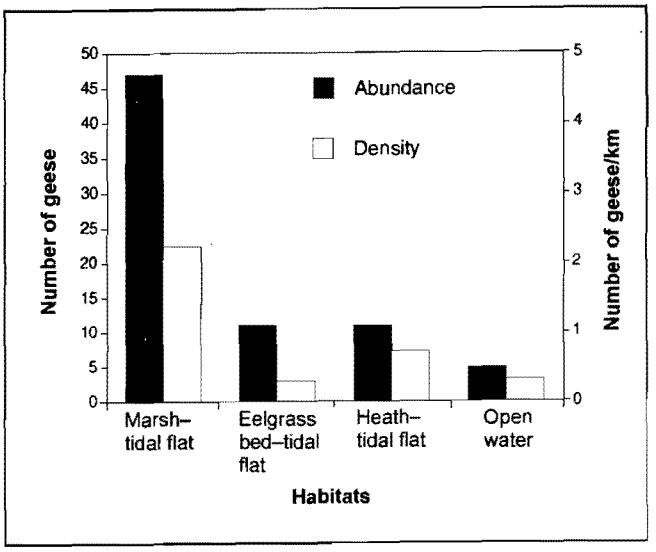
4.1.1 Habitat use during migration

During our earliest spring observations (16–18 May 1991), ice and snow covered all habitats except portions of some salt marshes and a few leads and small polynyas in open coastal waters; casual observations indicated regular movements of Canada Geese between roosting sites in open water and feeding areas in salt marshes.

An aerial survey on 6 June 1990, when all habitats were mainly ice-free, showed that Canada Geese occupied many macrohabitats, especially those associated with salt marshes and tidal flats (Fig. 4). Ground observations indicated that both feeding and other activities occurred almost exclusively in salt marshes (Fig. 5); this use of salt marsh was significantly greater than expected on the basis of habitat availability. Canada Geese also fed in heath during spring, but they used it more warily than other habitats, resulting in few observations during ground counts or aerial surveys. Use of heath was evident from the presence of fresh goose droppings; from 19 May to 26 June 1991, Canada Geese left droppings in eight of nine preestablished ground transects (Table 4).

During fall, salt marshes — especially low salt marshes — continued to be heavily utilized by Canada Geese, both for feeding and for other activities (Figs. 6 and 7); in most cases this use of salt marsh was significantly greater than expected on the basis of habitat availability. Other habitats were also used intensively in fall. At one site, we also recorded intensive use of mud/sand tidal flats for feeding (upper graph, Fig. 7), but this may be misleading, because most of these geese were very near the boundary of a salt marsh and were most likely feeding on salt-marsh plants that either had been washed seaward onto the mud/sand flats by tidal action or occurred in isolated clumps at the boundary of the salt marsh. At another site that included a heath-covered island, geese fed intensively on heath, concentrating on an expanse of upland *Empetrum* heath as well as in a grassy patch dominated by *Elymus mollis* near the shoreline (Fig. 8). Some remained in those habitats to rest and to preen, whereas others moved to nearby mud/sand tidal flats for these activities.

Figure 4
Distribution of Canada Geese by habitat type in an aerial survey on 6 June 1990 in the Bay of Many Islands (n = 74 geese)

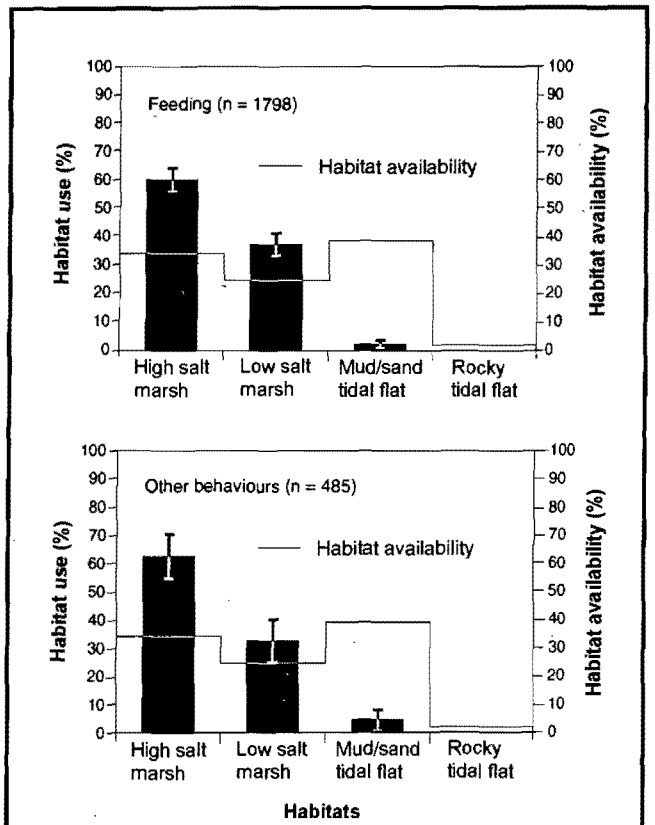


4.1.2 Diet during migration

At least 30 species of plants were found in the digestive tracts collected during spring migration (Table 5, Appendix 1). The most important items were *Carex paleacea* seeds, mare's-tail *Hippuris tetraphylla* (leaves, stems, and rhizomes), *Eleocharis acicularis* (entire plants or various parts), and marsh arrowgrass *Triglochin palustris* bulbs (Tables 6 and 7, Photos 1–4, Appendices 2.1 and 2.2). Graminoids (mainly roots and basal portions of stems), some of which could not be identified to species, were also important, both in frequency of occurrence and in proportion of total dry weight.

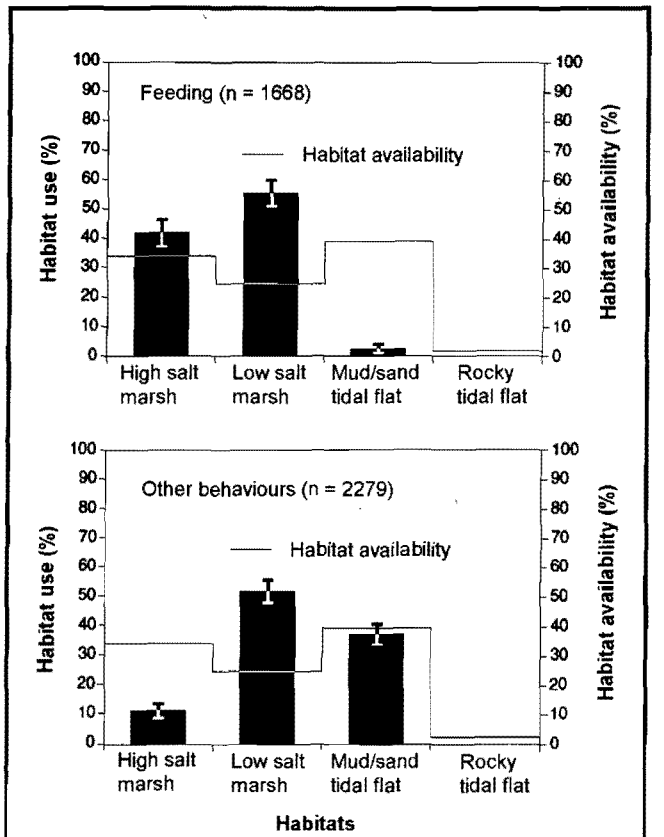
From a smaller sample of geese in fall, at least 10 species of plants were found (Appendix 1), the most important of which was burreed *Sparganium* sp. (leaves) (Table 6). Graminoids (Cyperaceae and Gramineae), as a group, were also important, accounting for 28% of total dry weight. Seeds and berries of *Empetrum nigrum* (Photo 5) and mountain cranberry *Vaccinium vitis-idaea* were also important.

Figure 5
Distribution of Canada Geese by habitat type at site S03 on 20 May 1991



The shaded bars indicate goose use. The stripe through the top of the bars indicates 99% confidence intervals. If the line indicating the proportional availability of a habitat passes through the confidence interval stripe, the habitat is considered to have been used in proportion to its availability. If the line crosses outside the stripe, the habitat is considered to have been significantly preferred or avoided ($p = 0.01$, Bonferroni's method; Byers et al. 1984). n = number of geese observed.

Figure 6
Distribution of Canada Geese by habitat type at site S03 on 23 September 1990



Symbols and explanation as in Figure 5.

