SAND DUNES OF NOVA SCOTIA

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By

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ABSTRACT

Forty-five coastal sand dune systems over one kilometre in length have been identified in the province of Nova Scotia. All were investigated in the field. Observations were made of morphology, vegetation cover, stability, and the impact of human activity. In order to facilitate comparison between systems a morphological classification scheme and a morpho-ecological model have been developed.

Sand dune systems exist in all the coastal areas of Nova Scotia, with the exception of the Bay of Fundy. The beaches and associated dunes tend to be limited in length by rocky headlands, the longest system, Merigomish, being less than five kilometres. Many systems are sediment deficient, and the dunes consist of a thin cap of sand on a gravel substrate, or a single foredune ridge. Vegetation cover is primarily pioneer species, although shrub-heath communities may exist in the lee of the foredune on more developed systems. The best developed, most complex systems are on the north coast, including those of Pomquet and Merigomish. Large volumes of sand storage also occur at Bartletts and Mavillette beaches on the southwestern shore. The dunes on the exposed southern coast are generally the most sediment impoverished, and the least developed. Although fifteen dune systems studied are now in local, provincial or national parks, many systems still exhibit degradation resulting from human activity, particularly Mavillette, Carters, Crescent, and Glace Bay.

ACKNOWLEDGEMENTS

Most acknowledgements begin by thanking the supervisor. Although mine, Dr. S.B. McCann, has been a good teacher and friend, I would first like to thank my two field assistants, Susan Vajoczki and Susan Holland. Sue and Sue were not only excellent assistance in the field, but have continued to be wonderful friends, willing to discuss ideas pertaining to my thesis (not to mention last minute photo processing and rides home at 1:00 am.).

Brian McCann has been very patient, and I appreciate the amount of time he has spent providing advice. A memorable piece of advice concerning my thesis, best not repeated here, has finally been taken seriously. Getting to know both Brian and his family have added to the enjoyment of my time at McMaster.

Graduate student life was made easier by NSERC scholarship, some of which was used towards field work. An EMR Research agreement to Dr. McCann helped finance the field work. I would like to thank Bob Taylor for his help. Chris Trider, Nova Scotia Parks and Recreation, provided information on the provincial management of dunes. Others who have been helpful are listed in a "Personal Communications" section at the end of the reference list.

Bob Bignell showed me Ontario as it should be seen, north of the 401. Finally, I would like to thank my office mates, especially Mary-Lou Byrne, who acted as a secondary supervisor when Brian was not available. Todd Randall and Roberta O'Daiskey put up with me while I was writing, and provided food, encouragement and Christmas lights at all the right moments.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Objectives of the Research

The purpose of this research was to complete a comprehensive study of the coastal sand dunes of Nova Scotia (Fig. 1.1). In order to fulfil this purpose, four goals were identified: 1) to locate all the dune systems greater than 1 km in length; 2) to describe and categorize the dune system morphology and the associated vegetation; 3) to describe and summarize the human use and abuse of the dunes; and 4) to identify problem areas and topics for future investigation. Extensive work has been done on the dunes of Sable Island and in the other Maritime Provinces, New Brunswick and Prince Edward Island, but no study of this magnitude has been carried out on the sand dunes of Nova Scotia.

1.2 Methods

For the purpose of this research, sand dunes were defined as any sand

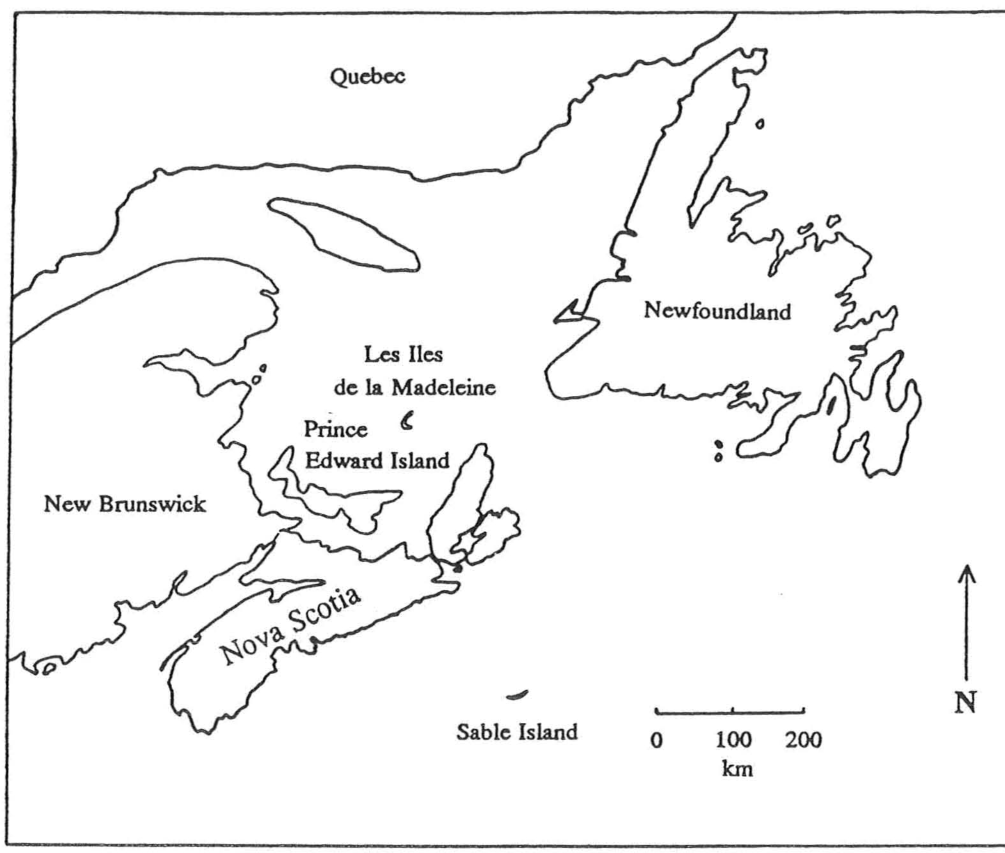


Fig. 1.1 Atlantic Canada.

accumulation deposited by aeolian processes, and having a morphology distinct from the underlying surficial material.

In order to achieve the objectives, the study was divided into a number of components. Initially a general aerial photography study (scale of approximately 1:50,000) was made of the coastline of Nova Scotia in order to identify all beaches greater than 1 km in length, which were potentially associated with sand dunes. This study was made at the National Air Photo Library in Ottawa, and seventy-three beaches were identified.

Field work was carried out on ninety-five beaches, including those identified by air photos, during June and July, 1991. Sand dunes existed at seventy one sites, of which forty-five had dune systems greater than 1 km in length. Dunes greater than 1 km in length were studied in detail, as was done in a similar study of the coastal dunes of New South Wales, Australia (Chapman, 1989). Table 1.1 provides a list of all the sites with sand dunes visited in Nova Scotia, and figure 1.2, with its accompanying table (1.2), provides the location and basic information about each dune system greater than 1 km in length. The systems were named primarily according to the provincial map book (Nova Scotia, 1985), although many have more than one name (table 1.3). If the name given in the book did not agree with that of local signs, the local name was used.

On the dune systems studied in detail, the length of the system was measured by pacing, or driving if a proper road was available, and observations were made on geomorphological and ecological features. A profile of the dune

SAND DUNE SYSTEMS IN NOVA SCOTIA			
Mavillette *	Summerville *	Framboise *	Sand Dunes
Bartletts *	Beach Meadows *	Fourchu *	potentially > 1 km
Port Maitland	Eagle Head	Morien Bay *	but not observed
Yarmouth Light	West Berlin	Glace Bay *	(usually inaccessible)
Cape Sable Island	Ragged Harbour	Dominion *	
- The Hawk *	Cherry Hill *	Florence	
- Absalom Point *	Rissers *	Ingonish	
- Bakers *	Crescent *	Aspy Bay	The Hawk (island
- Clam Point *	Hirtles *	- South Pond *	- Cape Sable)
Sand Hills *	Kingsburg *	- North Pond *	Little Port Joli
Baccaro *	MacCormicks	Cheticamp *	St. Esprit Lake
Round Bay	Rainbow Haven	Inverness	Indian Point
Red Head *	Conrads *	West Mabou	Malagash Beach
Roseway *	Lawrencetown *	Shipping Point *	
Fox Bar *	Martinique *	Pomquet *	
Crescent	Clam Harbour	Captains Pond	
(Lockeport)	Taylor Head	Dunns *	
Black Point *	Tor Bay *	Mahoneys *	
Louis Head *	Pondville	Merigomish *	
Johnstons	Rockdale	Kings Head	
Sandy Bay *	Point Michaud *	Melmerby *	
St. Catherines *	Grand River	south of Evans Point	
South West Port	Black Point	Pictou Harbour	
Mouton *	L'Archeveque	- Lighthouse *	
Carters *	Rorys Pond *	- Lowdens	
		Waterside	

Table 1.1. A total of 71 sites visited during June and July, 1991, had sand dunes. Of these 45 had dune systems greater than 1km in length (*). The sites are listed in order of occurrence around the province in an anti-clockwise direction from the Bay of Fundy. Some sites, such as Black Point near the Grand River were only viewed through binoculars. Other sites were too far from a road to access in the time available, and have been listed as potentially having dune systems greater than 1 km.

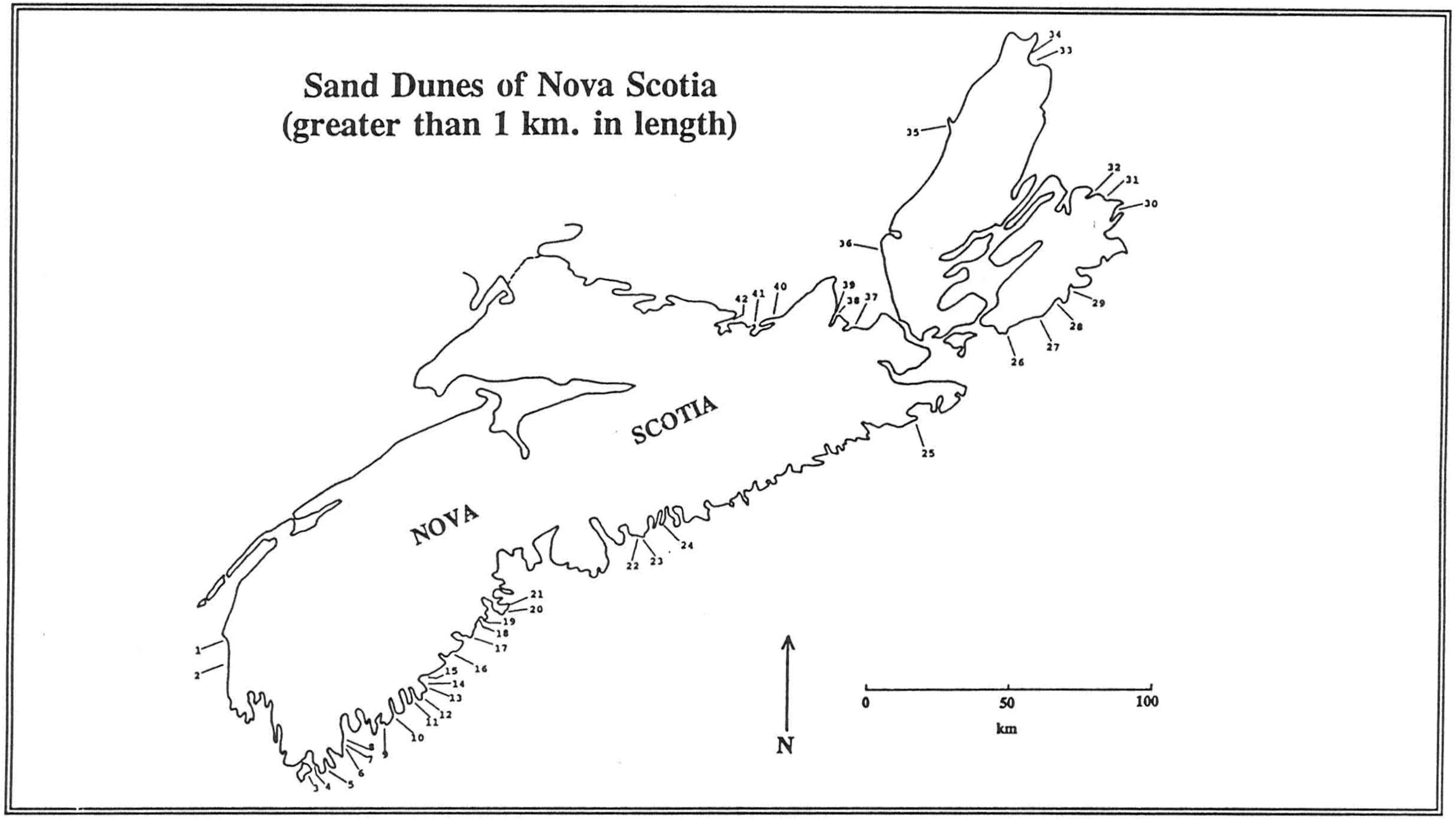


Fig. 1.2. 42 sites were identified as having dune systems greater than 1 km in length. At some of these locations, such as Cape Sable Island, more than one dune system occurs, bringing the total number of 1 km systems to 45.

The numbers correspond to Table 1.2.

LOCATION	HEIGHT (m)	WIDTH (m)	LENGTH (M)
1. Mavillette		224.0	1200
2. Bartletts	5.56	137.7	1150
3. Cape Sable Island			
Absolam Point	2.35	288.0	4360
Clam Point	1.96	63.0	1000
4. Sand Hills	2.18	93.9	2500
5. Baccaro	1.53	97.6	1575
6. Red Head	3.38	135.1	1570
7. Roseway	1.56	80.0	1000
8. Fox Bar			1000
9. Black Point	2.31	97.9	2520
10. Louis Head	1.38	58.5	1600
11. Sandy Bay	1.68	72.9	1320
12. St. Catherines	3.04	270.7	1600
13. South West Port Mouton			1340
14. Carters	4.03	50.0	1420
15. Summerville	3.09	103.4	1030
16. Beach Meadows	2.90	96.8	1200
17. Cherry Hill	3.03	129.0	2150
18. Rissers	2.74	58.2	1060
19. Crescent	1.94	32.6	2130
20. Hirtles	2.97	20.7	1610
21. Kingsburg	3.12	125.7	1000
22. Conrads	2.47	109.9	1300
23. Lawrencetown	4.80	123.7	1840
24. Martinique	3.05	84.8	3270
25. Tor Bay			1100
26. Point Michaud	2.25	76.9	3400
27. Rorys Pond	1.93	77.4	2000
28. Framboise	2.88	85.6	2250
29. Fourchu	2.88	101.6	*
30. Morien Bay	1.43	64.6	1380
31. Glace Bay	2.49	115.2	1430
32. Dominion	2.80	111.9	1980
33. Aspy Bay, South Pond	2.13	189.9	1820
34. Aspy Bay, North Pond	2.54	212.0	3480
35. Cheticamp	2.33	48.6	1000
36. Shipping Point	3.36	190.5	1500
37. Pomquet	4.24	212.8	3750
38. Dunns	2.25	99.2	1880
39. Mahoneys			2180
40. Merigomish	5:13	192.0	4920
41. Melmerby	3.75	132.0	1850
42. Pictou, south side	1.30	49.4	1460

Table 1.2. Summary of the sand dunes greater than 1 km in length. Height, above high water line, and width, from waterline to marsh, lagoon or forest, are measured at the transect. If more than one transect was done, the average of the two is provided. * Fouchu system is over 10 km in length, divided by headlands.

SAND DUNE SYSTEM NAMES	
Name Used	Other Known Names
Mavillette	
Bartletts	
Cape Sable Island - The Hawk	
- Absalom Point	
- Clam Point	
Sand Hills	Sabim
Baccaro	Crows Neck
Red Head	Atlantic
Roseway	Round Bay
Fox Bar	Salt Box, Thrumb
Black Point	Thomas H. Raddall Provincial Park
Sandy Bay	
St. Catherines River	Cadden, Kejimkujik Seaside Adjunct National Park
South West Port Mouton	
Carters	Wombakek
Summerville	
Beach Meadows	
Cherry Hill	Hell Bay, Conrad
Rissers	
Crescent	Green Bay
Hirtles	
Kingsburg	
Conrads	Fox Point
Lawrencetown	
Martinique	
Tor Bay	
Point Michaud	
Rorys Pond	
Framboise	Morrison
Fourchu	Belfry
Morien Bay	Phalens Bar
Glace Bay	Big Pond, South Street
Dominion	Lingan, Indian Bay
Aspy Bay - S. South Pond	Yellow Head
- N. South Pond	Dingwall South
- S. North Pond	Dingwall
- N. North Pond	Cabots Landing Provincial Park
Cheticamp	
Shipping Point	Port Hood
Pomquet	
Dunns	
Mahoneys	
Merigomish	Big Island
Melmerby	
Pictou Harbour - south	Lighthouse
- north	Lowdens

Table 1.3. One of the problems encountered while studying the sand dunes of Nova Scotia was the variety of names used to identify the dune systems. Where possible, the systems are referred to according to the provincial map book. Other names are provided in order to prevent incorrect identification.

system was surveyed at a representative area, chosen by visual observation, and not necessarily at the highest part of the dune ridge, but preferably at the centre of the system. The profiles, surveyed with an automatic level and a stadia rod, extended from the ocean water line to the beginning of the marsh or lagoon at the rear of the system, or to the point at which dense forest began. Due to time constraints, it was not possible to profile every beach at the low low water level, so a typical high water level is used as a datum to compare different dune profiles.

The transect selected for surveying also provided the location for analysing the dune vegetation and for sampling the beach and dune sand. Vegetation samples were taken using a 1 m^2 quadrat, counting the number of each species present, and making an estimation of the percentage of ground cover. A quadrat was analysed every time there was a visible change in species composition or density, as described by Chapman (1976). Detailed observations were also made of species composition and density during the surveying, and survey readings were taken at all changes in vegetation to enable accurate reconstruction of vegetation associations across the dunes. On those dune systems where time was limited, these observations were the only vegetation information collected.

Sand samples were taken on both the beach and the dune, since they are part of the same aeolian transport system. Samples were taken along the transect at the current water line (foreshore), between the high water line and the dune ramp (backshore), on the ramp (ramp), and on the crest of the first dune ridge (crest). At each location, several small grab samples were taken from an area of approximately 50 cm by 50 cm to a depth of about 5 cm. The surface material was included since it is most vulnerable to aeolian transport. Sediment greater than pebble size on the Wentworth scale (16 mm or -6 phi) was not sampled, but was visually assessed. The samples were later sieved, and the information compiled in table 4.1.

The Department of Lands and Forests was contacted in each county to inform them of the study and to attain permission to work in restricted areas. In Queens County, the senior park warden of the Seaside Adjunct of Kejimkujik National Park was also contacted. The personnel at both provided valuable information on the history and usage of various beaches. Local residents were also questioned when met on the beaches or dunes.

A second trip to Nova Scotia was made in May, 1992, in order to study air photos of the dunes (approximate scale of 1:10,000), and to view the video tapes of the coastline of the province prepared for Petro-Canada Exploration Inc. (1982), which are available at the Bedford Institute of Oceanography. At this time the dune systems from Halifax to Martinique were revisited, with Christopher Trider of the Department of Lands and Forests, Parks and Recreation Division, and the dunes at South West Port Mouton were visited for the first time.

The first objective was fulfilled by the air photo analysis, and observations made in the field. In order to complete the next objective, the profiles, sediment samples and observations on morphology were used to describe and categorize the dune systems. The information on vegetation species and density allowed vegetation associations to be classified for each dune system, providing a general summary of the dune vegetation which exists in Nova Scotia. The third objective, concerning the human impact on the dunes, was achieved by compiling the information obtained from observations made in the field, from various Provincial and Federal Park personnel, from local residents, and from previous studies. Analysis of the results gained from the first three goals, enabled the completion of the fourth objective, to identify areas for future study.

1.3 Format of Thesis

The following chapter includes a review of the literature of coastal sand dune processes and occurrence, with emphasis placed on dunes of eastern Canada. The environment of coastal Nova Scotia is described in chapter 3. The sand dunes are classified according to morphology, and the resulting groups are discussed in chapters 4 and 5. The geomorphology of the area in which each group is found, the sediment characteristics, the morphology of the dune systems, and the condition of the sand dunes are discussed in these two chapters. Chapter 6 describes the vegetation associations typical of Nova Scotia dunes, and also includes information about coastal sand dune vegetation in general. The impact of human activity on the dunes and the management policies of institutions involved are discussed in chapter 7. The final chapter, 8, contains the concluding comments.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter the occurrence of coastal sand dunes on a global scale, the physical processes involved in creating such dunes, and the several classification schemes will be considered before focusing on the eastern coast of North America, in particular Atlantic Canada and Nova Scotia. Literature pertaining to coastal sand dune vegetation will be reviewed at the beginning of chapter 6, and that dealing with dune management will be incorporated into chapter 7 where appropriate.

2.2 Occurrence of Coastal Dunes

Coastal sand dunes are found in all regions of the world and are an integral part of most depositional coasts (Goldsmith, 1985). In temperate regions, sand dunes are found in a wide range of locations, including the coasts of Baltic and Atlantic Europe (Olson and Van der Maarel, 1989), both the west and east coasts of North America, from Washington State to Baja California on the west (Orme and Tchakerian, 1986; Cooper, 1967; Cooper, 1958), and from Prince Edward Island to the Gulf of Mexico on the east (Godfrey, 1976; McCann, 1990). Large dune fields are found at Coos Bay, Oregon (Cooper, 1958), Lake Michigan (Olson, 1958), Cape Cod and Sandy Neck, Massachusetts (Goldsmith, 1985). Sand dunes also are found on northern coasts such as that of south western Alaska (Cooper, 1958). Coastal sand dunes have been studied in Australia by Short and Hesp (1982), in New Zealand by Wright (1989), in Japan (recent references are only in Japanese), and in Israel by Goldsmith (1989). Although vegetation plays a major role in the development and stabilization of coastal sand dunes, non-vegetated dunes are found along such arid coasts as Peru, Chile and Baja California.

The largest coastal dunes tend to be found on windward coasts with large, well-sorted sand beaches. These conditions exist along western shores in temperate mid-latitude regions, where westerlies dominate, and on eastern shores in the trade wind belt (Pye, 1983). Sand dunes are not only found backing large beaches, but also occur on small beaches, such as those of California and Nova Scotia, where protruding headlands interrupt longshore drift and prevailing winds (Orme and Tchakerian, 1986). Climbing and cliff top dunes may be found on coasts backed by cliffs, such as northern Scotland and Ireland (Goldsmith, 1985).

The only area in the world where there does not appear to be extensive coastal sand dune development is the humid tropical region. The poor development of sand dunes along tropical coasts seems to be the result of a number of factors. The potential for aeolian sand transport is reduced by low wind velocities, beaches backed by tall dense vegetation which impedes air flow, and damp, possibly salt crusted sand which requires higher velocities to initiate transport. The sand supply may also be poor, due in part to the intense weathering and the narrow, microtidal beaches found in the tropical region (Swan, 1979). However, there are unquestionably sand dunes in tropical areas, such as those of the coast of Sri Lanka which may reach 30 m above sea level (Swan, 1979).

2.3 Factors Controlling Dune Development

The processes involved in the formation of sand dunes have been reviewed by several authors (ie. Pye and Tsoar, 1990; Davidson-Arnott, ed., 1990). An adequate wind and a supply of sand are the vital components of aeolian sand transport. The wind must be above a threshold velocity in order to move the sand, and must reach this level often enough for the development of dunes to occur. Wind dynamics on sand dunes have been studied by Bagnold (1954), Olson (1958a; 1958b), and Greeley and Iversen (1985). By influencing the effectiveness of the wind and the availability of the sand, a number of other factors also play a role in controlling this transportation system. These include the local topography of the beach and the coastline, the climate, and the vegetation.

The amount of sand available for aeolian transport is potentially a limiting factor in the growth of sand dunes. Even if there is abundant sand on the beach, other factors may render it unavailable for transport. On beaches covered by gravel or pebble lags, the sand layer is effectively protected from the wind. This coarser layer also increases the surface roughness, thus reducing the wind velocity (Carter, 1988). In high latitudes, beaches may be frozen for much of the year, restricting the development of sand dunes to the summer season. Moisture in the sand of humid regions, can greatly decrease sand transport due to the increase in the threshold shear velocity of wet sand (Goldsmith, 1985). Chemical precipitates, such as salt crusting, may increase the bonding between the sand grains, also resulting in greater threshold velocities (Carter, 1988).

There are a variety of sources from which beach sand can be derived. Longshore transport may supply sand from river deltas or areas of active coastal erosion (Goldsmith, 1989; Boorman, 1977). Sand may also be derived through the reworking of sediments which were deposited at an earlier time (Olson, 1958c; Short and Hesp, 1982; Orme and Tchakerian, 1986; Carter, 1988).

The profile of the beach greatly affects the ability of the wind to move sand. On flatter surfaces, there are fewer fluctuations in wind velocity and, consequently, larger quantities of sand can be transported (Short and Hesp, 1982). The potential for sand transport is greatest on the wide, flat dissipative beaches (high wave energy beaches) and least on the narrow, steep reflective beaches (low wave energy beaches; Short and Hesp, 1982).

2.3.1 Coastal Dune Formation

According to Wilson (1972, as in Greeley and Iversen, 1985), a dune requires the presence of a nucleus, some irregularity or disturbance, for development to be initiated. In the case of a coastal dune, this nucleus is often a plant or an object in the tidal litter (Pethick, 1984; Hesp, 1981; Olson, 1958a). A pyramidal-shaped shadow dune forms in the lee of the object, where the wind flow is disturbed, creating eddies or vortices (Hesp, 1981). In the lee of semi-prostrate plants, drift dune formations may occur (Hesp, 1981). As shadow dunes grow (also referred to as embryo dunes), they gradually coalesce, creating incipient foredunes. Carter (1988) described two categories of developing foredunes, ephemeral foredunes, which are destroyed by the next high tide or storm, and embryonic foredunes, which grow into more stable landforms. Hesp (1984) suggested four methods of foredune initiation, by deposition within or in the lee of 1) discrete plants; 2) discrete zones of seedlings; 3) laterally extending colonies of seedlings; and 4) laterally extending rhizomes.

Once a foredune is developed, it may stabilize in situ due to a lack of sand, or it may continue to grow if sand is abundant. One of two things can happen to developing dune systems (Ranwell, 1972). On a coast with a broad backshore and moderate onshore winds, a prograding system may develop, in which a series of dune ridges tend to form and stabilize in situ, with the youngest nearest the sea. An eroding system tends to develop on a coast where the backshore is narrow, limiting the sand supply, and the prevailing and dominant winds are onshore. Due to local patterns of erosion and deposition, the seaward ridge moves landward as either a dune ridge or a parabolic dune (Boorman, 1977). These dunes may continue to shift for centuries before becoming stabilized by vegetation. If prograding systems become unstabilized, for example, as a result of vegetation loss, they may develop into eroding systems (Ranwell, 1972).

As foredunes grow, the crest of the dune eventually reaches a critical height at which vegetation is no longer able to hold the sand (Ranwell, 1972). Consequently, the crest and seaward face become susceptible to erosion. Although some foredune ridges, such as at Newborough Warren, Anglesey (Ranwell,1972) and on Hog Island, Prince Edward Island (McCann and Byrne, 1989), have been known to erode landward in a uniform manner, most foredunes experience irregular erosion. A lowering of a dune crest or ridge, either by natural forces or by human interference, such as the trampling of vegetation, will cause a blowout. The wind is funnelled across this lowered section with a greater velocity than in the neighbouring areas, resulting in increased sand removal (Goldsmith, 1985). Series of U-shaped parabolic dunes may form behind the foredune as a result of the blowouts. Natural gaps or corridors in the dunes, possibly originating from shoreline erosional features,may also result in the formation of blowouts (Carter, 1988).

Landward of the foredunes, a number of aeolian features may develop. Separating ridges of foredunes, elongated depressions, which are often moist due to the nearness of the water table to the surface, known as dune slacks or swales, are found. The depth of weathering and soil formation in these depressions increases landward, providing a possible indication of the age of the dune system (Bird and Jones, 1988).

Dunes on coasts consisting of deltaic barrier systems, such as that of much of the eastern coast of North America, are often controlled by storm washover events. Washovers affect beach width and gradient, the rate of vegetation growth, and the dune morphology (McCann and Byrne, 1989; Ritchie, 1988). The height of storm tides restricts the seaward growth of dunes on all shores, by undercutting the windward slope of the dune (Ranwell, 1972).

2.4 Coastal Dune Classification

Sand dunes may be classified according to either morphology or mode of formation, or by a combination of the two. Numerous classification schemes exist in the literature, however, only four, proposed by Davies (1972), Pye (1983), Pethick (1984), and Hesp (1988), will be considered.

The classification schemes developed by Davies (1972) and Pye (1983) are both based primarily on morphology (Fig. 2.1). Pye's scheme consisted of two main divisions, impeded dunes and transgressive dunes. These two divisions also exist in Davies' classification as sub-groups of his main categories, labelled primary dunes (derived from beaches) and secondary dunes (derived from

Davies (1972)

A Primary Dunes (derived from the beach)
1. Free dunes (vegetation unimportant)
- transverse ridges
- barchans
- oblique ridges
- precipitation ridges
- etc.

2. Impeded dunes (vegetation important)
- foredunes
- sand beach ridges
- dune platforms
- etc.

B Secondary Dunes (derived from A2)
1. Transgressive dunes
- blowout dunes
- parabolic dunes
- longtitudinal dunes
- transgressive sheets
- etc.

2. Remnant dunes
- eroded remnants of vegetated primary dunes

Pye (1983)

A Impeded Dunes
- shadow dunes
- sand platforms
- foredune ridges
- transverse ridges (non-transgressive)
- hillock dunes
- crescentic dunes

B Transgressive Dunes
- barchans
- transverse ridges (precipitation ridges)
- transgressive sand sheets
- parabolic dunes
- oblique dunes

Figure 2.1. Dune classification schemes based primarily on morphology (Davies, 1972; Pye, 1983).

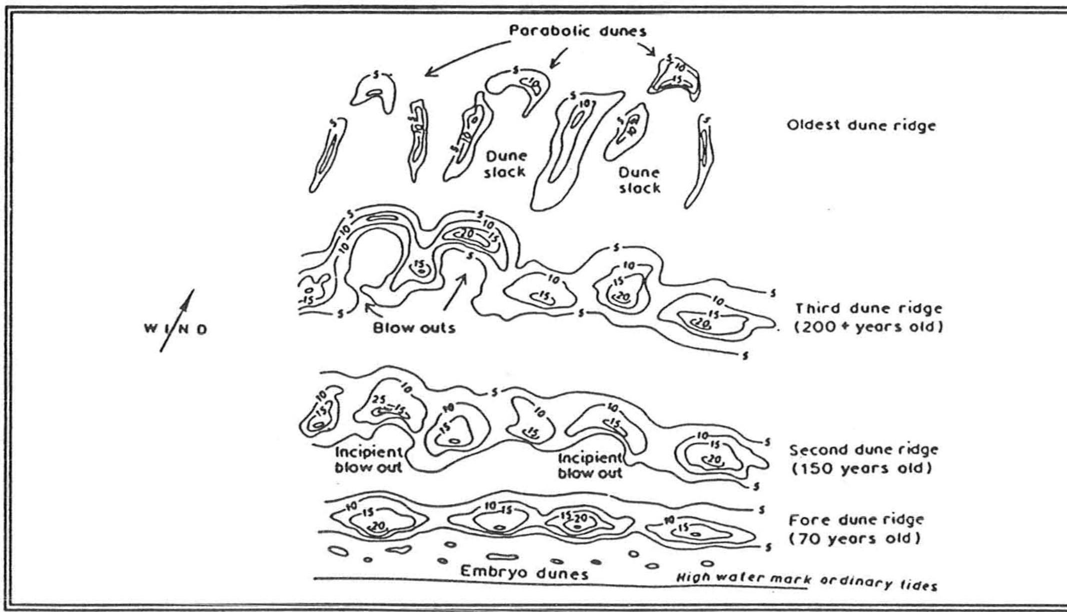


Figure 2.2. Dune classification scheme based on morphology and incorporating temporal and spatial scales (Pethick, 1984).

impeded primary dunes). Davies' scheme implies a sequential development of dunes, from primary to secondary dunes, possibly finishing as either remnant or lithified dunes. The classification proposed by Pethick (1984) also involves the notion of sequential dune development. Pethick followed the development of coastal dunes from embryo dunes through foredune ridges to blowouts and parabolic dunes, incorporating the concept of temporal and spatial scales (Fig. 2.2). Hesp (1988), unlike the other schemes, only reviews foredunes. This scheme consists of five stages based on morphology and vegetation cover (Fig. 2.3). Although the term "stage" implies that this classification defines consecutive periods in dune development, this is not necessarily the case. Hesp's stages may develop independent of one another or in a different order due to their environmental setting.

2.5 Coastal Sand Dunes on the Eastern Coast of North America

Sand dunes are found along the eastern coasts of both the United States of America and Canada. A brief review of the morphology of the dunes of these two countries will be provided in order to set the context for the dunes of Nova Scotia. The focus will be on the sand dunes of Canada.

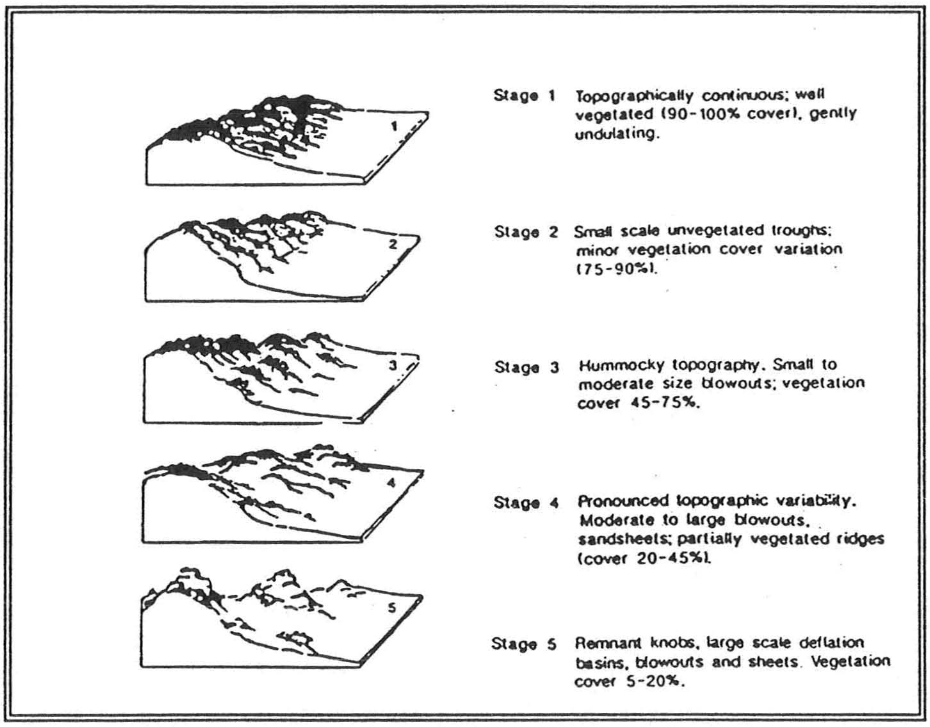


Figure 2.3. Classification of foredunes based on morphology and vegetation cover (Hesp, 1988).

2.5.1 Coastal Sand Dunes of the Eastern United States

Sand dunes of the eastern coast of the United States of America range from small dunes backing pocket beaches of Maine to the extensive dunes of the barrier islands, which form much of the outer coast of the continent south of New Jersey. Godfrey (1976) provides a brief overview of the dunes of this area and their vegetation; the latter will be discussed in chapter 6.

The coastline of Maine was scoured by glacial action, leaving rocky headlands, separated by small pocket beaches and spits. Dunes in this area are small and low, as described by Baye (1990)in his discussion of the artificial dunes created on a spit at Ogunquit, Maine. Natural dunes on the spit were typically 1 to 1.5 m in height, with maximum elevations of 4 m above mean sea level.