Table 4
Numbers of goose droppings recorded in nine transects in the Bay of Many Islands in May and June 1991

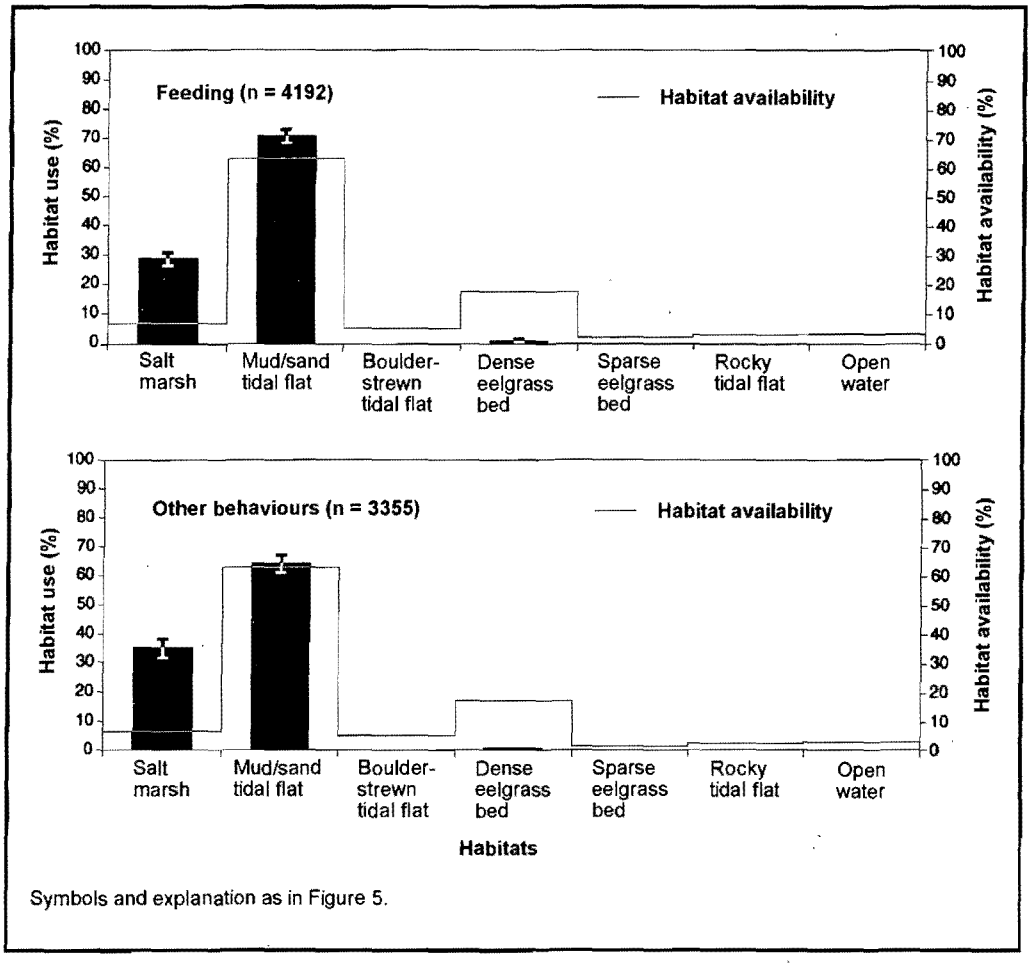
Site	Transect[a]	% cover: Black crowberry[b]	% cover: Lichens	% cover: Dwarf birch[c]	No. of droppings removed (18 and 19 May 1991)[d]	No. of droppings deposited between 19 May and 26 June 1991
T01	1	95	–	5	2	0
(island heath)	2	85	15	–	2	4
	3	45	40	15	0	3
T02	1	90	10	–	0	2
(island heath)	2	60	40	–	2	2
	3	30	70	–	3	7
T03	1	70	25	5	1	1
(mainland heath)	2	30	70	–	1	1
	3	60	40	–	1	2

[a] Transect 0.5 × 20.0 m.
[b] *Empetrum nigrum*.
[c] *Betula glandulosa*.
[d] Date on which plots were established; these droppings probably dated from the previous fall.

4.1.3 Habitats used for nesting, brood rearing, and moulting

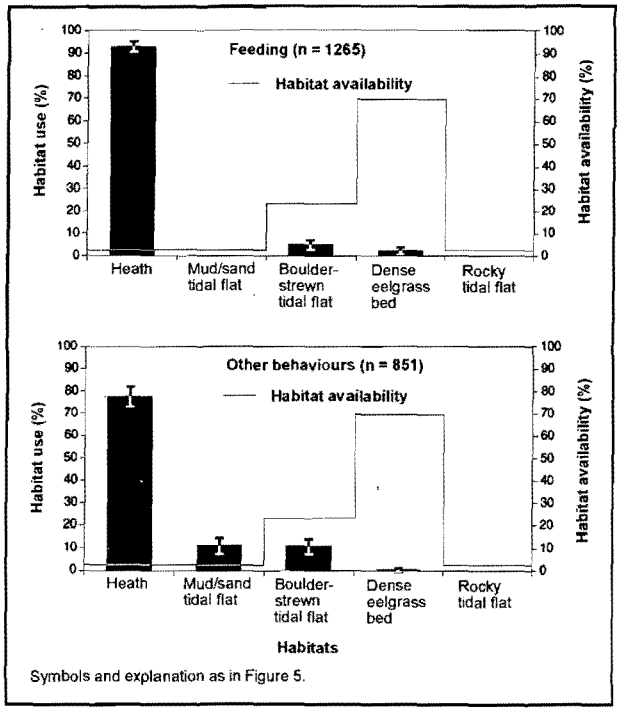
Canada Geese were not abundant during the summer. In the three sectors surveyed along the coast in August 1991 (Fig. 3), all but nine of the 208 Canada Geese observed were in the central sector (Bay of Many Islands), and all of them were in either the innermost (mainland) or outermost (offshore islands) quadrats. Similarly, in August 1990, all of the 322 geese observed in

Figure 7
Distribution of Canada Geese by habitat type at site S02 on 22 September 1990



Symbols and explanation as in Figure 5.

Figure 8
Distribution of Canada Geese by habitat type at site S11 on 12 and 13 September 1991



Symbols and explanation as in Figure 5.

the Bay of Many Islands were in mainland or offshore island quadrats (Fig. 9). Geese observed during June and August transect surveys within the Bay of Many Islands were associated with a variety of macrohabitats (Fig. 10), but the August quadrat surveys (Fig. 11), as well as casual observations, suggested that the most frequently used habitats were salt marshes (along the mainland coast) and heathland ponds (on the outer islands). Several of the groups observed in August were flightless, indicating that the geese were using the area as a moulting location.

None of the Canada Geese observed on 28 June 1990 in the Bay of Many Islands appeared to be nesting. This low level of nesting effort was confirmed by our numerous observations throughout the study area in 1990 and 1991 and by the cumulative experience of our Cree guides. Indeed, the only indications of breeding we obtained were limited to the finding of an egg destroyed by a predator on one offshore island, the observation of a newly hatched brood near another island, and the sighting of four broods in salt marshes along the mainland coast.

4.2 Habitat use by Brant

4.2.1 Habitat use during migration

During a transect survey in spring (6 June 1990) in the Bay of Many Islands, >95% of the 150 Brant observed

Table 5
Plant species recorded in the spring and fall diets of Canada Geese on the northeast coast (and elsewhere) of James Bay

	Spring								Fall	
Taxa	Northeast A[a] (n = 6)	Northeast A[b] (n = 5)	Northeast B[b] (n = 35)	Northeast C[b] (n = 43)	Northeast D[b] (n = 9)	Northeast E[b] (n = 50)	Northwest[c] (n = 124)	Southeast[d] (n = 52)	Southeast[d] (n = 46)	Northeast C[b] (n = 14)
Eleocharis spp.	×	×	×	×	×	×	×	×	×	×
Triglochin palustris		×	×	×	×	×	×	×	×	
Carex paleacea			×	×		×		×	×	×
Hippuris sp.			×	×	×	×		×	×	
Vaccinium spp.	×					×		×		×
Equisetum sp.						×	×	×	×	
Puccinellia phryganodes				×			×	×	×	
Carex aquatilis	×					×	×		×	
Scirpus spp.						×	×	×	×	
Menyanthes trifoliata				×		×		×	×	
Empetrum nigrum	×							×	×	×
Festuca rubra						×	×			×
Carex limosa	×						×		×	
Ranunculus spp.						×	×		×	
Sparganium sp.		×	×							×
Triglochin maritima						×	×	×		
Carex rariflora			×			×				
Carex chordorrhiza	×						×			
Plantago maritima			×				×			
Calamagrostis neglecta				×					×	
Polytrichum juniperinum				×	×					
Potamogeton sp.						×				
Carex diandra									×	
Carex mackenziei						×				
Carex salina							×			
Carex crinita									×	
Eriophorum angustifolium				×						
Drosera rotundifolia						×				
Lathyrus japonicus										×
Myriophyllum spicatum						×				
Glaux maritima							×			
Bidens cernua									×	

Note: The species are listed in decreasing order of occurrence by area. The capital letters A to E refer to hunting camps along the northeast coast (see Fig. 1).

[a] Reed et al. (1990): mostly gizzard contents.
[b] This study. Eight specimens were excluded from this table because the precise location of origin was unknown.
[c] Prevett et al. (1985).
[d] Consortium Gauthier & Guillemette–G.R.E.B.E. (1992).