South of Maine, along the New Hampshire and Massachusetts coast, sediment from eroding drumlins has been reworked into barriers (Godfrey, 1976). From Merrimac Estuary, Massachusetts, to southern Long Island barrier systems occur, interspersed with glacial bluffs, from which sediment is derived. Large sand accumulations occur in the dunes of Barnstable and Cape Cod, where sand dunes reach heights of over 21 m and 30 m respectively (Oldale, 1992).

The coastline from New Jersey south to Mexico was not glaciated during the last glacial period, and the barriers are the result of rising sea level drowning beach ridges and the subsequent transgression (Godfrey, 1976). The outer barrier islands of North Carolina are the most exposed to ocean storms, and consequently are low and wide, with well developed dunes only occurring in some areas. South of Beaufort Inlet the barriers are more protected, and well developed dunes exist.

2.5.2 Coastal Sand Dunes of Atlantic Canada

Sand dunes are found in all the provinces of Atlantic Canada, with the largest systems being found in New Brunswick, Prince Edward Island, Les Iles-de-la-Madeleine, Quebec, and Sable Island, Nova Scotia (Fig. 2.4). These systems have been reviewed by McCann (1979 and 1990).

Barrier islands and spits extend for much of the coast of New Brunswick, from Miscou Island to Pointe aux Renards. The northern systems, Miscou Island to Point Escuminac, consist of low dunes subject to frequent washover events (Rosen, 1979; McCann, 1979). Further south along the coast the dunes tend to be higher, reaching heights of 9 m above the low water line on the North Beach of the Kouchibouguac system. The dunes of this area primarily consist of a single foredune ridge, but multiple ridges are found on the South Beach (Bryant, 1972).

The most extensive dune systems of Prince Edward Island are located on the barrier islands and spits which constitute much of the northern shore of the

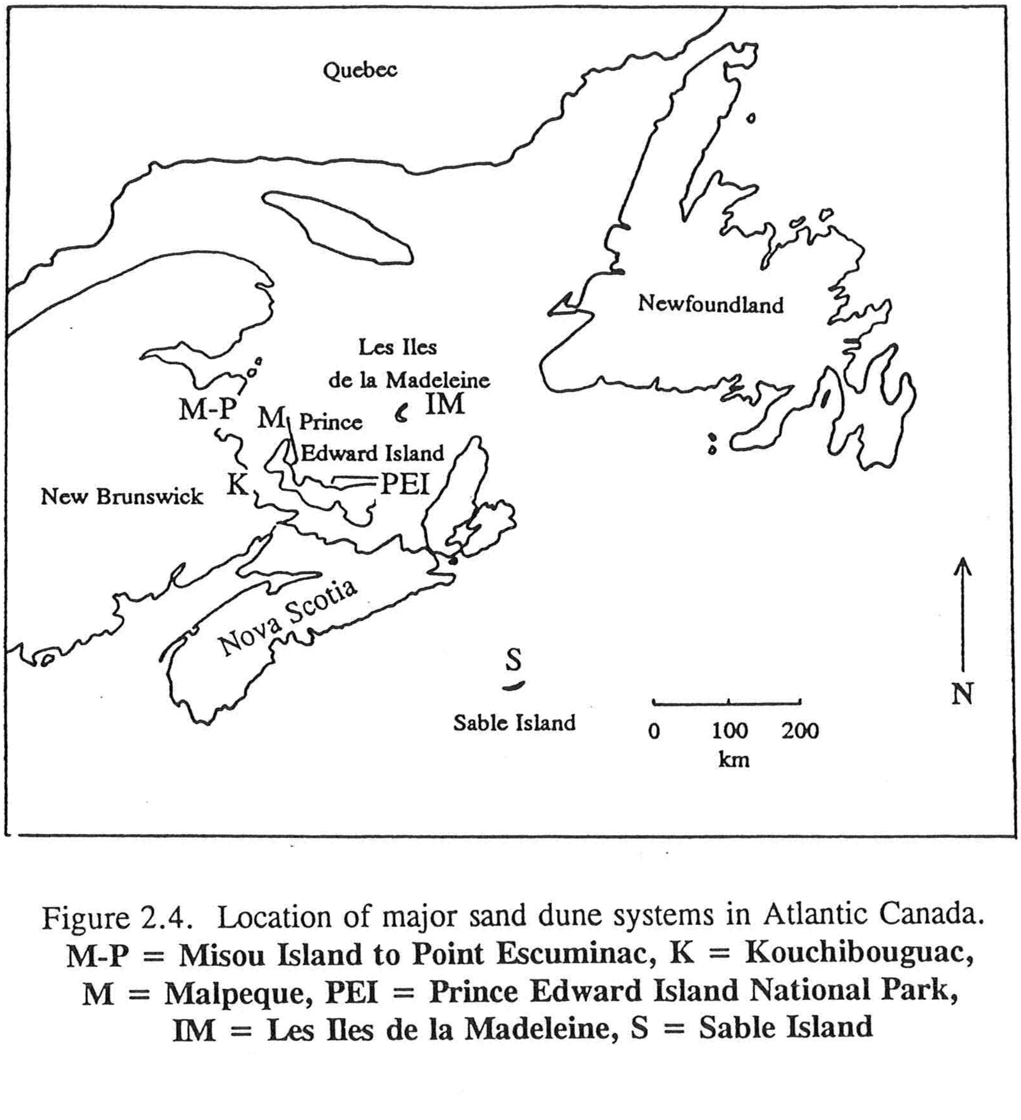


Figure 2.4. Location of major sand dune systems in Atlantic Canada. **M-P = Misou Island to Point Escuminac, K = Kouchibouguac, M = Malpeque, PEI = Prince Edward Island National Park, IM = Les Iles de la Madeleine, S = Sable Island**

island. The large Malpeque barrier system across Malpeque Bay, Cascumpec Bay and Conway Narrows at the north end of the north shore, has been studied by Armon (1975). The main dune ridges on Kildare Spit, the most northern section, reach heights of 5 m above low low water. The dunes of Conway and Cascumpec Sand Hills are usually less than 4 m, with a high foredune ridge of 8 m. Those of Hog Island, the largest island of the system, have a similar height, with multiple ridges reaching 4 to 6 m in height on the main part of the island, and 8 m in height on the southern end, known as Billhook Island. The foredune ridge of the Malpeque system is typically steep, eroded by wind and wave action on the seaward side, and also steep, but vegetated on the lee side. South of the Malpeque system, making up the central part of the northern shore, are the barriers and spits of Prince Edward Island National Park. Dunes in this area have been studied by Byrne (1986), Atkinson (1986) and Nutt (1990). Nutt and McCann (1990) looked at the sand dunes near Point Deroche, just east of the National Park. Here the barrier consisted of a narrow, 50 m wide, foredune ridge 2 to 6 m high, with a steep seaward slope and a gentle lee slope. The foredune ridge on the spits within the National Park are slightly higher, 4 to 9 m (Nutt, 1990), similar in height to those of the Malpeque and Kouchibouguac barrier systems. Large old dunes exist on Cavendish Spit and Blooming Point, reaching heights of 8 to 12 m and 15 to 20 m respectively (Atkinson, 1986; Byrne, 1986).

The foredunes of Les Iles-de-la-Madeleine are slightly higher and have a greater variation in height than those of the New Brunswick and Prince Edward Island barriers, with typical heights of 1 to 11 m (Giles, 1992). Les Iles-de-la-Madeleine are a set of bedrock islands connected by sand barriers and spits to make a continuous land area of approximately 70 km in length (Owens and McCann, 1980; Giles, 1990).

The largest dunes of Atlantic Canada are those of Sable Island, an arcuate island composed of reworked glacial outwash sediments located on the outer part of the Scotian Shelf, approximately 150 km from mainland Nova Scotia (Byrne, 1991). The highest dunes are those along the northern coast, reaching heights of 8 to 30 m, while those of the southern shore tend to be less than 6 m high (Taylor and Frobel, 1990; Byrne, 1991).

The coast of Newfoundland, unlike those previously discussed, consists primarily of bedrock or gravel deposits, with sand beaches occurring only in limited locations (McCann, 1990), such as along the northeastern coast between Bonavista Bay and Hamilton Sound, where they have been observed by Shaw and Forbes (1990). Dunes backing these beaches are low, typically less than 2 m above mean water line, and occasionally exceeding 3 m in height. A series of ancient beach and dune ridges, blanketed under fresh water peat deposits up to 2.9 m thick, were also observed in this area at Mann Point. Samples from the base of the peat provide dates of roughly 3000 years before present, making these the oldest Holocene coastal dunes recorded in Atlantic Canada (Shaw and Forbes, 1990; McCann, 1990).

2.6 The Coast of Nova Scotia

The majority of the literature concerning the coastal areas of Nova Scotia deals with either the impact of rising sea level on the coastal zone (ie. Forbes et al., 1989; Carter et., 1989; Shaw et al., in review), or the transgression of coarse clastic beaches along the eastern shore of the province (ie. Carter et al., 1990; Forbes et al., 1990; Forbes et al., 1991). Studies and models of transgressive coastlines associated with drumlin deposits along the eastern shore of the mainland (Boyd et al., 1983) and of Cape Breton Island (Wang and Piper, 1982) have been developed. General surveys of the coastal environment have been undertaken by Owens and Bowen (1977) for the Southern Gulf of St. Lawrence, including Nova Scotia, and of the Atlantic coast of Nova Scotia by Munroe (1982). The environments defined by these studies will be discussed in chapters 4 and 5.

Three studies of the beaches of Nova Scotia exist. The earliest, "The Maintenance of Beaches" by Bowen et al. (1975), looks at the morphology and condition of thirteen beaches around the province. Of these thirteen, the following have sand dunes greater than 1 km in length associated with them: Melmerby, Pomquet, Dominion, Framboise, Point Michaud, Martinique, Crescent, Summerville, Sand Hills, Bartletts, and Mavillette. The general conclusion of this study is that there is a serious conflict between human use and natural processes on most of the beach-dune systems, and that careful management is required.

The second study is that done by the Parks and Recreation Division of the Department of Lands and Forests, "Results of the Nova Scotia Beaches Study" (Rutherford, 1986). This report provides an inventory of all the Nova Scotia beaches in table form by county, with information such as ownership, use and development, and problems and issues. This information is summarized in a general chapter at the end of their report. Although it is useful as a quick reference, this report does not provide detailed descriptions of each beach, or make any attempt to classify them. The following beaches with sand dunes are identified as requiring immediate attention due to the number of problems reported: Mavillette, Bartletts, Crescent, Rainbow Haven, Conrads, Lawrencetown, Point Michaud, Dominion, Mahoneys, and Melmerby.

The final study of beaches in Nova Scotia is that by Taylor et al. (1985), "Beach Morphology and Coastal Changes at Selected Sites, Mainland Nova Scotia". This report discusses the physical characteristics and evolution of eight beaches, of which only Martinique, Conrads, Crescent and Bakers (Cape Sable Island) have dune systems greater than 1 km in length. The result of beach surveys at a further nine beaches, showed that net erosion had taken place at Bartletts and Martinique, while some sediment accumulation had occurred at Mavillette, Crescent, Summerville, and Cherry Hill. Dune degradation was observed at Cherry Hill and Martinique, and all the beaches studied, with the exception of Waterside on the Northumberland Strait, exhibit signs of landward transgression. The report by Taylor et al. (1985) includes an extensive bibliography, however most of the studies included are unpublished reports or university theses available only in Nova Scotia. Where applicable, observations and comments made by Bowen et al. (1975) and Taylor et al. (1985) have been included in the descriptions of the dune systems, chapters 4 and 5.

2.7 Terminology

The terminology used to describe coastal depositional features follows that of King (1972). Beaches are attached to the mainland along their whole length, while barriers are attached at both ends and may or may not have inlets through them. Spits are free forms, attached at only one end, and tombolos attach islands to the mainland or to other islands. A foreland is a feature which protrudes from the coast, making it more irregular. Figure 2.5 provides examples of the terms which are used to describe the coastal forms of Nova Scotia.

The terms used to describe the various zones of the shore and the dunes are taken from King (1972) and Pethick (1984). The offshore is that area which extends from the low water line to the limit of substantial movement of material by wave action. The area between the tide levels is the foreshore (also referred to as the nearshore), and the area above the extent of normal high water swash, but covered by exceptionally high swash, is the backshore. These are depicted in figure 2.5.

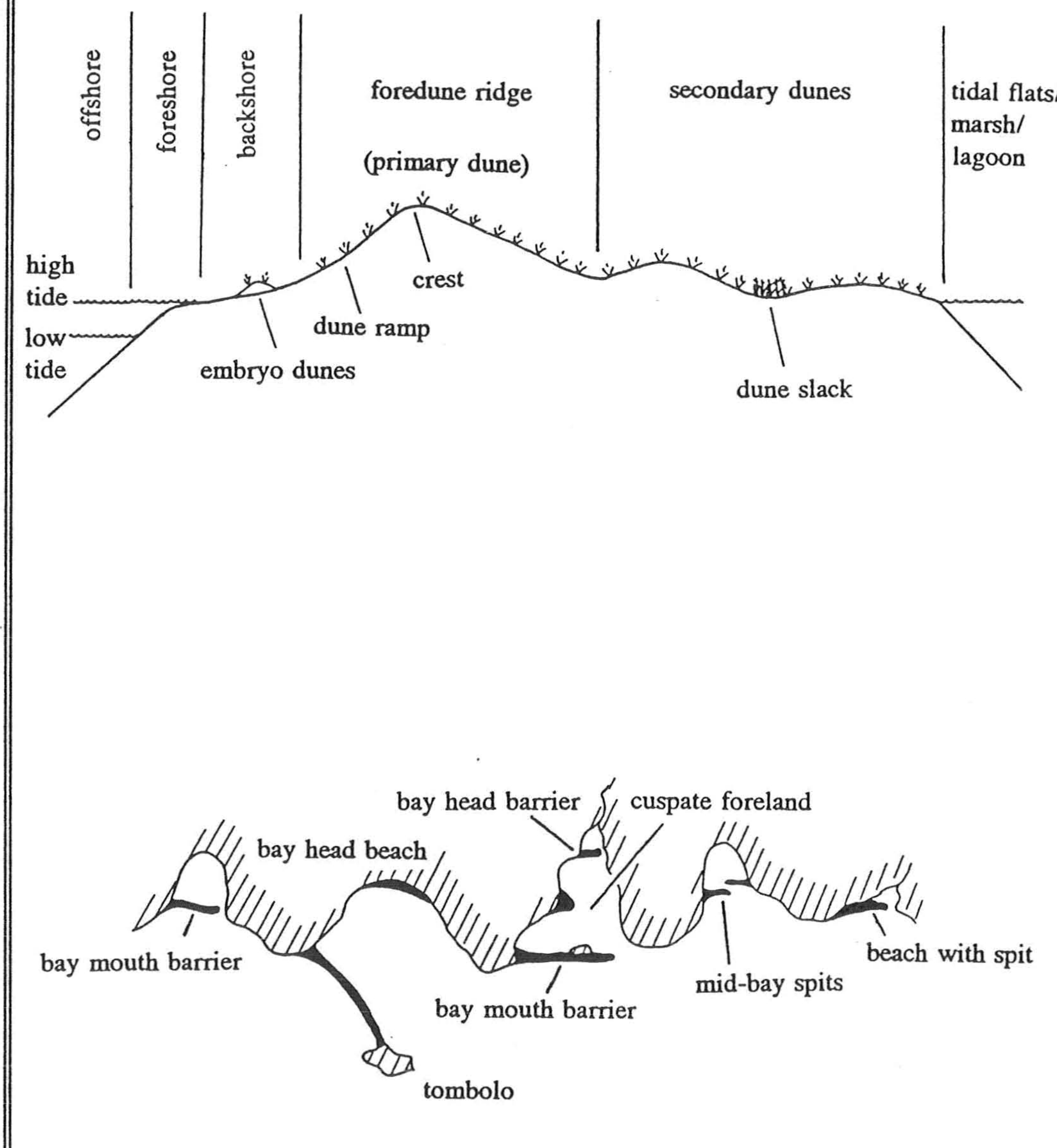


Figure 2.5. Terminology used to describe the sand dunes of Nova Scotia (after King, 1972 and Pethick, 1984).

CHAPTER 3

ENVIRONMENTAL SETTING

3.1 Introduction

The coast of Nova Scotia is comprised of glacial structures and materials. It is the topography of this coastline and the availability of sediment along it which control the development of beaches and their associated sand dune systems. In order to understand the distribution and morphology of the sand dunes of Nova Scotia, it is necessary to have an appreciation of the glacial history and the resulting sediment deposits, the rising relative sea level, and the wind and wave climate. The coastline of Nova Scotia has been divided into eleven units based on local geology, relief, wave climate, tidal range, and sediment supply (Owens and Bowen, 1977; Fig. 3.1). Since these factors influence sand dune development, it is not surprising that these divisions are similar to the five regional groups identified according to sand dune morphology and sediments, which will be discussed in the appropriate sections of Chapters 4 and 5.