Photo 1. Marsh arrowgrass *Triglochin palustris*, commonly found in the lower salt marshes of northeastern James Bay, is one of the most important food items for Canada Geese in spring (Photo: M. Salathé).

Photo 3. Scaly sedge *Carex paleacea* grows in dense tall stands in the upper salt marshes of northeastern James Bay. Large numbers of seeds from this and other sedges are eaten by Canada Geese in spring (Photo: M. Salathé).

Photo 4. Mare's-tail *Hippuris tetraphylla* grows abundantly in areas of rocky heath on islands along the northeast coast of James Bay. Canada Geese feed extensively on the stems, leaves, and rhizomes of this plant in spring (Photo: A. Reed).

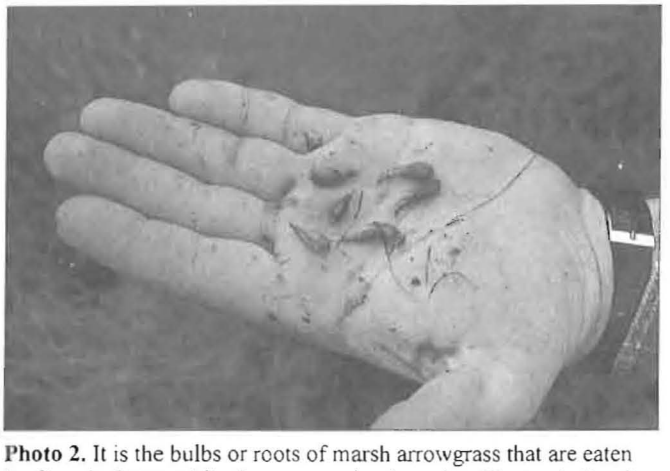


Photo 2. It is the bulbs or roots of marsh arrowgrass that are eaten by Canada Geese while they are staging in spring (Photo: A. Reed).

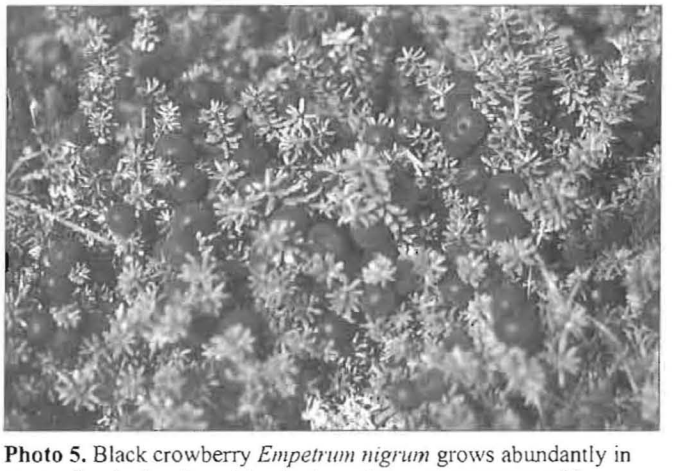


Photo 5. Black crowberry *Empetrum nigrum* grows abundantly in areas of rocky heath on islands along the northeast coast of James Bay. Canada Geese feed extensively on the berries of this shrub during fall migration (Photo: A. Reed).

Photo 6. Eelgrass *Zostera marina* grows abundantly in protected subtidal (below the low tide line) waters in northeastern James Bay. Atlantic Brant feed almost exclusively on the leaves of this plant during both spring and fall migration (Photo: A. Reed).

were in the eelgrass bed–tidal flat macrohabitat, the remainder being in adjacent areas of open water (Fig. 12). Subsequent ground observations showed that dense eelgrass beds were used significantly more than any other habitat, and feeding occurred almost exclusively in this habitat (Figs. 13 and 14).

During fall, Brant used mainly dense eelgrass beds (Figs. 15 and 16); for feeding, a strong and significant preference for that habitat was evident. For spring and fall migration periods, both our scheduled observation sessions and casual observations indicated that only a small fraction of feeding activity occurred outside eelgrass beds, notably in open water areas or in boulder-strewn or mud/sand tidal flats; no use of salt marsh was recorded.

No Brant were observed during late June, July, or August, indicating that the study area is not used for breeding or moulting.

Figure 9
Distribution of Canada Geese in four quadrats (5 × 5 km) surveyed in the Bay of Many Islands on 3–6 August 1990 (n = 322 geese)

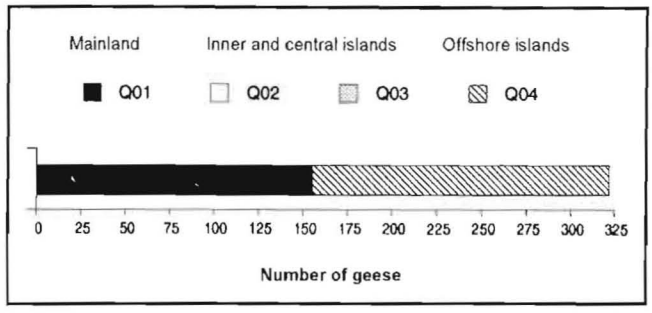
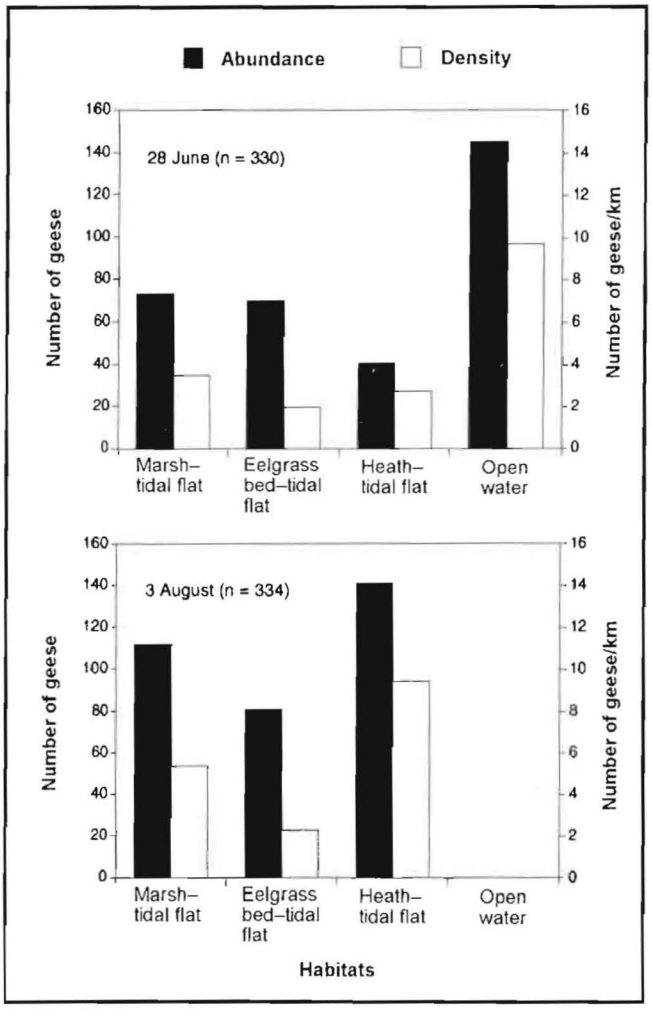


Figure 10
Distribution of Canada Geese by habitat type in the Bay of Many Islands during aerial surveys on 28 June and 3 August 1990



4.2.2 Diet and feeding behaviour

Examination of the esophageal contents of Brant collected in 1990 and 1991 revealed that eelgrass leaves largely dominated the diet in both spring and fall (Table 8, Photo 6). In spring, all 27 Brant containing identifiable material had consumed eelgrass leaves, and the leaves and rhizomes of eelgrass made up 99.8% of the dry weight of

Table 6
Frequency of occurrence and dry weight of the principal plants found in Canada Goose esophagi from the northeast coast of James Bay in spring and fall 1990

		Spring (n = 150)			Fall (n = 14)		
Taxa	Plant part	No. of esophagi	Frequency of occurrence (%)	Dry weight (%)	No. of esophagi	Frequency of occurrence (%)	Dry weight (%)
Carex spp.	Seeds	46	30.7	17.0	2	14.3	1.6
	Leaves and stems[a]	5	3.3	3.3	1	7.1	12.1
Eleocharis spp.	Seeds	11	7.3	2.1	–	–	–
	Leaves and stems	28	18.7	17.2	3	21.4	2.5
Gramineae	Leaves, stems, and roots	30	20.0	17.0	3	21.4	2.5
Triglochin palustris	Bulbs	21	14.0	18.2	–	–	–
Hippuris spp.	Seeds	7	4.7	3.8	–	–	–
	Leaves, stems, and roots	29	19.3	9.6	–	–	–
Empetraceae and Ericaceae	Berries, seeds, and leaves	1	0.7	0.2	3	21.4	5.9
Sparganium sp.	Leaves	6	4.0	1.7	7	50.0	64.0

[a] Two esophagi contained leaves and roots of *Carex mackenziei*.