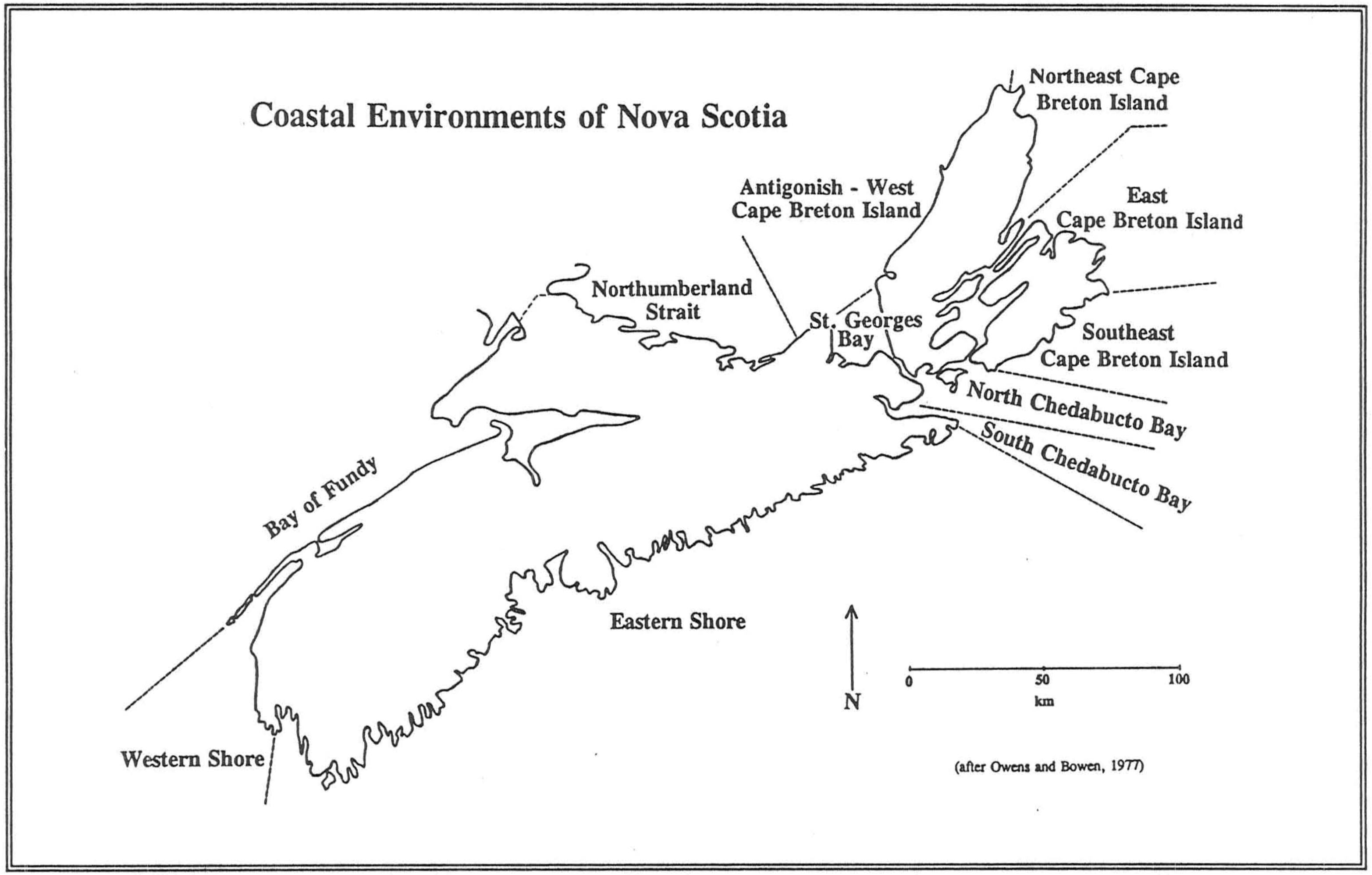


Figure 3.1. The coastal environments of Nova Scotia as defined by Owens and Bowen, 1977.

3.2 Glacial History

Nova Scotia was most recently glaciated during the Wisconsinan glaciation, during which ice moved across the province in at least three directions, towards the east, the northeast and the south (Wang and Piper, 1982; Grant, 1989). Ice advance reached its maximum between 32,000 and 12,000 years before present, and most of the province was ice free by 12,000 to 10,000 years ago (Boyd et al., 1983; Grant, 1989). Glacial action stripped the region of any weathered material and removed large quantities of solid rock, in many cases carving out deep valleys and producing arched, elongated structures lying parallel to the strike of the bedrock. Much of the surficial geomorphology of Nova Scotia reflects the underlying glaciated surface.

Glacial till is the dominant surficial material of the province, locally reaching depths of 100 m in lowlands, although deposits are often thin and discontinuous (Grant, 1989). The main glacial deposit of Nova Scotia, which overlies an earlier grey coloured till, is a distinctive till with a fine, red, clayey matrix. It is found all along the Atlantic shore, where it forms several large drumlin fields. Overlying the red till and occupying the areas between the drumlins are tills that tend to be grey in colour and are of a sandy-silty texture. Following the deposition of this grey till an ice-free interval may have occurred, as is suggested by subaerial weathering of the till surface and local proglacial fluvial deposits of the Yarmouth area. The most recent till deposits tend to be thin, discontinuous, and of varying textures. Glaciofluvial deposits, limited to major outwash channels, are of minor importance in Nova Scotia. The depth, distribution and texture of glacial deposits, particularly drumlins, are extremely important in the coastal area where they are often the only current source of new sediment (Fig. 3.2).

3.3 Sediment Availability

One of the major controlling factors of beach and sand dune development along the coast of Nova Scotia is the availability of sediment, which is often very localized (Fig. 3.3). Bowen et al. (1975) identified four possible sources of beach sediment; onshore deposits, nearshore sediments, reworked beach and dune sediments, and fluvial sediments.

3.3.1 Onshore Sediment Sources

The quantity of onshore sediment available to the littoral zone, and from there to the beaches and dunes, depends on the thickness of glacial deposits along the shore and the rate of erosion. Glacial materials vary in thickness from drumlins tens of metres in height, till veneers less than 1 m thick, to discontinuous deposits overlying bedrock. Coastal drumlins are found in northern Queens county and the adjacent area of Lunenburg county, along the coast east

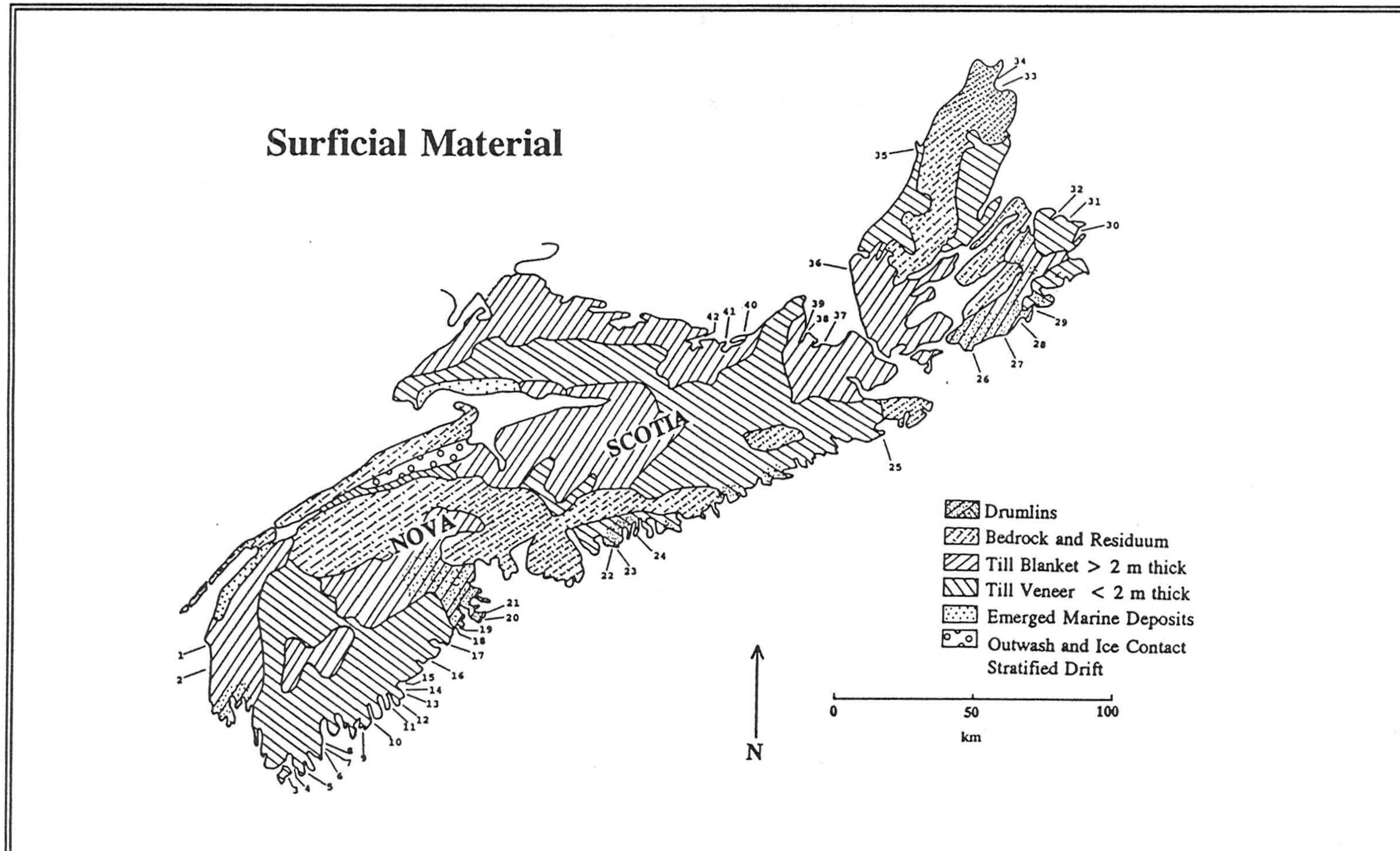


Figure 3.2. Glacial deposits cover most of Nova Scotia, and are an important sediment source, especially in areas with drumlins (after Grant, 1989).

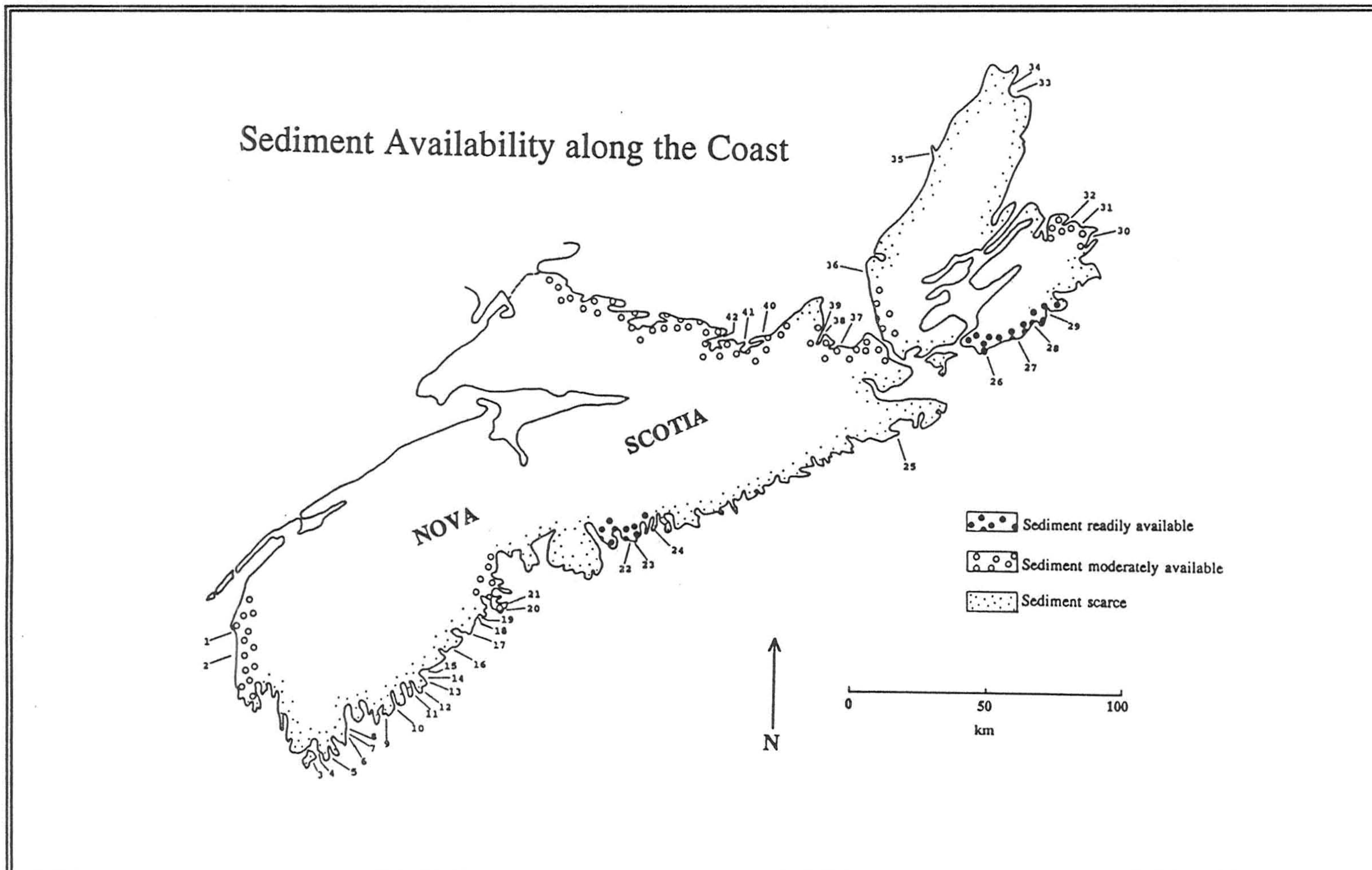


Figure 3.3. Estimated sediment availability along the coast of Nova Scotia.

of Halifax, and in the southeastern portion of Cape Breton Island (see Fig.3.2).

Studies of erosion in unconsolidated bluff material have been made at sites on all shores of the province, including those of the Bay of Fundy (Bowen et al., 1975; Taylor et al., 1985; Shaw et al., in review). Typical bluff retreat rates between 1980 and 1991 were 0.2 to 0.4 m/a, with a greater rate of 0.6 m/a at more exposed sites (Shaw et al., in review). Bowen et al. (1975) found average cliff erosion rates of 0.25 m/a in unresistant bedrock. The amount of sand-sized material released by the retreat of coastal bluffs can be quite substantial given the rapid rates of erosion and the quantity of sand contained in the till. Drumlins along the shore east of Halifax consist of up to 15 % coarse pebble to boulders, 35 to 65 % finer gravel and sand, 21 to 50 % silt, and 5 to 30 % clay (Sonnichsen, 1984 as in Carter et al., 1990). The rate of sediment supply to the nearshore zone from erosion of glacial deposits is cyclic as consecutive drumlins attain the seaward position and are subsequently eroded as the coastline moves landward. With the average length of a drumlin being 1 km, its life expectancy and that of adjacent beaches may range from several hundred to several thousand years depending on the rate of sea level rise and the consequent erosion (Carter et al., 1990).

3.3.2 Nearshore Sediment Sources

Very little is known about the sediments in the nearshore zone of Nova

Scotia. Sediment distribution has been mapped for the Scotian Shelf, however surveys rarely extended into waters less than 40 m in depth. Krank (1971) mapped the surficial geology of the Northumberland Strait, but was usually limited to a depth greater than 10 m offshore, at which point even storm waves are not efficient at moving sediment (Bowen et al., 1975). Other studies of offshore sediments in St. Mary's Bay and off northeastern Cape Breton Island have also been restricted to deep waters (ie. Miller and Fader, 1988). Hall (1985) surveyed the nearshore zone just northeast of Halifax and found sand deposits immediately adjacent to every major sandy beach, extending to a depth of at least 10 m. Sand also exists off the barriers in Aspy Bay (Taylor et al., 1991). Most of the nearshore coastline between these beaches appears to be dominated by a gravel or a sand-gravel substrate. These offshore sand deposits may be the result of beach material being abandoned on the nearshore slope as the coastline moves landward under the pressure of rising sea level (Forbes et al., 1990). However, Boyd et al. (1983) found little evidence of extensive sand bodies in the location of former barriers, suggesting that much of the sand keeps pace with beach transgression. If offshore sand deposits do exist, they may still be available for beach and dune formation if they can be transported back onto shore. Waves and tidal currents will move sand into tidal inlets where it may accumulate and eventually be reworked into sand dunes, as is currently happening in Chezzetcook Inlet.

3.3.3 Reworked Beach and Dune Sediment

A third potential source of sediment is reworked sand from degraded beach and dune systems. Ongoing coastal erosion is forcing beaches to migrate landward, releasing sediment from the seaward slope to be re-incorporated at a new landward position. Beach material removed by wave attack may also be transported along shore, enhancing the elongation of spits and barriers, or may be carried into lagoons by tidal currents where it can be reutilized as the barrier migrates landward over back-barrier deposits. On some beaches south of Halifax, large relict sand dunes are being cannibalized by smaller modern dune systems. This is most common along the coast south of Halifax where there are few alternative sources of sediment.

3.3.4 Fluvial Sediment Sources

Very little sediment is supplied to the littoral zone of Nova Scotia by rivers (Bowen et al., 1975; Wang and Piper, 1982). Although sand-sized sediment would be primarily transported as bedload which is seldom measured, studies of suspended load suggest a denudation rate of only 0.7 cm in 1000 years for the mainland of the province (Bowen et al., 1975). Drainage basins in Nova Scotia are small and the coastal relief is typically low, so any sand-sized material is likely to be deposited in the lower reaches of the river or in the estuarine areas before reaching the open coast, as is suggested by the lack of large deltaic deposits.

3.4 Relative Sea Level Rise

Relative sea level has been changing throughout Atlantic Canada since deglaciation. The northern regions have experienced continuous emergence, while the central areas were subjected to early emergence followed by submergence, and the outer regions, including Nova Scotia, may have undergone a period of initial emergence which was exceeded by later submergence (Grant, 1989) (Fig. 3.4). The submergence of the coast of Nova Scotia can be explained primarily by isostatic depression of the crust under the weight of eustatically increasing water depth over the continental shelf. Other factors include crustal downwarping associated with relaxation of a glacial margin forebulge, and an increase in tidal range (Grant, 1970). Evidence of rising sea level includes tidal gauge records, continuous upward growth of salt marshes, exposure of marsh deposits and tree stumps below the present level of high tide, and archaeological finds from early European settlements and native encampments (Grant, 1970; Bowen et al., 1975; Carter et al., 1990).

Carter et al. (1989) propose that it is the rate of relative sea level rise rather than the magnitude that determines the evolution of the coastal zone. The greatest rate of submergence, 1.1 cm/a occurred about 7500 years ago. Over the

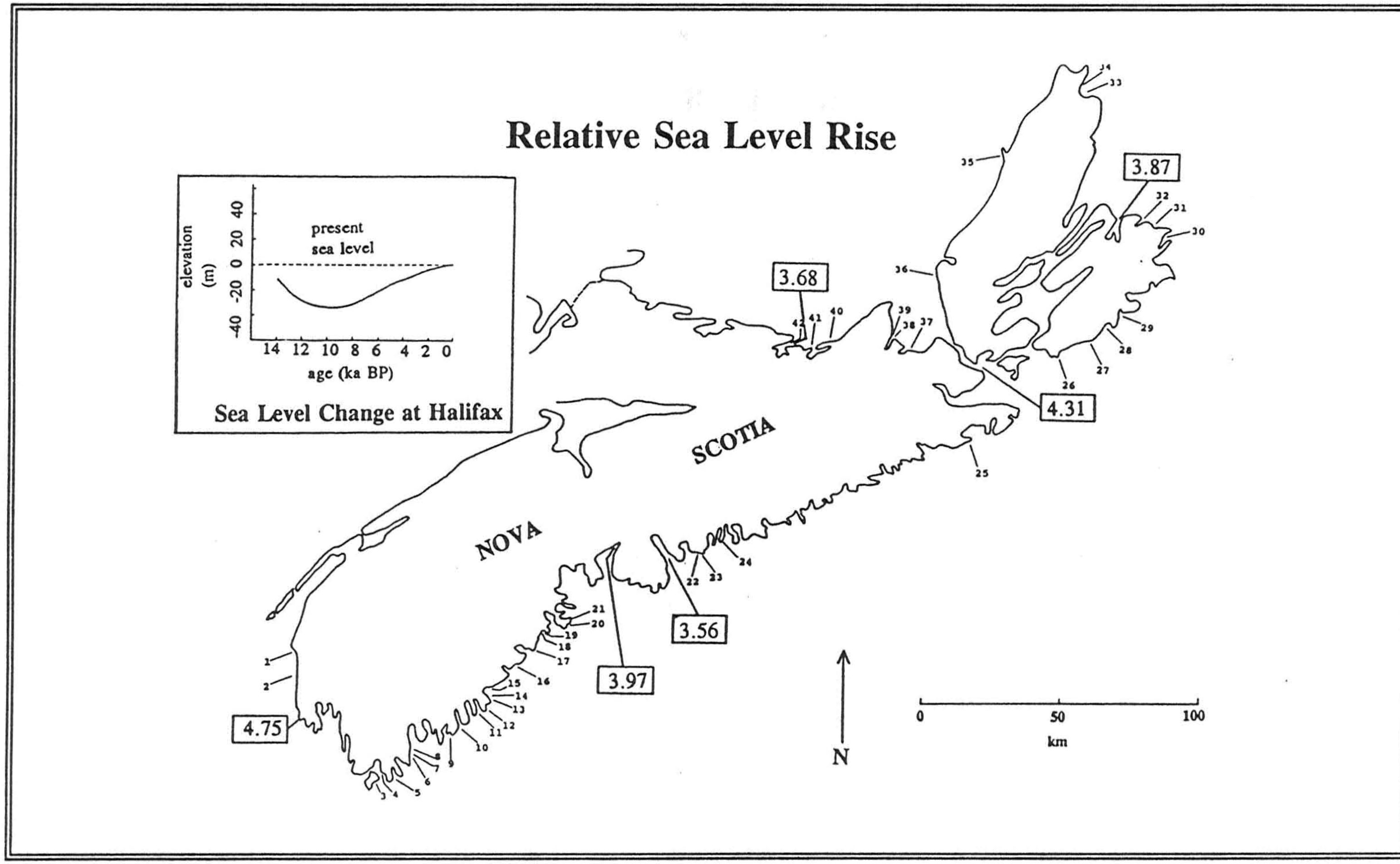


Figure 3.4. Rates of Relative Sea Level Rise (mm/a) derived from tidal records (Shaw et al., in review) and sea level change since the last glaciation at Halifax (Grant, 1989).

last 5000 years the average rate of sea level rise has been 0.2-0.3 cm/a (Grant, 1970; Carter et al., 1990; Shaw et al., in review). The impact of this rapidly rising sea level on the coastline has been continuous erosion and consequent landward migration. Bowen et al. (1975) estimated that the rate of retreat of an exposed beach would be 0.6-1.6 m/a with a sea level rise of 0.4 cm/a.

The overall result of sea level rise during the early to mid Holocene was the submergence of the coastal area, creating inlets and headlands, and, in some areas, drumlin islands. Subsequent sea level rise caused further marine erosion, which released sediment enabling the formation of barriers and spits, many of which remain today (Wang and Piper, 1982; Shaw et al., in review). The final stage in coastal development under a rising sea level would be a shoreline of exposed bedrock, stripped of all surficial material. Although this final stage has been reached on some sections of the coast, the process of shore erosion and landward retreat is generally cyclical, as demonstrated by the development model for drumlin associated barriers proposed by Boyd et al. (1983) (Fig. 3.5). The model consists of six stages, 1) glaciation, 2) sea level rise and estuary formation, 3) barrier genesis and progradation, 4) barrier retreat, 5) barrier destruction and 6) barrier re-establishment, with stages three to six repeating themselves.

3.5 Tidal Regime

Mean tidal range around Nova Scotia varies from microtidal (less than 2

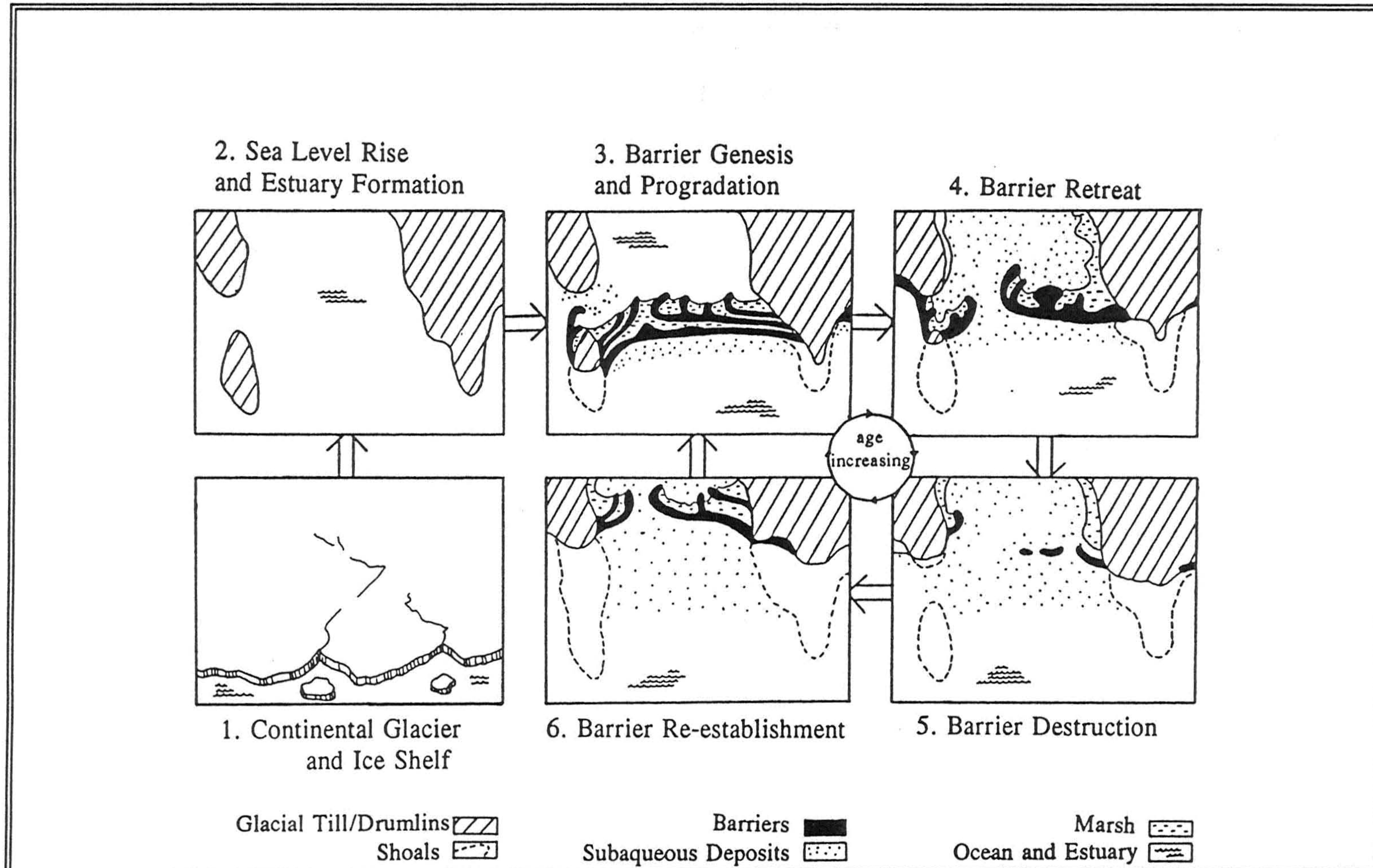


Figure 3.5. Cyclic model of drumlin associated barrier development in areas of rising sea level (Boyd et al., 1983).

m) along the coast of Cape Breton Island and the Northumberland Strait area, to mesotidal (2 to 4 m) along the Atlantic coast south of the Strait of Canso, to macrotidal (greater than 4 m) in the Yarmouth region, St. Mary's Bay and the Bay of Fundy (Canadian Tide and Current Tables, 1991) (Fig. 3.6).

3.6 Climate

Other than wind, climate influences sand dunes primarily by restricting the growing season, by reducing sand movement due to damp or frozen surface sand, and by reducing wave action as the result of sea ice formation, which can also result in scouring along the base of the dune ramp. The mean annual temperature for most of Nova Scotia is between 5 and 7°C, with the mean daily temperature falling below freezing between late November and early April. The southern parts of the province experience freezing temperatures for approximately 80 days of the year, while the more northern regions have winter conditions for 120 days (Simmons et al., 1984). Measurable precipitation occurs on average 152 to 179 days a year, with the mean total annual precipitation varying from 1250 mm along the Northumberland Strait to over 1500 mm along the southern shore. Coastal fog is experienced approximately 15 to 25 % of the year, most frequently in July, and most often along the southwestern tip of the province (Simmons et al., 1984). Sea ice conditions are mentioned in the next section.

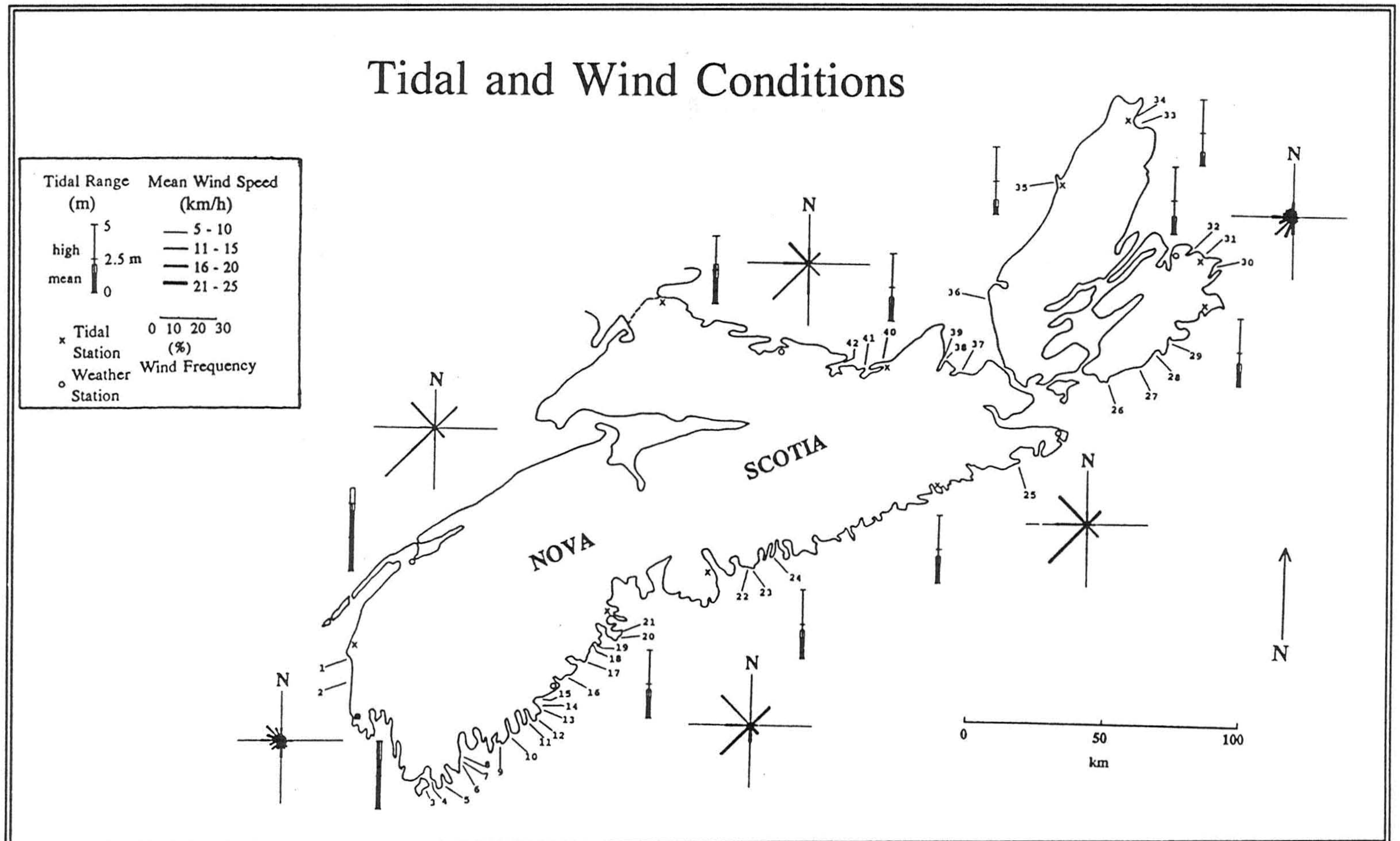


Figure 3.6. Tidal range and wind climate (length depicts frequency and width represents frequency). (Canadian Tide and Current Tables, 1991; Canadian Climatic Normals: Wind, 1982).

3.7 Wind and Wave Climate

The coast of Nova Scotia can be divided into three general regions of wave energy according to their level of exposure and the length of the fetch: the Gulf of St. Lawrence, the Atlantic coast, and the Bay of Fundy (Owens and Bowen, 1977). Figure 3.6 provides wind roses for various regions of the province. The greatest storm activity, with the strongest winds and largest waves tends to occur during the winter months.

The sheltered Gulf of St. Lawrence, including the Northumberland Strait, St. Georges Bay and the western shore of Cape Breton Island, has a limited fetch, the longest being 200 km to the north from St. Georges Bay and western Cape Breton. The strongest winds in this region tend to come from the northwest, producing waves which effect the western shore of Cape Breton Island and St. Georges Bay, and creating longshore transport to the south or southwest. The Northumberland Strait shoreline is protected from northwesterly winds by Prince Edward Island, but is subject to the prevailing winds from the southwest, creating longshore drift to the east. Wave activity in the southern Gulf of St. Lawrence is locally developed, and may be limited by ice formation between December and April (Owens and Bowen, 1977).

The second region is the exposed, high wave energy Atlantic coast, from northern Cape Breton Island to Cape Sable Island. Wave energy along this coast is seasonally variable, with the highest winds and waves occurring during the winter when significant wave heights of more than 4 m are common (Owens and Bowen, 1977; Wang and Piper, 1982; Carter et al., 1990). Due to the shoreline orientation, the coast is sheltered from strong winds from the north and west, and consequently the southwesterly winds and associated waves have the greatest impact. The highly indented nature of the coast affords varying degrees of shelter, allowing low wave energy environments to exist in the lee of headlands, islands and shoals (Munroe, 1982). Longshore transport is variable, since the complex structure of the coastline has resulted in each embayment acting as a separate cell. Tropical hurricanes may hit the Atlantic coast during the late summer and early autumn, with wind speeds in excess of 180 km/hr. Ten such storms passed across Cape Breton Island between 1871 and 1977 (Wang and Piper, 1982). Ice is typically not a factor on the exposed coast, however it may occur in sheltered areas from three to four months of the year (Owens and Bowen, 1977).

The western shore, from Yarmouth to the head of St. Mary's Bay, was classified as part of the Atlantic region by Owens and Bowen (1977), but it is protected from direct attack by Atlantic waves and is only vulnerable to waves refracted into the eastern Gulf of Main. Ice may form in sheltered areas up to two months of the year. The third general region of Nova Scotia is that of the Bay of Fundy, however, since no sand dunes exist in this area it need not be discussed.