Table 7
Frequency of occurrence of plants found in Canada Goose esophagi in James Bay in spring

	Northeast (1990) (n = 150) (Quebec, present study)		Northwest (1978–1980) (n = 124) (Ontario, Prevett et al. 1985)	
Taxa	%	Rank	%	Rank
Carex spp.	32.0	1	57.3	1
Carex mackenziei	5.3	8	–	–
Carex paleacea	22.7	3	–	–
Carex salina	–	–	6.5	9
Carex limosa	–	–	10.5	7
Carex chordorrhiza	–	–	27.4	2
Carex aquatilis	0.7	15	4.0	10
Carex rariflora	7.3	7	–	–
Eleocharis spp.	25.3	2	12.9	5
Eleocharis smallii	2.7	12	–	–
Eleocharis acicularis	17.3	5	–	–
Scirpus sp.	0.7	15	0.8	12
Eriophorum angustifolium	1.3	14	–	–
Festuca rubra	0.7	15	6.5	9
Puccinellia phryganodes	0.7	15	14.5	4
Triglochin palustris	14.0	6	6.5	9
Triglochin maritima	0.7	15	1.6	11
Hippuris sp.	4.0	10	–	–
Hippuris tetraphylla	19.3	4	–	–
Sparganium sp.	4.0	10	–	–
Myriophyllum spicatum	0.7	15	–	–
Vaccinium oxycoccos	0.7	15	–	–
Menyanthes trifoliata	4.7	9	–	–
Ranunculus gmelinii	0.7	15	–	–
Drosera rotundifolia	0.7	15	–	–
Equisetum spp.	0.7	15	16.1	3
Polytrichum juniperinum	2.0	13	–	–
Potamogeton sp.	3.3	11	–	–
Ranunculus spp.	–	–	8.1	8
Glaux maritima	–	–	0.8	12
Plantago maritima	–	–	12.1	6

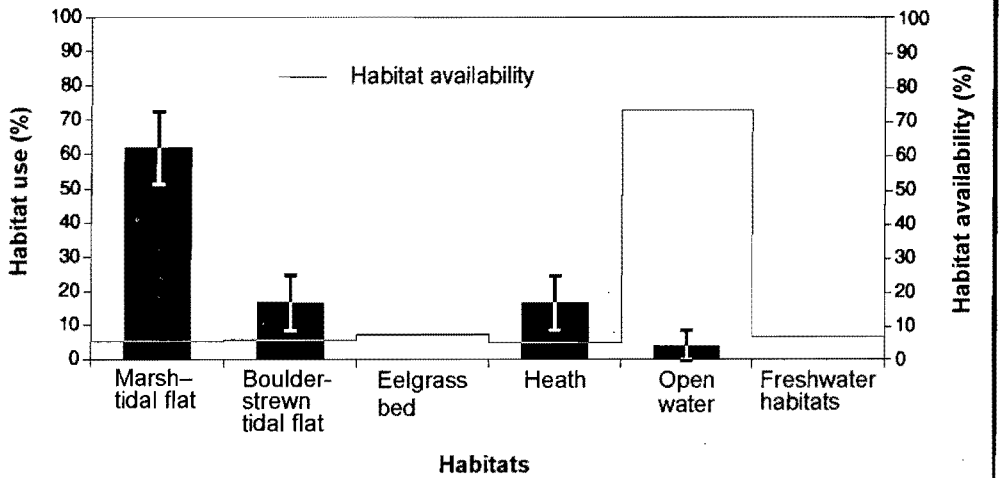
all food items. In fall, 26 of 30 Brant had consumed eelgrass leaves, which made up 95% of the total dry weight of food ingested; three individuals had eaten small quantities of graminoid plants. In both seasons, a single individual contained a small quantity of algae.

Repeated scans at one site in September 1991 showed that Brant fed on eelgrass through the diurnal tidal cycle (Fig. 17). Feeding was most intense from a few hours before to a few hours after low tide, during which time most Brant fed by upending directly over dense eelgrass patches (presumably by pulling off leaves from growing plants). At higher tide levels, Brant were more dispersed, but many continued to feed by pecking at dislodged leaves floating near the surface (at these tide levels, growing plants were probably beyond their reach). Although it was not possible to document consumption rates during the intensive upending feeding sessions near low tide, we were able to record the time required for Brant to consume five blades of eelgrass while pecking at the water surface during higher tides; the average time was 64.5 seconds (average of individual means for five Brant, 57 records total, SD = 22.4, September 1990 and 1991). Early during spring migration, Brant were also observed feeding along the edge of a retreating ice flow, picking off eelgrass leaves that had become imprisoned in the ice over the winter.

4.3 Other species of geese

The only other geese observed were Snow Geese, all judged to be of the Lesser subspecies Anser c. caerulescens. Only a few hundred were observed over two years of study. They occurred only during spring and fall migration, usually in scattered small groups seen in flight or in salt marshes.

Figure 11
Distribution of Canada Geese by habitat type in 44 quadrats (2 × 2 km) surveyed in three sectors (Point Attikuan, Bay of Many Islands, and Dead Duck Bay) on 8–13 August 1991 (n = 208 geese)



Symbols and explanation as in Figure 5.

Figure 12
Distribution of Brant by habitat type during an aerial survey on 6 June 1990 in the Bay of Many Islands (n = 150 geese)

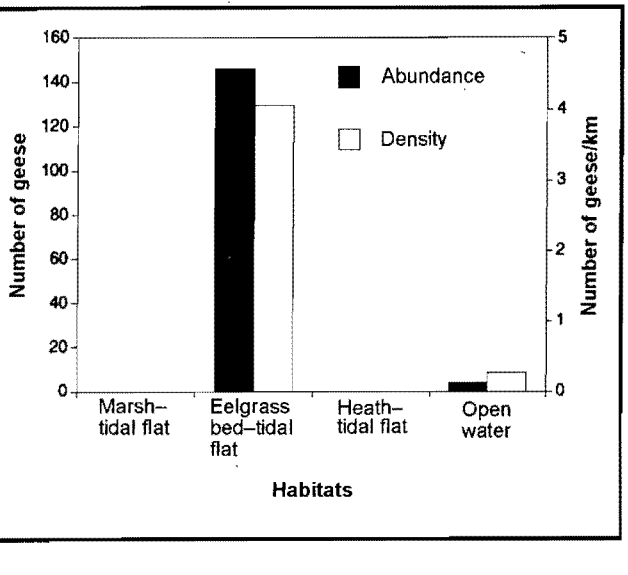
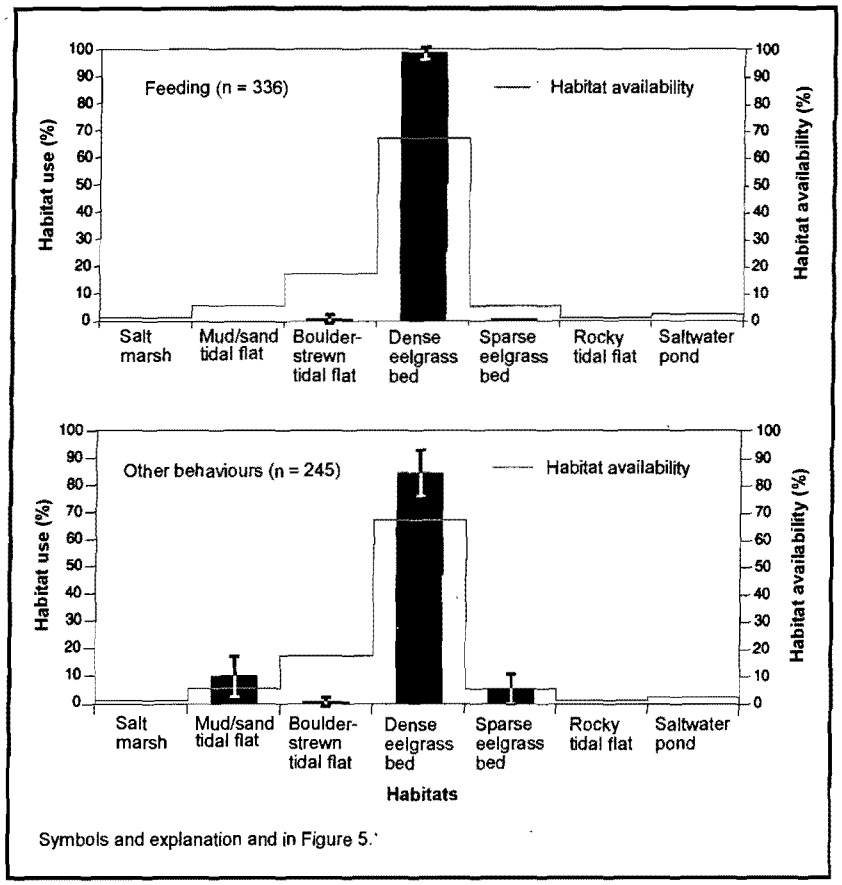
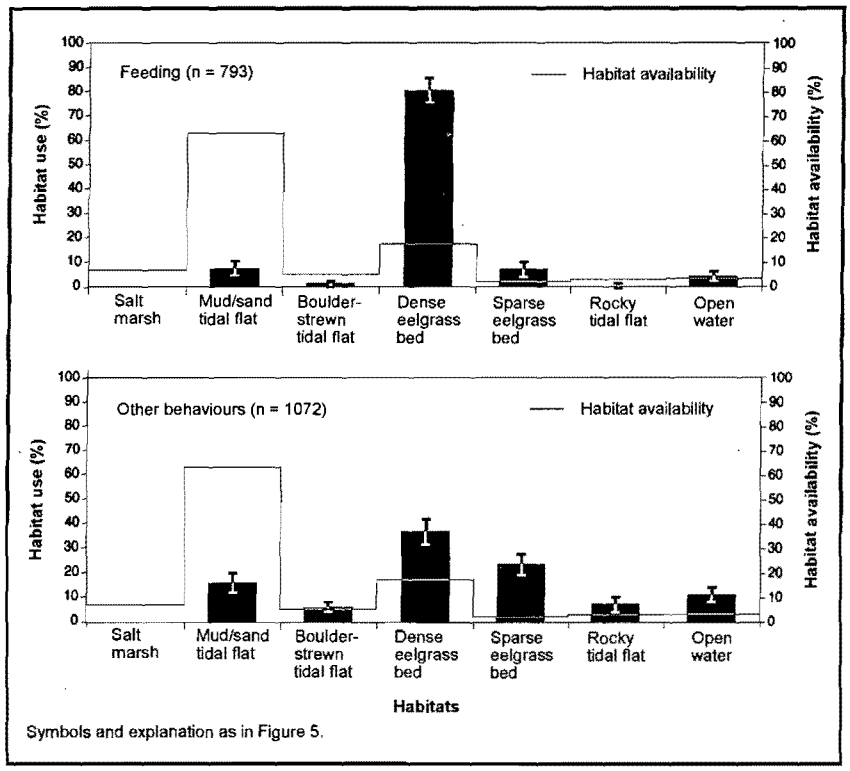