CHAPTER 4

SAND DUNE DESCRIPTION: SOUTHERN NOVA SCOTIA

4.1 Introduction

The sand dunes of Nova Scotia may be placed into five regional groups; the Western Shore, the Atlantic Shore, East Cape Breton Island, Northeast Cape Breton Island, and the Northern Shore (Fig. 4.1). The sand dunes were grouped according to their profile normal to shore, the geomorphology of the system, and the sediment of the dunes and associated beaches (Fig. 4.2). The dunes on the Western Shore are the highest in the province, consist of many parallel ridges and occur on bay head barriers. The Atlantic Shore dunes are much smaller than those of the Western Shore, and tend to have a single high foredune ridge, backed by lower dunes. These dunes occur on barriers, tombolos, or behind beaches. The sand dunes of East Cape Breton Island are characterized by multiple ridges averaging just over 2 m above the high water line, and their location on mid-bay barriers. The Northeast Cape Breton sand dunes typically consist of a low ridge subject to washover, and are found on bay mouth barriers. The sand dunes of the Northern Shore are high, having an average elevation of 3.2 m above the high

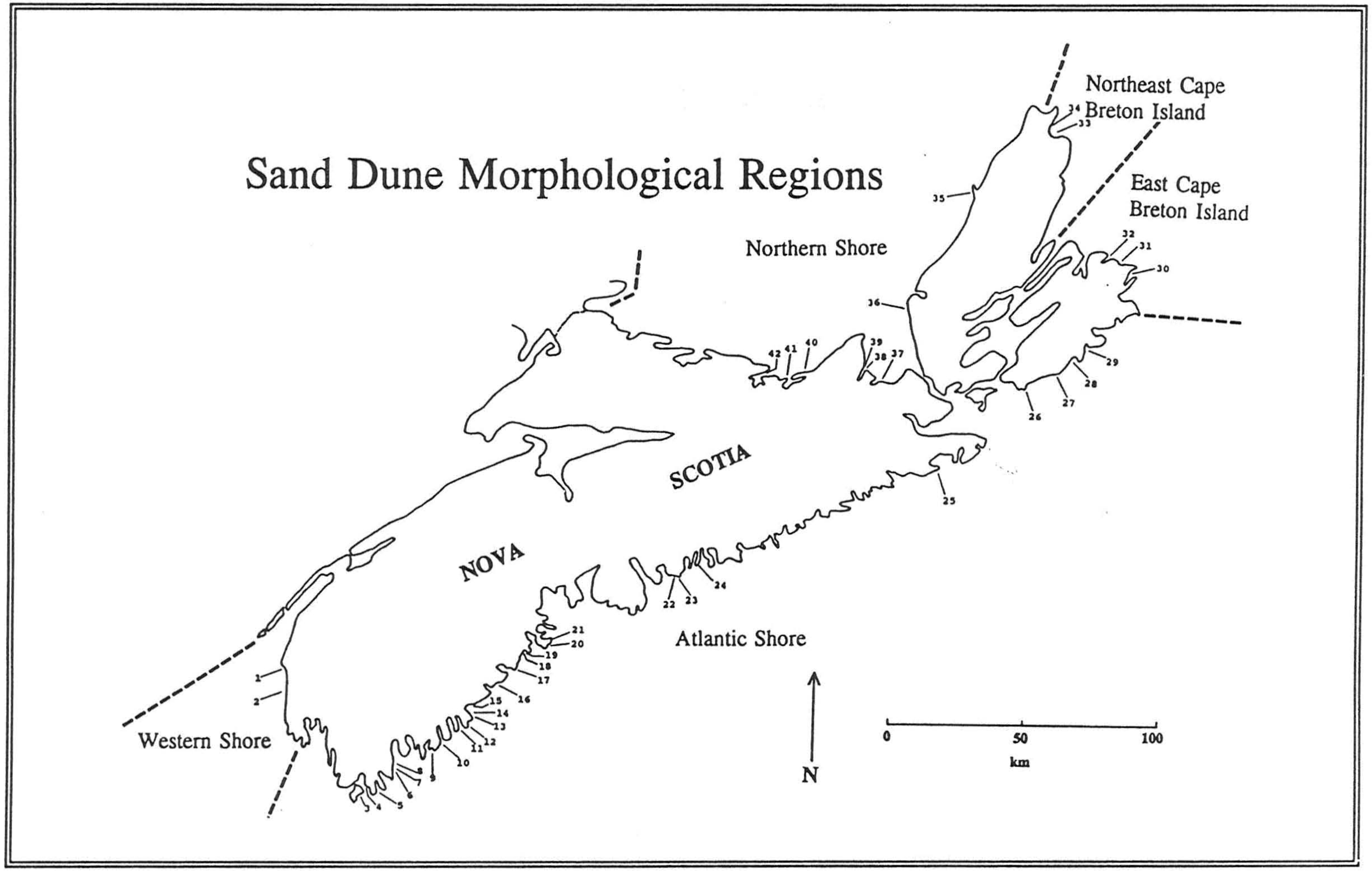


Figure 4.1. Sand dune regions of Nova Scotia based on morphology.

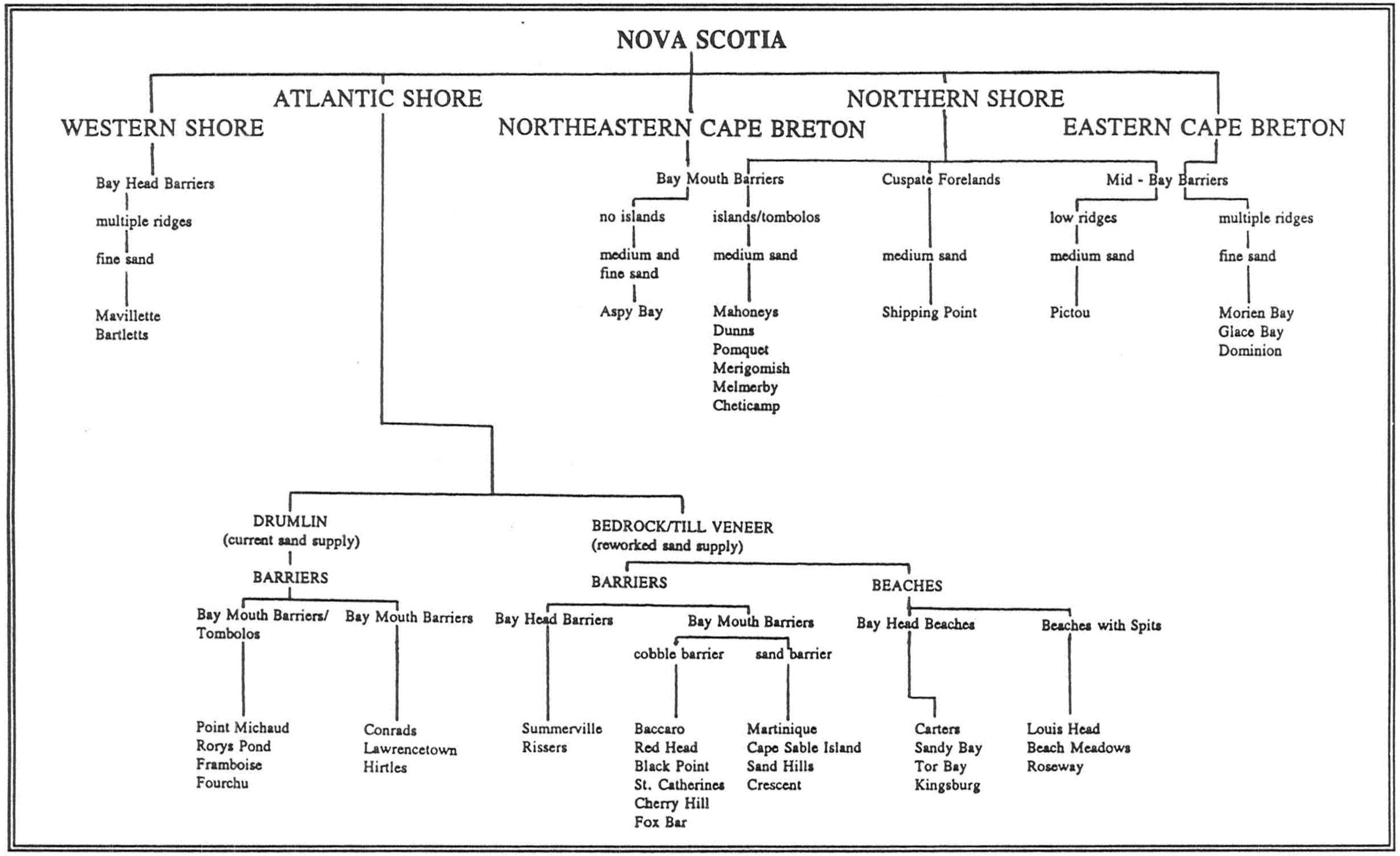


Figure 4.2. Regional groups of sand dune systems based on morphology and sediment.

water line, and most often occur as bay mouth barriers attached to islands at somepoint along their length. The height, width and length of the sand dune systems greater than 1 km in length are provided in table 1.2. The mean grain sizes for each beach-dune system are listed in table 4.1. The Western Shore, Atlantic Shore and East Cape Breton Island dunes typically consist of fine grained sand, while those of Northeast Cape Breton Island and the Northern Shore are primarily medium grained sand. The sand dunes and beaches of the southeastern area of Cape Breton Island, part of the Atlantic Shore classification, are usually coarse grained sand.

The environment of the five regions along with the sediments of each region and the morphology of the dune systems will be discussed in chapters 4 and 5 in an anti-clockwise direction starting with the Western Shore. The present condition of the sand dunes is also considered, along with human disturbance of the dunes. Some of this information is based on the views of local residents, and is included as such, although it was never substantiated. The Western Shore and the Atlantic Shore are examined in chapter 4, while the northern portions of the province, East Cape Breton Island, Northeast Cape Breton Island and the Northern Shore are discussed in chapter 5. A conclusion for both chapters 4 and 5 is located at the end of chapter 5.

Beach	Coarse Sand (0 - 0.99 phi)				Medium Sand (1 - 1.99 phi)				Fine Sand (2 - 2.99 phi)			
	fore shore	back shore	ramp	crest	fore shore	back shore	ramp	crest	fore shore	back shore	ramp	crest
Mavillette		0.97										2.25
Bartletts										2.10	2.17	
South Side									2.49	2.42	2.28	2.08
Clam Point									2.35	2.65	2.43	2.08
Sand Hills 1					1.40					2.15		2.04
Sand Hills 2										2.03		2.25
Baccaro						1.85			2.51		2.01	2.29
Red Head									2.13	2.28	2.40	2.39
Roseway									2.38	2.49	2.71	2.72
Black Point									2.67	2.66	2.69	2.62
Louis Head										2.23	2.64	
Sandy Bay									2.27	2.42	2.08	2.59
St.Catherines					1.86	1.78					2.24	2.02
Carters									2.42	2.48	2.44	2.97
Summerville												
Beach Meadows												
Cherry Hill												

Rissers												
Crescent												
Hirtles												
Kingsburg												
Conrads												
Conrads 1												
Lawrencetown												
Martinique												
Tor Bay												
Point Michaud 1	0.26	0.23	0.64	0.90								
Point Michaud 2									2.11	2.40	2.68	2.65
Rorys Pond [1]	0.56		0.31									
Framboise [2]		0.71	0.75	0.56								
Fourchu [3]		0.36	0.18									
Morien Bay [4]								1.78		2.35	2.27	
Glace Bay 2									2.39	2.40	2.26	2.18
Dominion						1.59			2.45			2.04
South Pond Aspy Bay 1						1.12	1.34	1.75	2.01			
South Pond Aspy Bay 2						1.23	1.37	1.47	2.13			
North Pond Aspy Bay 1						1.24	1.30	1.11	2.21			

North Pond Aspy Bay 2		0.94					1.05	1.22	2.10			
Cheticamp		0.96			1.35					2.27	2.35	
Shipping Point 1	0.99					1.58	1.66	1.70				
Shipping Point 2					1.23	1.54	1.81	1.84				
Pomquet					1.95	1.45	1.68	1.70				
Dunns [5]								1.67				
Mahoneys	0.54											
Merigomish	0.36					1.20	1.41	1.58				
Melmerby					1.92	1.81	1.75	1.72				
Pictou (south)	0.15					1.82	1.97	1.56				

[1] Rorys Pond — backshore -1.47 (granules); crest -0.17 (very coarse sand)
[2] Framboise — foreshore -0.63 (very coarse sand)
[3] Fourchu — backshore -0.81 (very coarse sand)
[4] Morien Bay — foreshore -1.77 (granules)
[5] Dunns — foreshore -2.27 (pebbles); backshore -0.02 (very coarse sand); ramp -0.44 (very coarse sand)

Table 4.1. Sediment sizes at four locations on the beach-dune systems. Note that those of the Western Shore and the Atlantic Shore tend to be fine grained, with the exception of those of southeastern Cape Breton Island. Other areas are generally medium grained.

4.2 Western Shore

The Western Shore is located at the very southeastern end of the Bay ofFundy, in St. Mary's Bay. Sand dunes greater than 1 km in length are found on bay head barriers at Mavillette and Bartletts on the western side of St. Mary's Bay (Fig. 4.3). The western coastline is primarily resistant Cambrian and Ordovician rock overlain by till and post glacial fluvial outwash, which provide most of the littoral sediment. Raised beach deposits, laid down during an interglacial, may be another source of sand (Stea et al., 1992). The northeastern shore of St. Mary's Bay is formed by a Triassic basalt dyke and has little sediment along the shore. St. Mary's Bay is sheltered from direct wave attack from the open Atlantic, but is exposed to waves from the Gulf of Maine, which produce a strong longshore current to the northeast (Owens and Bowen, 1977). The western Shore has the greatest tidal range, over 4 m, of any area in Nova Scotia with sand dunes.

4.2.1 Sediment

Sand dune systems on the Western Shore form to the south of resistant bedrock outcrops, which effectively trap sediment that is being moved northward by the longshore current. Most of the sediment in the area is derived from the erosion of till bluffs at a rate of 0.3 m/a (Shaw et al., in review), or fine offshore

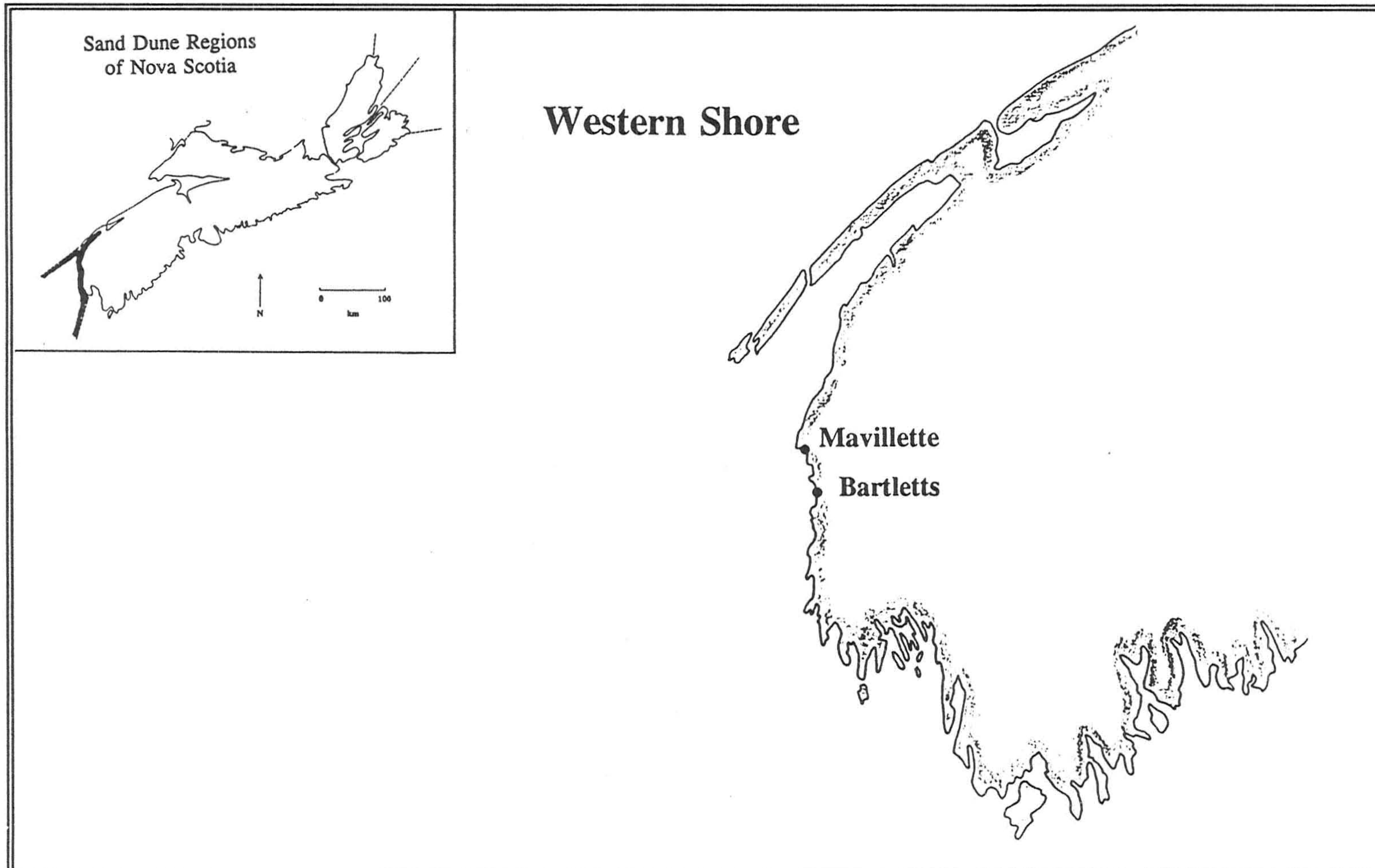
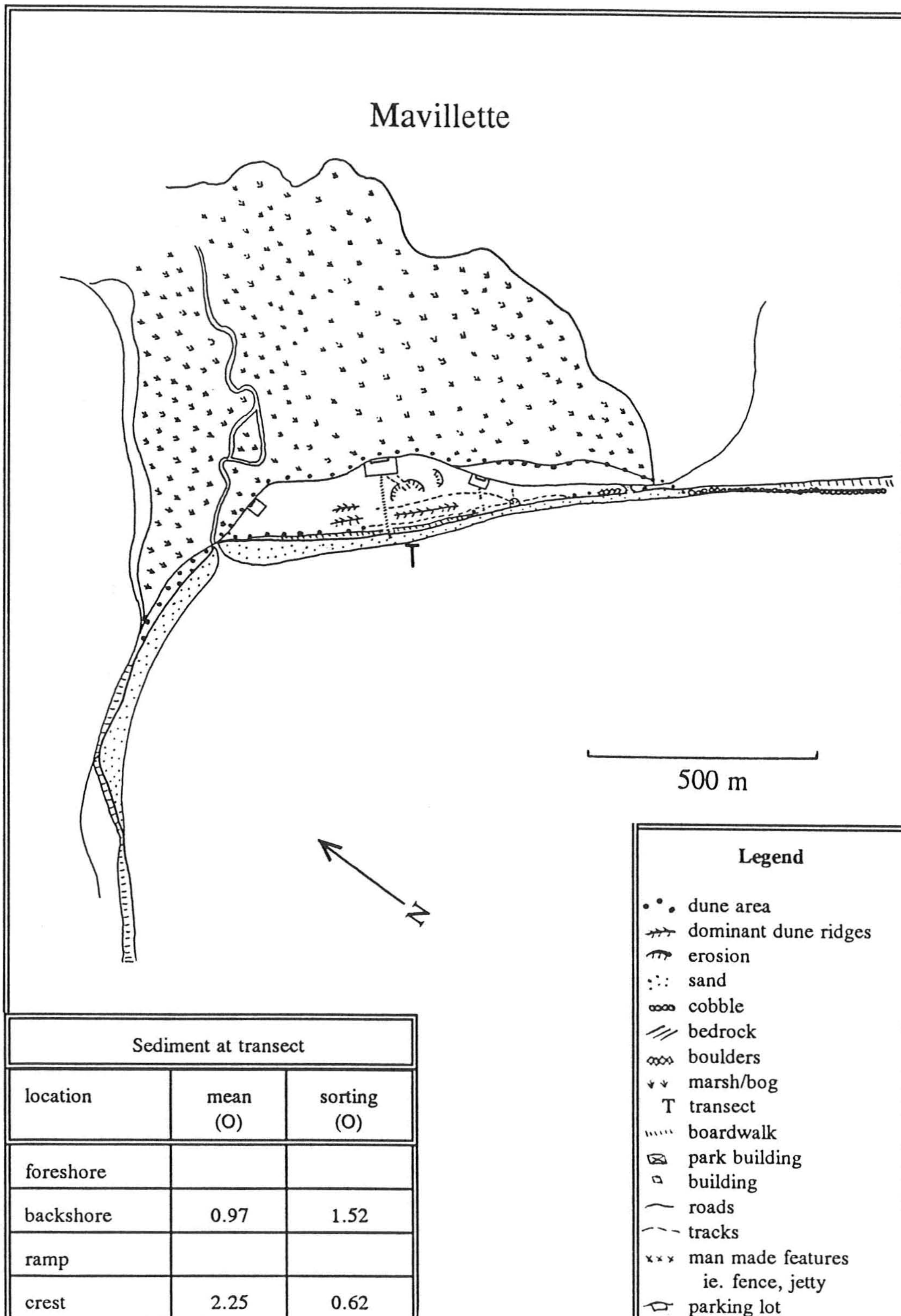


Figure 4.3. Sand dunes of the Western Shore.

sand deposits (Bowen et al., 1975). The beach material is bimodal, with a band of shingle the length of Bartletts beach and along the southern half of Mavillette beach. The sand portion of the beach at Mavillette is coarse sand, while that onBartletts was fine grained.