Figure 13
Distribution of Brant by habitat type at sites S01 and S05–S08 on 6–12 June 1990



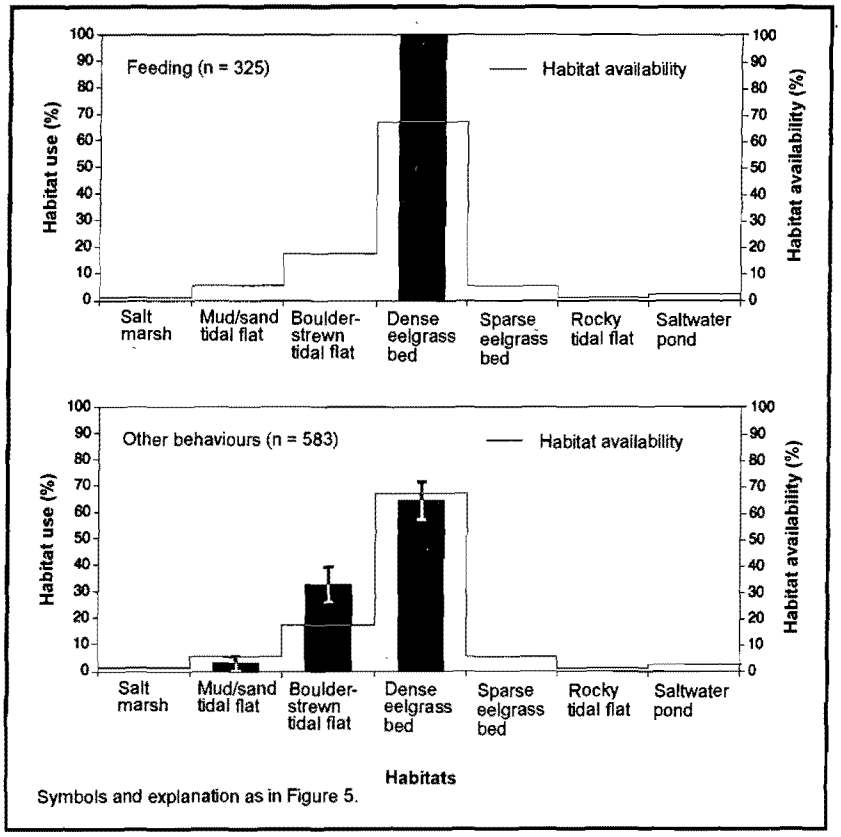
Symbols and explanation and in Figure 5.

Figure 14
Distribution of Brant by habitat type at site S02 on 6 and 8 June 1990



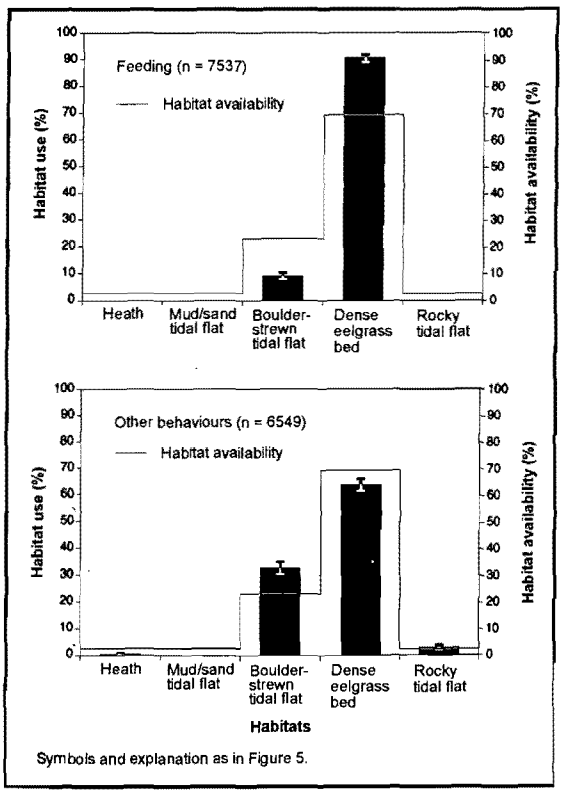
Symbols and explanation as in Figure 5.

Figure 15
Distribution of Brant by habitat type at sites S01 and S05–S08 on 23 September 1990



Symbols and explanation as in Figure 5.

Figure 16
Distribution of Brant by habitat type at site S11 on 12 and 13 September 1991

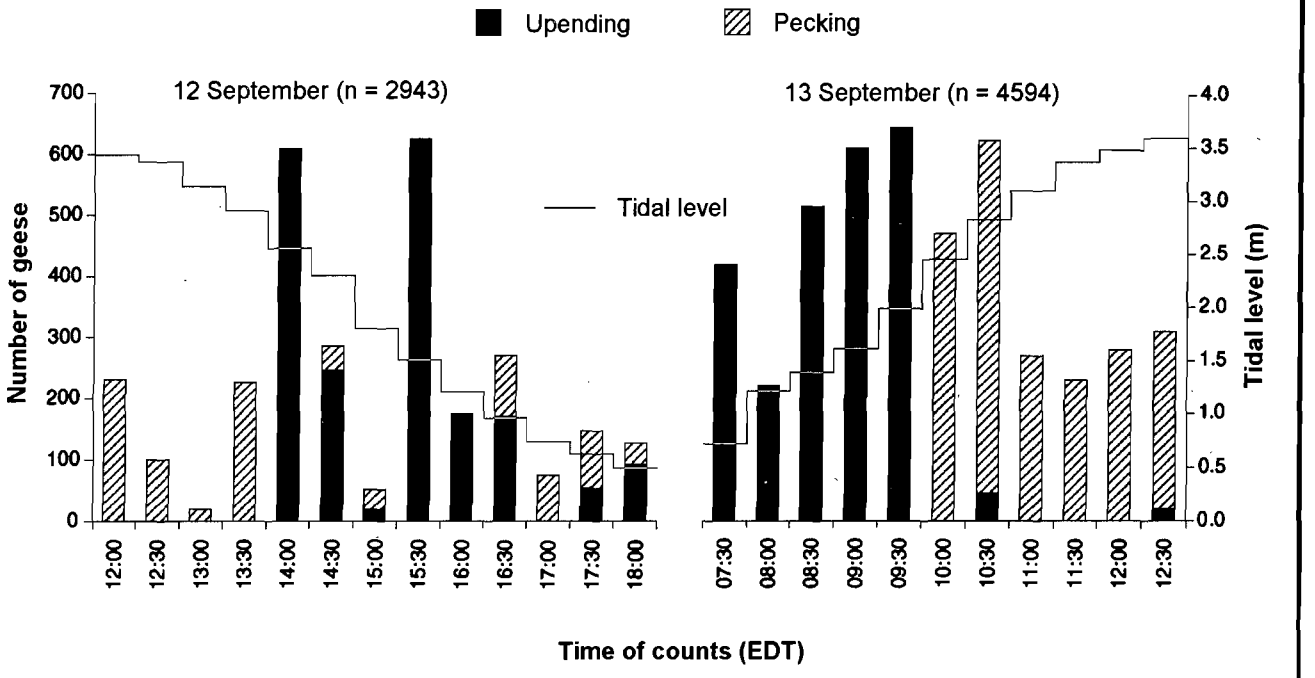


Symbols and explanation as in Figure 5.

Table 8
Frequency of occurrence and proportion of dry weight of plants found in the esophagi of Brant on the northeast coast of James Bay in 1990 and 1991

	Spring (n = 27)		Fall (n = 30)	
Species	Occurrence (%)	Dry weight (%)	Occurrence (%)	Dry weight (%)
Zostera marina				
leaves	100.0	98.3	86.7	95.7
rhizomes	7.4	1.5	–	–
Carex and other graminoids	–	–	10.0	4.1
Algae	3.7	0.1	3.3	0.2
Unidentified plant material	3.7	0.1	–	–
Total dry weight (g)		4.2		1.8

Figure 17
Diurnal feeding behaviour of Brant in a dense eelgrass bed at site S11 on 12 and 13 September 1991



n = number of geese observed.

5. Discussion

5.1 Goose–habitat relationships

5.1.1 Canada Geese

Many coastal areas of the James Bay–Hudson Bay lowlands are used by large flocks of migrating Canada Geese in spring; for most of these geese, it represents their last opportunity to lay down nutrient reserves before reaching the breeding area (Thomas and Prevett 1982a; Morrison and Gaston 1986). Similarly, in fall, that coastline is used by adult geese and their newly flying young to accumulate energy reserves before undertaking the long overland flight south.

Large numbers of Canada Geese stage along the northeast coast of James Bay in both spring and fall (Bourget 1973a, 1973b; Curtis and Allen 1976; this study). Most of these geese are *Branta canadensis interior* associated with the Atlantic Flyway population (Addy and Heyland 1968; Bellrose 1980; Reed 1984), whose breeding range includes much of the boreal forest of north-central and west-central Quebec and especially the tundra areas of Ungava (Addy and Heyland 1968; Malecki and Trost 1990). Thus, many of the geese staging on the northeast coast are from breeding areas some distance away, and few nest nearby. This contrasts with other *B. c. interior* staging on the west coast of James Bay or the south coast of Hudson Bay, many of which breed short distances inland or directly along the coast (Raveling and Lumsden 1977; Thomas and Prevett 1982a; Bruggink et al. 1994). Thomas and Prevett (1982a) reported use of the west coast (Ontario) for staging but considered the area to be more important for breeding.

The low level of breeding activity in northeastern James Bay might be linked to a variety of factors. Salt marshes of the northeast coast are floristically similar to those elsewhere in the Hudson and James bay lowlands (Dignard et al. 1991), including those identified as prime brood-rearing habitat near Winisk, Ontario (Bruggink et al. 1994), but they differ by occurring mainly in discrete patches at the base of bays and inlets rather than in broad expanses; perhaps smaller confined patches are less attractive to brood-rearing geese. Those breeding inland (but within the coastal lowlands) nest in fens and bog ponds (Raveling and Lumsden 1977; Thomas and Prevett 1982a; Benoit et al. 1994), which occur more regularly in the vast muskeg areas in the lowlands to the west of the bay than to the east. Subsistence activity (hunting, fishing, gathering) and associated boat travel by the Cree are relatively intense along the northeast coast and may serve as an impediment to the establishment of breeding geese in coastal habitats.

Groups of Canada Geese of unknown racial identity congregated on some of the outer islands of the northeast coast during summer to undergo the wing moult. These heath-covered islands may have been attractive to moulting geese because of 1) the abundance of freshwater ponds, herbaceous vegetation (food), and low shrubs (escape cover); 2) the proximity to open waters of the bay (also used as escape cover); 3) their remoteness from areas of human disturbance and predatory activity; and 4) lack of breeding Canada Geese with which to compete.

Canada Geese staging in spring and fall along the northeast coast of James Bay showed a stronger preference for salt marshes than for any other habitat, especially for feeding. Their reliance on this habitat may be related to the array and abundance of preferred plant foods that occur there (Dignard et al. 1991) and to the early date at which the habitat becomes ice-free in spring. By mid-May, when adjacent coastal habitats as well as most boreal forest and tundra wetlands of northern Quebec were largely covered by snow or ice, the salt marshes were becoming progressively available to the geese. This enabled them to migrate early and to benefit from an extended period of fattening prior to breeding.

Many of the important items in the diet were salt-marsh plants. About 50% of the food items in the fall diet were salt-marsh plants. Eighty percent of the 30 species recorded in the spring (Appendix 1) were also plants that occur in the salt marsh. Among the five most important were *Carex paleacea* (seeds), *Hippuris tetraphylla* (leaves, stems and rhizomes), *Eleocharis acicularis* (entire plants or various parts), and *Triglochin palustris* (bulbs) (Appendices 2.1 and 2.2), all of which are major components of the salt-marsh community (Dignard et al. 1991). Furthermore, most of these plants were found in geese from several sites along the northeast coast as well as in geese from southeastern and northwestern James Bay (Table 7), suggesting that the preference for salt marshes is general throughout the bay.

Windrows of seeds of salt-marsh sedges, noted along the margin of melt pools in both northeastern and northwestern James Bay (Prevett et al. 1985; Reed et al.

1990), provide an abundance of readily obtained, energy-rich food. *Triglochin* bulbs (Photos 1–2), also eaten by Canada Geese on both sides of the bay, were identified as being of special nutritional value to geese (Thomas and Prevett 1980). In fall, *Carex paleacea* and *Eleocharis* remained important in the diet along the northeast coast, as did several other salt-marsh taxa along the southeast coast (Tables 5 and 7).

The high ranking of *Hippuris* (Photo 4) in the spring diet in our study area was surprising, because it was not recorded in the diet of Canada Geese on the northwest coast in spring (Prevett et al. 1985) or on the southern coast of Hudson Bay in fall (Craven and Hunt 1984), even though it occurs in the salt marshes of both of these locations (Glooschenko et al. 1988). Furthermore, it is not eaten by Lesser Snow Geese in either spring or fall on the northwest coast of James Bay (Prevett et al. 1979, 1985). Further research is required to determine whether *Hippuris* is used heavily in spring on northeastern James Bay because of preferential selection for its nutritive or energetic value or because the plant is available in sites where more nutritious plants have been depleted.

Carex paleacea (Photo 3) seeds, the item occurring in the highest percentage of individuals in our study area (Appendix 2.1), did not appear in the diet of Canada Geese on the northwest coast in spring, despite its presence and its use by Lesser Snow Geese there (Prevett et al. 1979, 1985); this might reflect niche segregation, with Canada Geese being able to feed heavily on this item only where competition with Lesser Snow Geese is absent.

Fewer plant species were found in Canada Geese collected in fall; although based on a small sample of geese, this suggests a more restricted diet. *Sparganium* sp., a minor food item in spring, dominated the fall diet (Table 5). Graminoids, as a group, were relatively important in both spring and fall. *Empetrum* (Photo 5) and *Vaccinium* spp. berries were more important in fall than in spring. *Triglochin* and *Hippuris,* which were important in spring, were not observed in the fall diet. It is noteworthy that storage organs such as seeds and underground parts of plants were consumed mainly in spring, before new growth appears.

Visual observation of feeding activity and the presence of goose droppings suggested that heathland was also an important habitat in our study area, especially in fall. This is supported by the occurrence of heathland plants, particularly berries of *Empetrum nigrum* and *Vaccinium* spp., in both spring and fall diets on the northeast and southeast coasts (Table 7). These plants were not reported in the diet of birds from the northwest coast (Prevett et al. 1985), perhaps because that area has fewer outcrops supporting rocky heath in which these plants thrive.

We did not conduct behavioural observations on feeding geese in freshwater wetlands (fresh marshes, fens) near the coast. However, casual observations and diet analysis indicated that some coastal staging geese were frequenting freshwater habitats. About one-third of the food items in the spring diet were from plants that may occur in freshwater habitats. These included *Equisetum*, *Menyanthes*, *Eriophorum*, and a few species of *Carex*; none was among the important items in the diet. However, *Sparganium* was important in the fall diet, and this plant is typically found in freshwater lakes near the coast, although it also occurs in salt marshes (Dignard et al. 1991). *Equisetum* was considered an important component of the spring diet in northwest James Bay, in terms of both nutritional value and proportion of total food consumed (Thomas and Prevett 1982a, 1982b; Prevett et al. 1985); its presence in the diet was taken to indicate use of inland fens and other freshwater wetlands that occur in abundance near the northwest coast.