4.2.2 Sand Dunes

The sand dunes at Mavillette beach and at Bartletts beach represent some of the largest accumulations of sand in the province with heights of over 5 m, and widths of greater than 200 m (Fig 4.4 and 4.5). They both have up to five dune ridges at their widest point, near the centre of the beach, with fewer, lower ridges to the north and south (Fig. 4.6). Unlike the dunes of the North Shore, which also have multiple ridges, the dominant ridge tends to be toward the back of the Western Shore systems. Mavillette and Bartletts were formed as bay head barriers across lagoons. At Mavillette, however, the lagoon is nearly completely filled with marsh vegetation, and only a creek remains (Bowen et al., 1975). According to a local resident, the lagoon at Bartletts was once reclaimed fields with a creek, and that within the last thirty years a road ran across the lagoon on a causeway to a house on the northwestern shore. Bowen et al. (1975) observed an old control structure in the tidal inlet, which was probably used to restrict tidal entrance and to control water level in the lagoon. The location of the inlet at Bartletts may have influenced the development of the dunes since the largest dunes occur immediately north of the inlet, not towards the northern end of the beach, as would be expected given the northward direction of the regional longshore transport (Bowen et al., 1975). The northern end of the beach, however, is more exposed to wave attack from the south, since it is beyond the shelter provided by Burns Point to the south, possibly creating local currents which focus sediment in the centre of the beach. The highest dunes and the greatest number of ridges also occur at the centre of Mavillette beach. Bowen et al. (1975) determined that the oldest dune ridge at Mavillette formed as a spit, which swung to a more westerly position as the cliffs were eroded back and the system adjusted as exposure to wave attack from the southwest increased. The northern half of the beach is still actively building, while the southern end is retreating (Bowen et al., 1975; Taylor et al., 1985). However, storms during the winter of 1990 - 1991, severely eroded the ramp the full length of the beach, leaving a scarp over 1.5 m in height. No new deposition was observed in June, but sand may have accumulated over the summer. Large scale erosion was not observed at Bartletts, with the exception of a large hole in the back of the foredune ridge, most likely the result of human activity, and the oversteepening of the most southern edge of the high dunes where they are being cut by the tidal channel. The worst erosion is at Mavillette, where numerous foot paths and vehicle tracks have resulted in large unvegetated areas in the middle of the highest dunes. Sand movement in this area has resulted in a complex pattern of hills formed out of the original dune ridges.



Sediment at transect		
location	mean (O)	sorting (O)
foreshore		
backshore	0.97	1.52
ramp		
crest	2.25	0.62

Figure 4.4. Mavillette dune system.

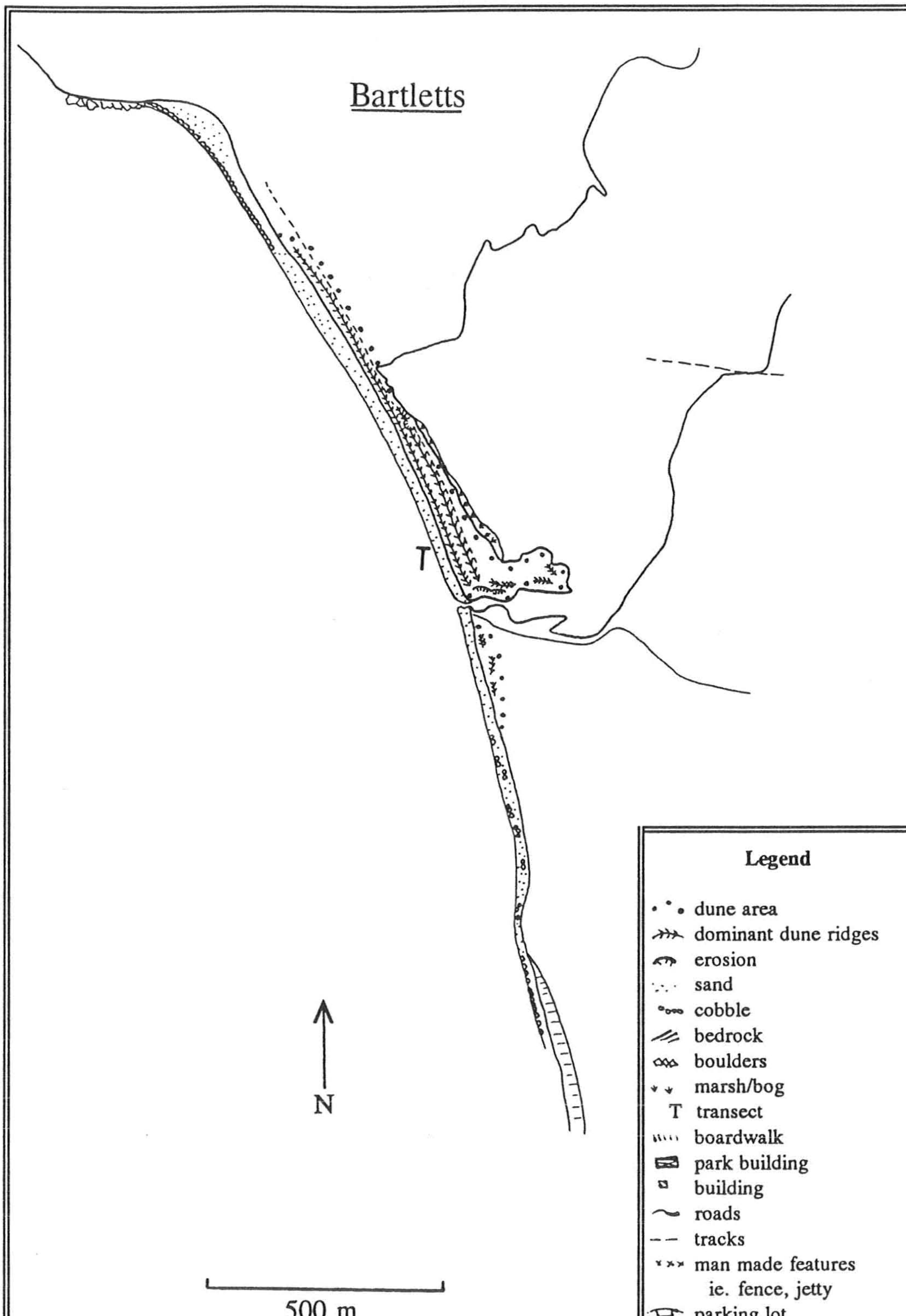
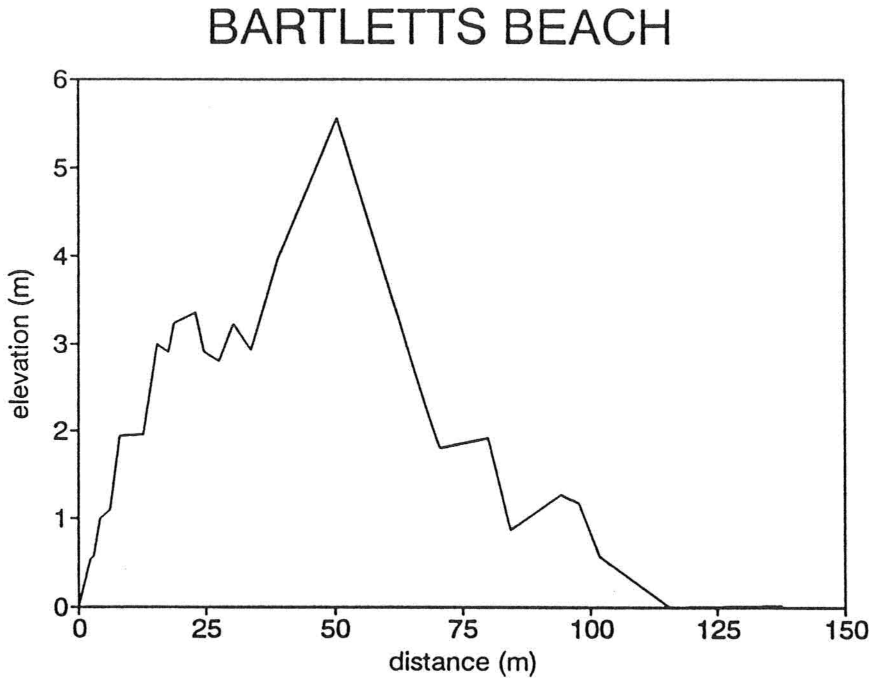


Figure 4.5. Bartletts dune system: map, profile and sediment sizes.



Bartletts

Sediment at transect		
location	mean (O)	sorting (O)
foreshore		
backshore	2.10	0.42
ramp	2.17	0.35
crest		

4.2.3 Dune Condition

As previously mentioned, the high dunes at Mavillette, a Provincial Park, have been seriously damaged by human activity. Despite beach access boardwalks existing at each of the three parking areas, people still walk across the dunes and trails are visible in all areas of the dunes, some cutting several decimeters deep into the dune ridges. The most severe damage is to the high dunes to the southeast of the central boardwalk, where large blowouts have developed, creating favoured party sites (Fig. 4.7). Mavillette has a long history of misuse. The inland areas of the older dunes were once mowed for hay and sand has been removed for local use for a long time. The most devastating user, however, was the Canadian Armed Forces, who used it as a training site and are most likely responsible for the many tracks still visible on the dunes (Bowen et al., 1975). The area has been a Provincial Park for over two decades, and although vehicle access to the dunes has been limited, pedestrian use is still causing damage and preventing revegetation in certain areas. However, the scenario is much better than that observed by Bowen et al. (1975), who saw cars parked on the outer dune ridge, tents and trailers scattered across the system, and described Mavillette as the dirtiest of all the beaches they studied.

The dunes at Bartletts beach, on the other hand, are not easily accessed by vehicles, and most people seem to stay on the beach. Sand and gravel removal has occurred for a long time, and is the most likely cause of the large hole

Figure 4.6. Parallel ridges at Mavillette, with a beach access boardwalk.

Figure 4.7. Large eroded area at Mavillette. Note people playing ball.

previously described in the back of the foredune ridge. Commercial aggregate removal continued until 1967, with approximately 2000 tons/a being removed from the beach during the 1950s and early 1960s (Bowen et al., 1975). Bartletts was given protected status in June, 1972.

4.3 The Atlantic Shore

Sand dune systems greater than 1 km in length occur at twenty-seven locations along the Atlantic Shore (Fig 4.8). These can be grouped into several categories, as will be discussed in section 4.3.2.

The Atlantic Shore of Nova Scotia, which follows the southwest - northeast structural trend of the Appalachian system has a highly indented coastline with numerous islands, the result of post glacial sea level rise drowning lowlands. The coast consists of resistant bedrock, primarily Ordovician and Cambrian meta-sedimentary rocks of the Meguma Group on the mainland and Precambrian rock of the Fourchu Group on Cape Breton Island, with outcrops of igneous rock. This is overlain by glacial till, which varies in depth from less than 1 m to drumlins with relief of greater than 20 m. Drumlin fields exist in several areas of Nova Scotia, with drumlins occurring on the Atlantic Shore in the Lunenburg area, between Halifax Harbour and Petpeswick Inlet, and on the southeastern part of Cape Breton Island (see Fig. 3.2). The whole shoreline is exposed to waves from the Atlantic, resulting in a high energy environment along the outer coast, while the numerous embayments and the many islands and shoals provide

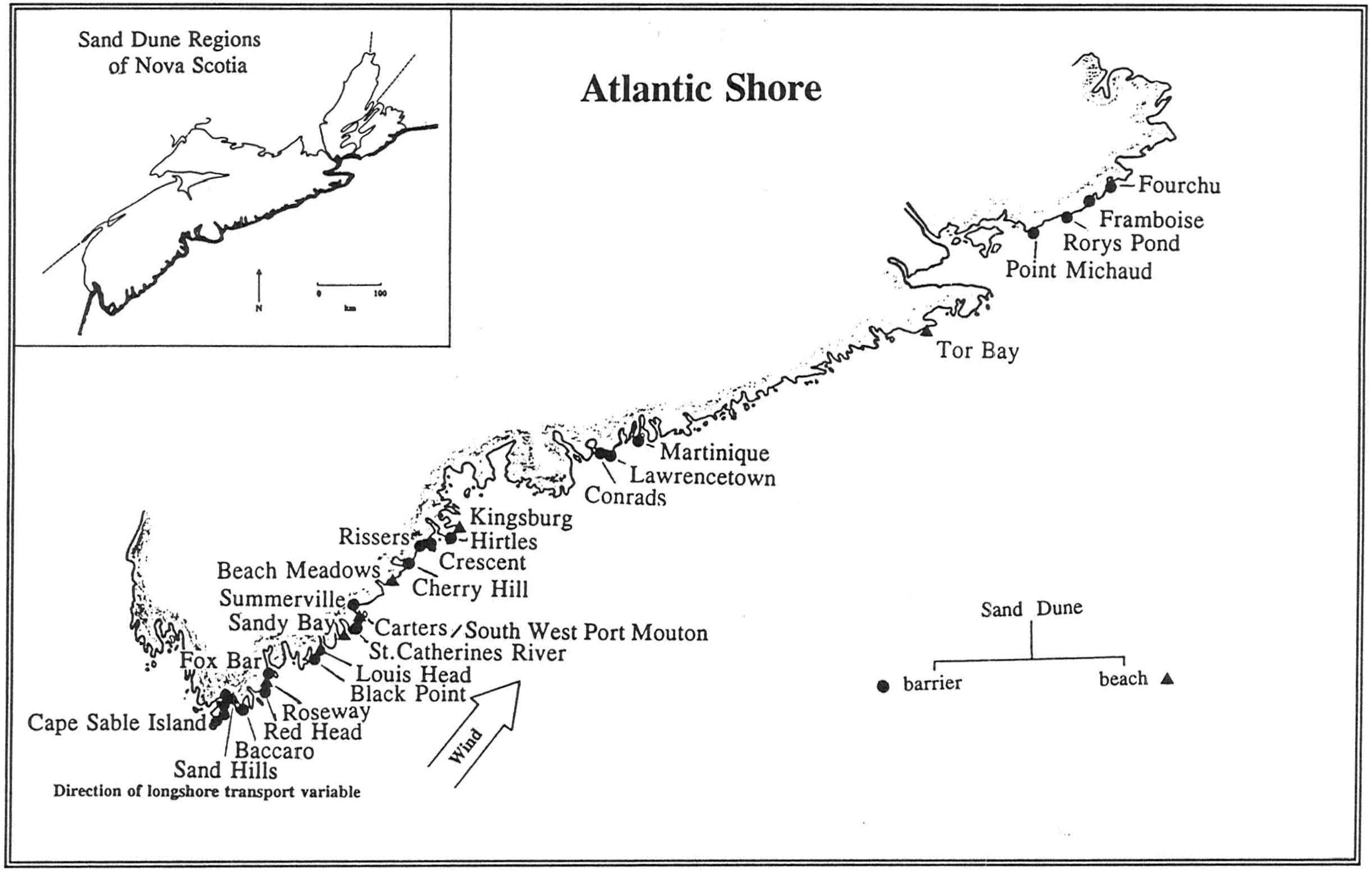


Figure 4.8. Sand dunes of the Atlantic Shore.

sheltered areas of lower energy. Most of the storms along this coast result from the passage of mid-latitude cyclonic depressions, although the area may also be affected by tropical hurricanes.

4.3.1 Sediment

Sediment is scarce in the littoral zone of Atlantic Nova Scotia, with the only large sand accumulations being in areas of actively eroding drumlins. Any other sand deposits along this coast are old beach sediments, believed to have been originally supplied by postglacial rivers or other offshore glacial deposits, which have been reworked and moved landwards with rising sea level (Munroe, 1982). Sediment of this type tends to be well sorted, fine grained, white sand, from which all the less resistant components have been removed (Bowen et al., 1975). Often large quantities of sand are stored in the areas behind the barriers as either salt mash deposits or sand flats. The sediment, deposited in these areas by tidal currents, washovers or aeolian transport of eroding dune material, may be reincorporated into the sand dunes as the whole system moves landward, reworking back-barrier deposits. In areas of frequent offshore winds, sand may be blown seaward and deposited on the "lee" slopes of the dunes. Embryo dunes may also form on the surface of the salt marsh or the sand flats, as was observed at Chezzetcook Inlet.