5.1.2 Brant

The coasts of James Bay are used by large numbers of migrating Brant in spring and fall (Curtis and Allen 1976; Thomas and Prevett 1982a; Morrison and Gaston 1986). These geese are Atlantic Brant migrating between their wintering grounds along the U.S. coast (Massachusetts to North Carolina) to their breeding grounds on Southampton Island and around Foxe Basin (Bellrose 1980; Reed et al. 1996b). Although formerly a segment of that population migrated overland by a more easterly route bypassing James Bay (from the Gulf of St. Lawrence to Ungava Bay) (Lewis 1937), all are now believed to pass through James Bay (Reed et al. 1996b). Probably more than half of the population uses the east shore of the bay, especially the northeast coast (Curtis and Allen 1976; Bellrose 1980), where dense meadows of eelgrass occur (Dignard et al. 1991; Lalumière et al. 1994). The potential importance of James Bay as a staging area for this population was emphasized by the research of Vangilder et al. (1986), which revealed that many Brant departed the wintering grounds with only sufficient stored reserves to cover the energetic costs of migration to James Bay; clearly, for completion of spring migration and to ensure successful reproduction, Brant would have to be able to store additional reserves while staging in James Bay.

Our study clearly establishes the close link between staging Brant and eelgrass. Feeding occurred almost exclusively over eelgrass beds, and feeding that occurred in other habitats also involved eelgrass that had been dislodged and transported by ice or tide action. Eelgrass (Photo 6) made up >95% of the total dry weight of food found in digestive tracts in both spring and fall. This heavy reliance on eelgrass is not surprising, given that eelgrass is the staple food of wintering and staging Brant on both the Atlantic and Pacific coasts of North America, as well as in several European sites (Reed et al. 1996b). This almost monospecific relationship may be related more to the large quantities of eelgrass that can be consumed (high biomass of plants in dense beds, feeding behaviour adapted specifically to eelgrass) than to nutritional value (Sedinger 1992). The distribution of eelgrass does not, however, extend northward as far as the breeding grounds. There, the Brant rely on the short graminoids Phrygian alkaligrass *Puccinellia phryganodes* and subspathaceous sedge *Carex subspathacea* of Arctic and sub-Arctic salt marshes. These same graminoids are abundant in the salt marshes of James Bay (Dignard et al. 1991), which cover more than 100 km^2 along the northeast coast (Benoit et al. 1996), but we recorded no use of those marshes over two years of observations; the small size of these plants may make them less attractive than eelgrass

to staging Brant, which are seeking to lay down large body reserves for migration and reproduction. Some use of salt marshes by Brant was noted on the northwest coast of James Bay (Thomas and Prevett 1982a), suggesting that staging Brant may revert to salt-marsh vegetation when eelgrass is not available or is in short supply.

5.2 Conclusions and considerations regarding northern development

By clarifying the role played by certain coastal habitats in the ecology of geese, our study supports earlier indications that James Bay is one of North America's most important goose staging areas (Curtis and Allen 1976; Bellrose 1980; Thomas and Prevett 1982a).

The northeast coast is important to two staging species, Canada Geese and Atlantic Brant. In essence, three coastal habitats — eelgrass beds, salt marshes, and heath — provide the essential food resources to fulfill the birds' critical need for nutritive reserves for continued migration and for reproduction. Proper management of these goose stocks hinges on the existence of these essential habitats.

Hydro development could be a potential threat to the wetlands of coastal James Bay (Milko 1986; Gorrie 1990). Because of the current economic situation and present projections for energy needs, it appears unlikely that any new development projects will be initiated in the James Bay territory in the immediate future. One major project, the La Grande hydroelectric complex, was developed during the 1970s and 1980s (Messier et al. 1986, 1989), resulting in a reduced flow of fresh water into James Bay through the Eastmain River estuary (to the south of our study area) and a major increase in flow during winter through the La Grande River estuary (which enters James Bay within our study area). Several years after these changes had occurred, the few observable impacts on the coastal environment were largely limited to the La Grande and Eastmain estuaries themselves (Messier et al. 1986, 1989).

Changes in the freshwater plume of the La Grande River resulted in a reduction in water salinity during winter along an increasing portion of the east coast of James Bay (Messier et al. 1986, 1989). The possible effects of these modifications on the coastal marine ecosystems are of considerable biological interest. Given the increased freshwater plume in winter since the early 1980s, it is likely that many eelgrass beds, open water areas, and possibly some mud/sand tidal flats of our study area have been subjected to a reduction in salinity during winter months. Detailed monitoring of certain eelgrass meadows from 1986 to 1991 revealed no overall trend in eelgrass biomass and stem density (Lalumière et al. 1994).

Isostatic rebound is considerable along the coasts of James and Hudson bays (roughly 1 m per century: Hunter 1970; Martini 1986) and undoubtedly exerts a powerful influence by continually subjecting emerging habitats to changing ecological conditions (Hik et al. 1992). Recently, changes in the vegetation of certain salt marshes and eelgrass meadows have been attributed to this factor (Lalumière and Lemieux 1995). This suggests a continual natural process of change in the coastal habitats of James Bay; these changes could influence their use by geese and other waterfowl.

Although we have few comparative data on goose use before development, we observed intensive and abundant goose use of these eelgrass beds, adjacent salt marshes, and heathland during the course of the present study. Although there has been little evidence of deterioration of the subtidal and intertidal goose habitats due to development, it would be premature to conclude that none has occurred or will occur. Only long-term monitoring of these coastal habitats and their use by geese will allow detection of changes attributable to natural and human-induced factors. Without such habitat-based monitoring, it will be difficult to attribute with confidence any changes in goose numbers to local (vs. distant) events.

The northeast coast of James Bay — through the richness and diversity of its coastal habitats (Dignard et al. 1991), its importance to migrating geese (this study), and its importance to breeding, moulting, and staging ducks (Alexander et al. 1991; Reed et al. 1996a) — would readily qualify as a wetland of international importance. Currently, no part of that coast is effectively protected by legislation. It would be desirable to explore the possibility of formally designating a portion of this coastline under international legislation to ensure an adequate level of recognition of its ecological importance.

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Appendices

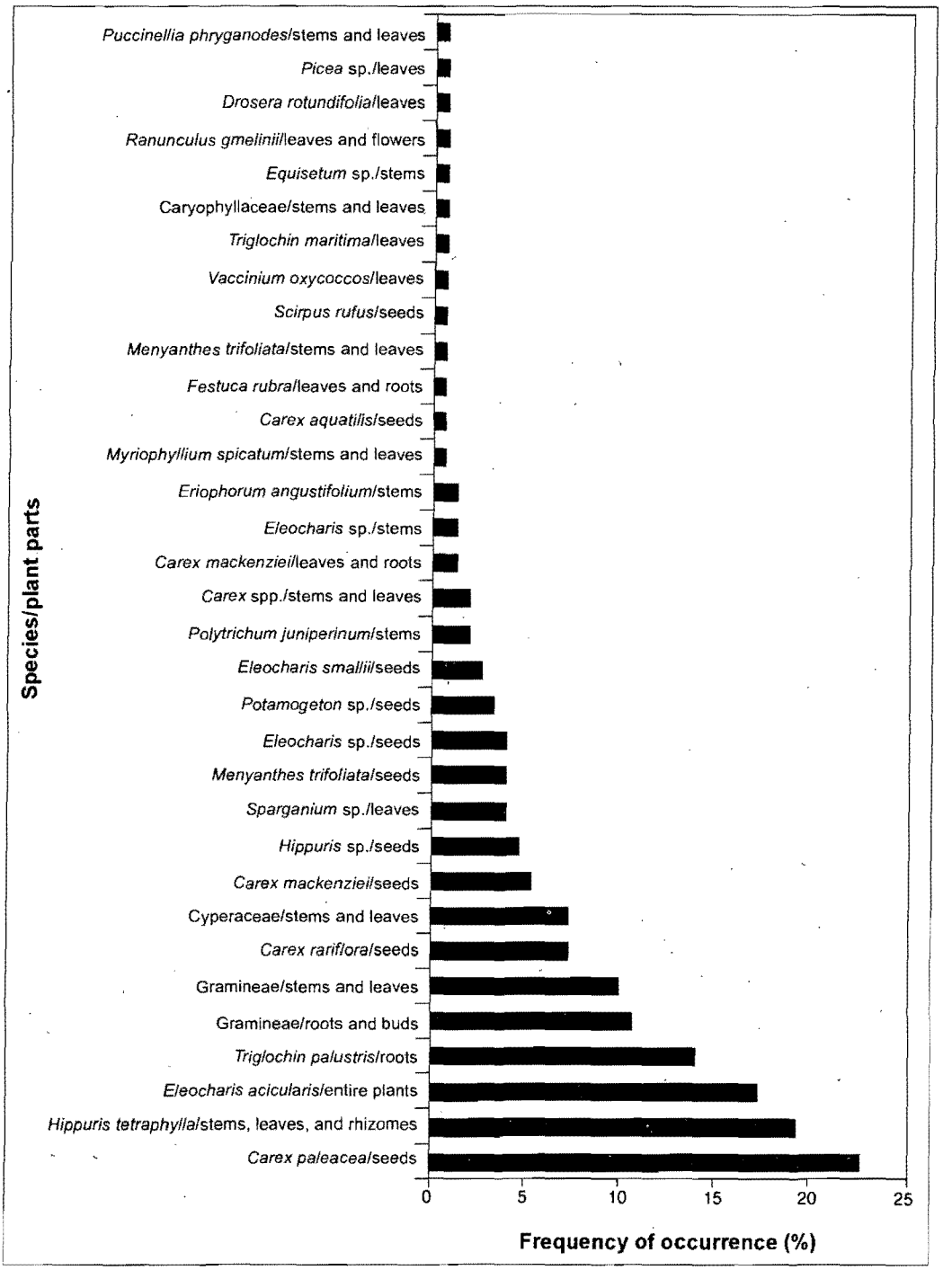
Appendix 1
List of plants identified in the esophagi and gizzards of Canada Geese collected on the northeast coast of James Bay in spring and fall 1990

		Spring (n = 150)		Fall (n = 14)	
Taxa	Plant part	Esophagus	Gizzard	Esophagus	Gizzard
CYPERACEAE					
Cyperaceae	Stems and leaves	×	×	×	×
Carex spp.	Stems and leaves	×	×	×	×
Carex spp.	Seeds	–	–	×	×
Carex mackenziei	Seeds	×	×	–	–
Carex mackenziei	Leaves and roots	×	×	×	×
Carex paleacea	Seeds	×	×	–	–
Carex aquatilis	Seeds	×	×	–	–
Carex rariflora	Seeds	×	×	–	–
Eleocharis sp.	Seeds	×	×	–	–
Eleocharis sp.	Stems and leaves	×	×	×	×
Eleocharis smallii	Seeds	×	×	–	–
Eleocharis acicularis	Entire plants	×	×	–	–
Scirpus rufus	Seeds	×	×	–	–
Eriophorum angustifolium	Stems	×	×	–	–
GRAMINEAE					
Gramineae	Stems and leaves	×	×	×	–
Gramineae	Roots	×	×	–	–
Puccinellia phryganodes	Stems and leaves	×	×	–	–
Festuca rubra	Entire plants and parts thereof	×	×	×	–
JUNCAGINACEAE					
Triglochin palustris	Roots	×	×	–	–
Triglochin maritima	Leaves	×	–	–	–
JUNCACEAE					
Juncus sp.	Leaves	–	×	–	–
HIPPURIDACEAE					
Hippuris tetraphylla	Leaves, stems, and rhizomes	×	×	–	–
Hippuris sp.	Seeds	×	×	–	–
SPARGANIACEAE					
Sparganium sp.	Leaves	×	×	×	×
FABACEAE					
Lathyrus japonicus	Leaves	–	–	–	×
EMPETRACEAE					
Empetrum nigrum	Seeds and berries	–	–	×	×
HALORAGACEAE					
Myriophyllum spicatum	Stems and leaves	×	×	–	–
ERICACEAE					
Vaccinium oxycoccos	Seeds	–	×	–	–
Vaccinium oxycoccos	Leaves	×	–	–	–
Vaccinium vitis-idaea	Leaves, seeds, and berries	–	–	×	×
GENTIANACEAE					
Menyanthes trifoliata	Seeds	×	×	–	–
Menyanthes trifoliata	Stems and leaves	×	×	–	–
PLANTAGINACEAE					
Plantago juncoides	Seeds	–	×	–	–

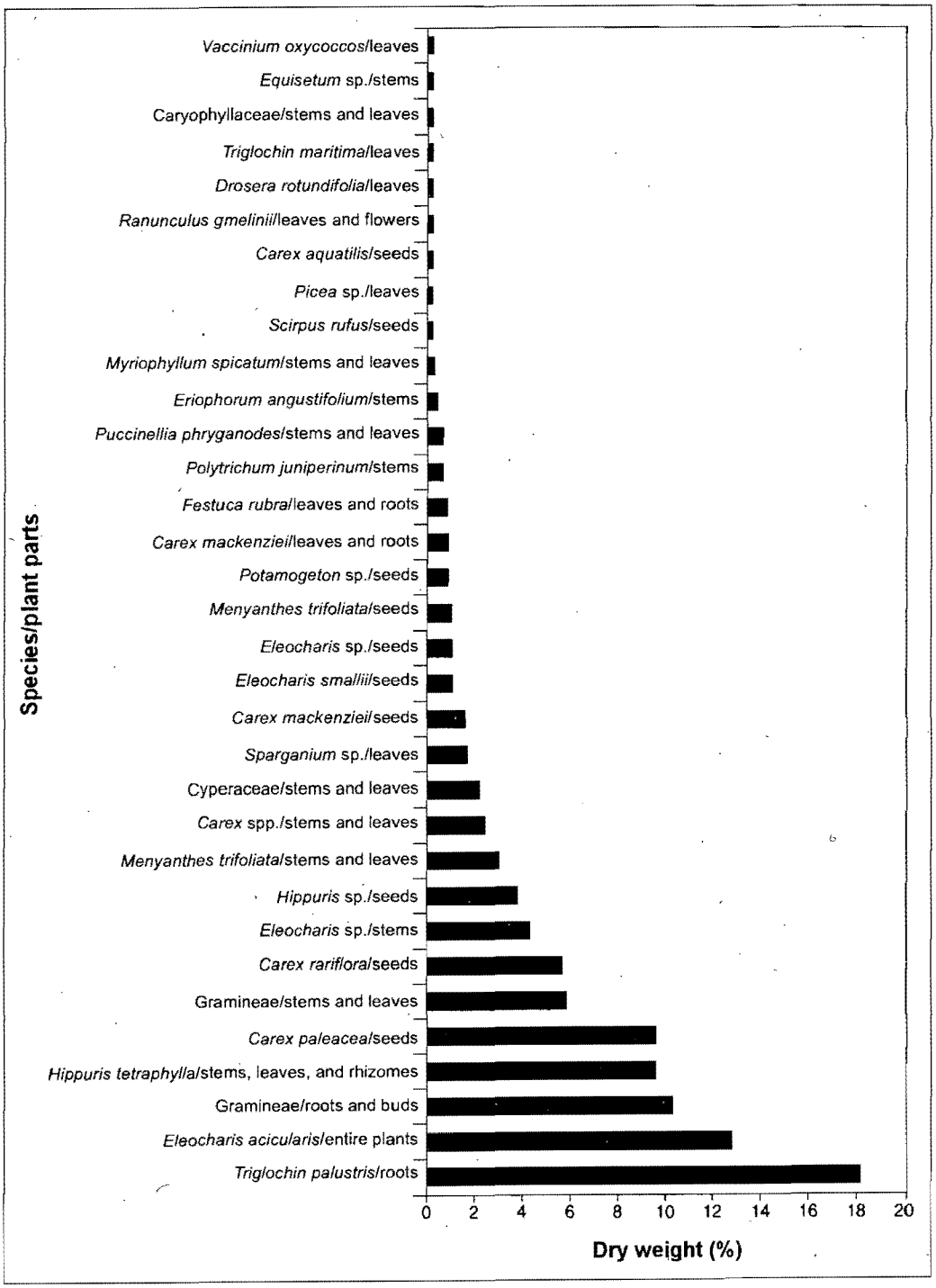
Appendix 1 *cont'd*
List of plants identified in the esophagi and gizzards of Canada Geese collected on the northeast coast of James Bay in spring and fall 1990

		Spring (n = 150)		Fall (n = 14)	
Taxa	Plant part	Esophagus	Gizzard	Esophagus	Gizzard
RANUNCULACEAE					
Ranunculus aquatilis	Leaves	–	×	–	–
Ranunculus gmelinii	Leaves and flowers	×	–	–	–
CARYOPHYLLACEAE					
Caryophyllaceae	Stems and leaves	×	–	–	–
Stellaria humifusa	Stems	–	×	–	–
MYRICACEAE					
Myrica gale	Seeds	–	×	–	–
ROSACEAE					
Rubus chamaemorus	Seeds	–	×	–	–
DROSERACEAE					
Drosera rotundifolia	Leaves	×	–	–	–
EQUISETACEAE					
Equisetum sp.	Stems	–	×	–	–
POLYTRICHACEAE					
Polytrichum juniperinum	Stems	×	×	–	–
PINACEAE					
Picea sp.	Leaves	×	×	–	–
ZOSTERACEAE					
Potamogeton sp.	Seeds	×	×	–	–

Appendix 2.1
Frequency of occurrence of plants found in Canada Goose esophagi (n = 150) from the northeast coast of James Bay in May 1990



Appendix 2.2
Dry weight of plants found in Canada Goose esophagi (n = 150) from the northeast coast of James Bay in May 1990



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