Those beaches with a modern sediment supply derived from the till bluffs of eroding drumlins tend to have a reddy-brown colour, reflecting their source, and are also fine grained and well sorted, suggesting that this high energy environment quickly mobilizes and sorts any new material. Bluffs along the Atlantic Shore are eroding at an average rate of 1 m/a (Shaw et al., in review). The major exception to fine grained beaches and dunes associated with drumlins is that of Southeastern Cape Breton Island, where the beach and dune material consist of coarse sand.

Many of the beaches in this area have a bimodal sediment distribution, resulting from storm activity, with cobble sized material armouring the upper beach and the ramp where it provides some protection against erosion.

The direction of longshore transport varies depending on the morphology of each embayment and the resulting tidal currents. For example, the change in tidal currents and longshore transport following the construction of the causeway to Cape Sable Island in 1953, has resulted in a dramatic shift in the distribution of the beaches around Barrington Bay. The old sand dunes at Sand Hills Provincial Park are rapidly eroding, while a new spit with dune deposits has formed to the west, and a new beach has accumulated on the eastern side of the causeway.

4.3.2 Sand Dunes

The sand dunes of the Atlantic Shore typically consist of fine grained sand, have a dominant foredune ridge with a steep ramp, and occur on bay mouth barriers or tombolos. This is the only area in the province where sand dunes are associated with beaches, defined as being attached to the mainland for their whole length. Sand dunes of this region differ from those of other areas vulnerable to waves from the Atlantic Ocean, since the dunes of Eastern Cape Breton Island occur on mid-bay spits and have multiple ridges, and those of Northeastern Cape Breton Island have gentle slopes subject to washover events. Within the Atlantic region there are several subgroups of sand dunes based on their morphology, the sediment source, and sediment size. The sand dune systems are first divided according to their sediment source, drumlins or relict sand, and then further divided according to their morphology (Fig. 4.9).

4.3.2.1 Sand Dunes Associated with Drumlins

As previously mentioned, actively eroding drumlins are found in three locations along the Atlantic Shore, and in each case sand dune systems are found associated with them on either bay mouth barriers, or tombolos and bay mouth barriers associated with islands.

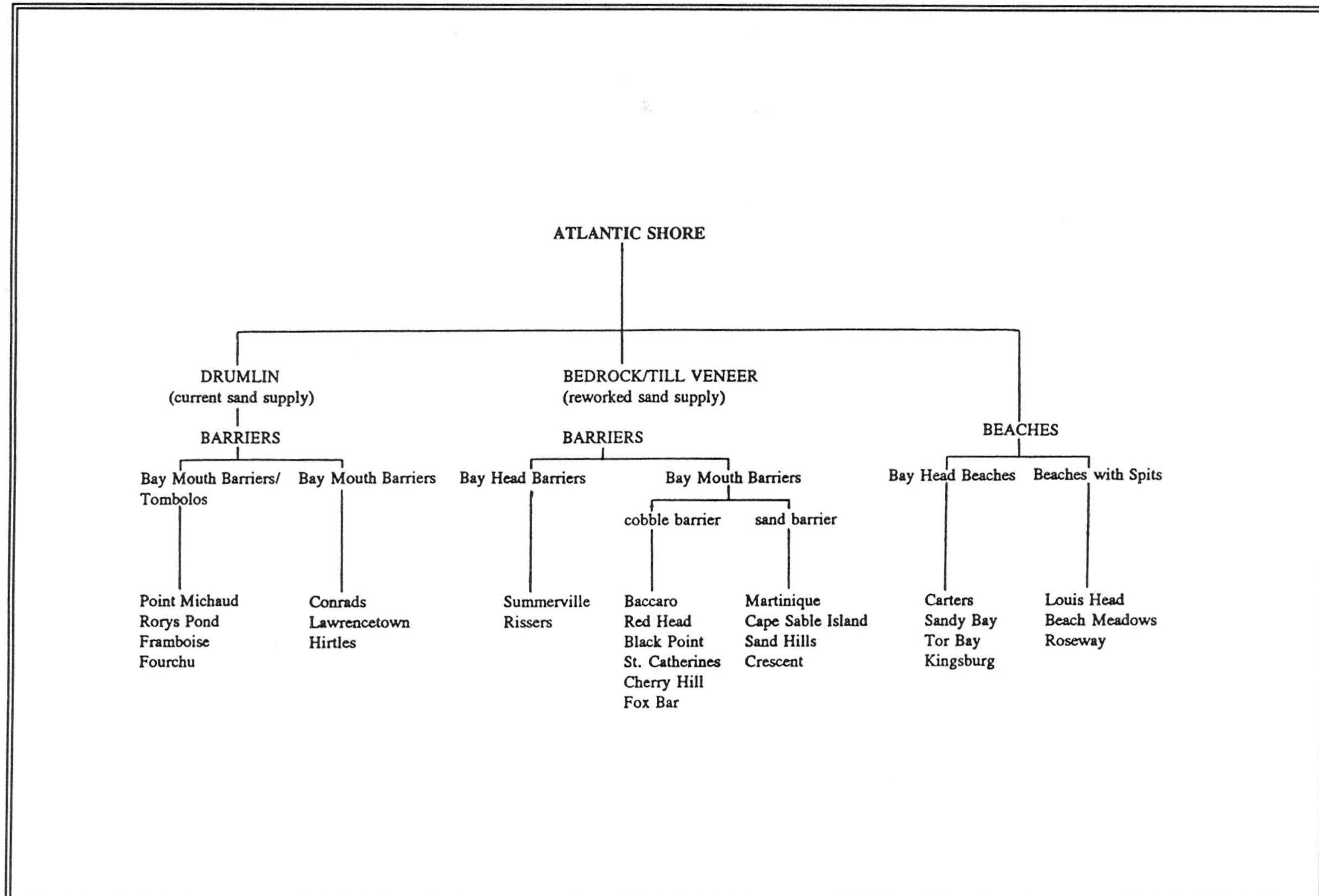


Figure 4.9. Subdivisions of the Atlantic Shore based on sediment supply and morphology.

Bay Mouth Barriers:

Sand dunes on bay mouth barriers are found at Conrads, Lawrencetown, and Hirtles beaches. The first two, within the Lawrencetown drumlin field, are large systems of over 500 m in width and 1.8 km in length (Fig. 4.10 and 4.11). They both have multiple ridges, reaching a typical height of 3.1 m at Conrads, and 4.8 m at Lawrencetown. In form these systems are similar to that of Pomquet on the Northern Shore, although not as large, in a much higher energy environment, and most likely retreating rather than prograding. Conrads beach consists of two sides, roughly divided by Fox Point. The western side has a high cobble berm, 1.5 m, which disappears to the west where the sand dune backing it decreases in height. A channel was cut through this end of the beach in 1962, essentially separating the beach from the mainland, making the causeway across the lagoon the only access. A set of low dune ridges formed parallel to this western inlet, which closed again during Hurricane Hugo in September, 1989, according to a park personnel at Lawrencetown. The closure of this inlet has changed the drainage pattern of the western marsh, requiring it to drain to the east, and consequently, increasing erosion of the causeway, as was observed in April 1992. According to Taylor (1985 and pers. comm.) the emerged ridges inland and east of Fox Point at Conrads are relict beach ridges, as are the partially submerged ridges in the lagoon at Lawrencetown. Since no study was done on the internal structure of these ridges, this cannot be disputed, except to point out that the surficial material consists of aeolian deposits. At Lawrencetown the highest dunes are in the centre of the beach, with a hummocky area of sand and gravel to the east, the remnants of intensive commercial mining. Conrads was also mined, as is evident by the huge holes in the back of the foredune ridge and the discarded mining equipment. Since mining ceased, both systems have been badly degraded by recreational activities, particularly vehicle use. By 1982, Lawrencetown was severely cut by vehicle tracks (Petro-Canada Exploration Inc., 1982). Both Lawrencetown and Conrads have recovered, an indication that they have an active supply of sand, and are now well vegetated, although trails still exist. Lawrencetown is a heavily used provincial park with full facilities (Fig.4.12) , while Conrads has been left primarily undeveloped and is used by pedestrians, bicycles and equestrians.

Hirtles beach, the only sand dunes associated with the Lunenburg drumlin field, consists of a series of bay mouth barriers across two ponds, and is separated into three sections by eroding drumlin bluffs (Fig. 4.13. The barriers are essentially cobble bars with a sand dune cap on them, together reaching a height of about 3.0 m and a width of 20.7 m (Fig.4.14). Despite the fact that the beach is a popular recreation area, the dunes are in good condition. Most likely their small size reduces their attractiveness as recreational targets, and the readily available sand supply quickly repairs any damage.

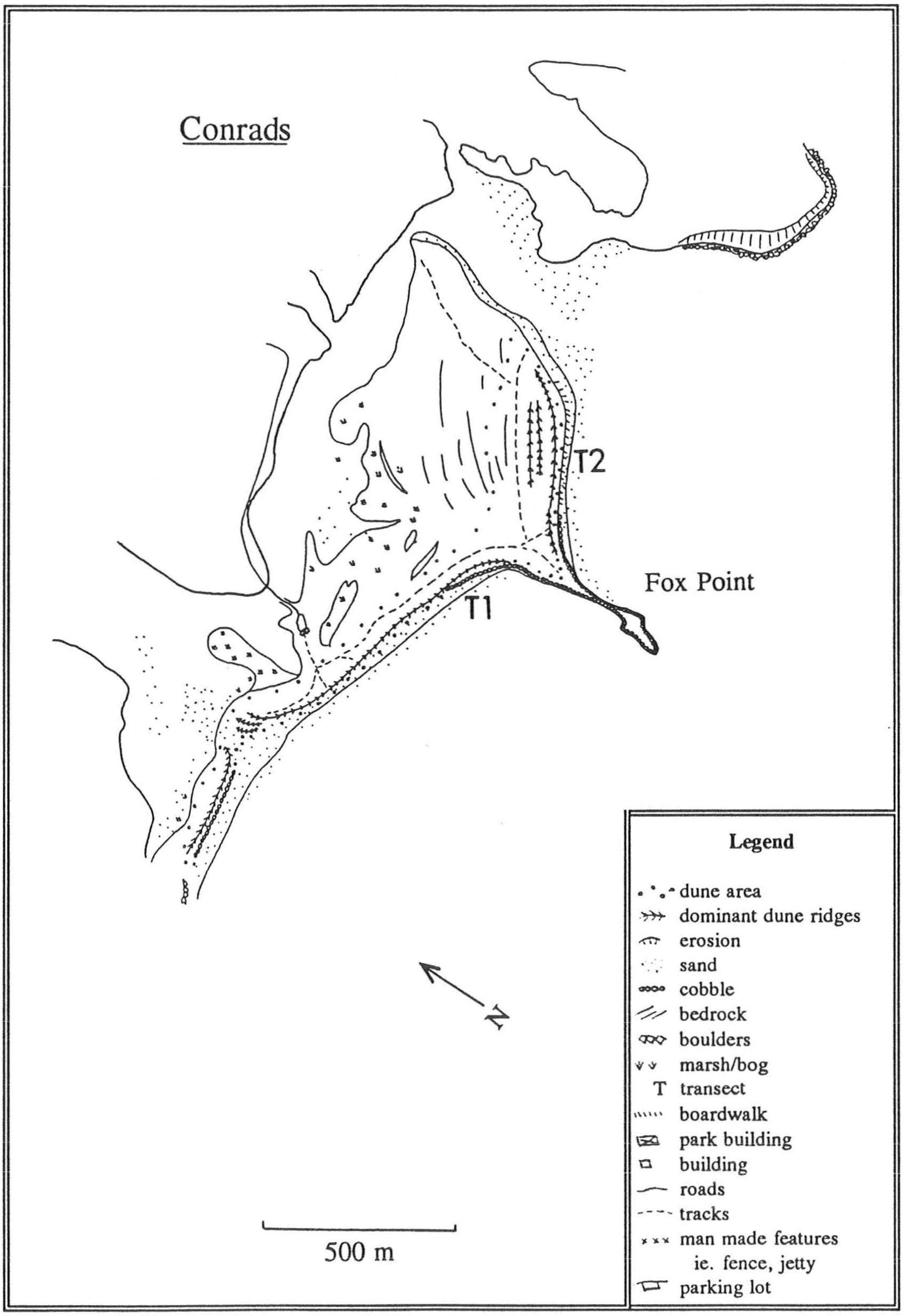
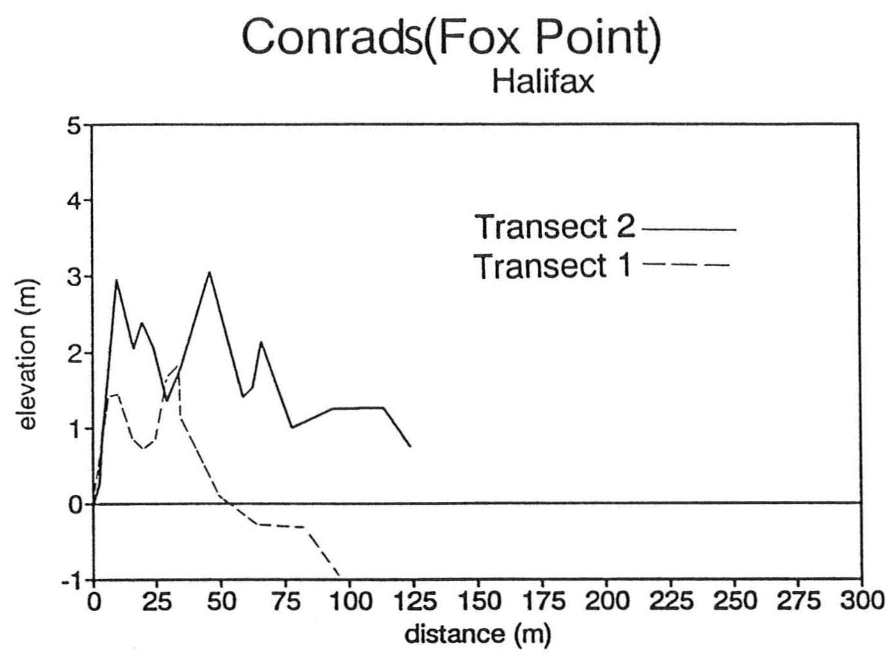


Figure 4.10. Conrads dune system: map, profile and sediment sizes.



Conrad T1 = s, T2 = n

Sediment at transects 1 and 2				
location	T1 mean (O)	T2 mean (O)	T1 sorting (O)	T2 sorting (O)
foreshore		2.35		0.35
backshore	2.39		0.37	
ramp		2.24		0.36
crest		2.33		0.39

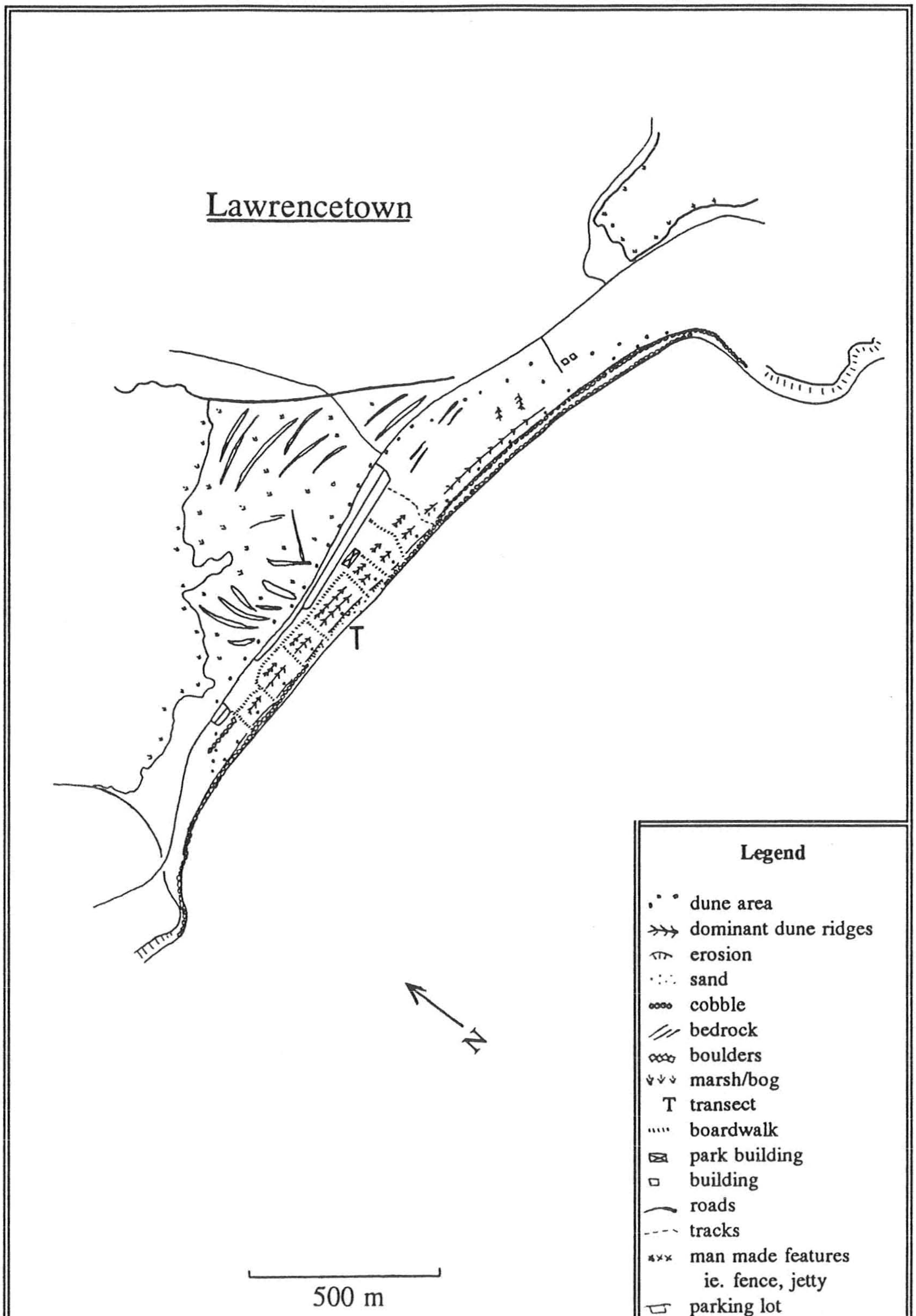
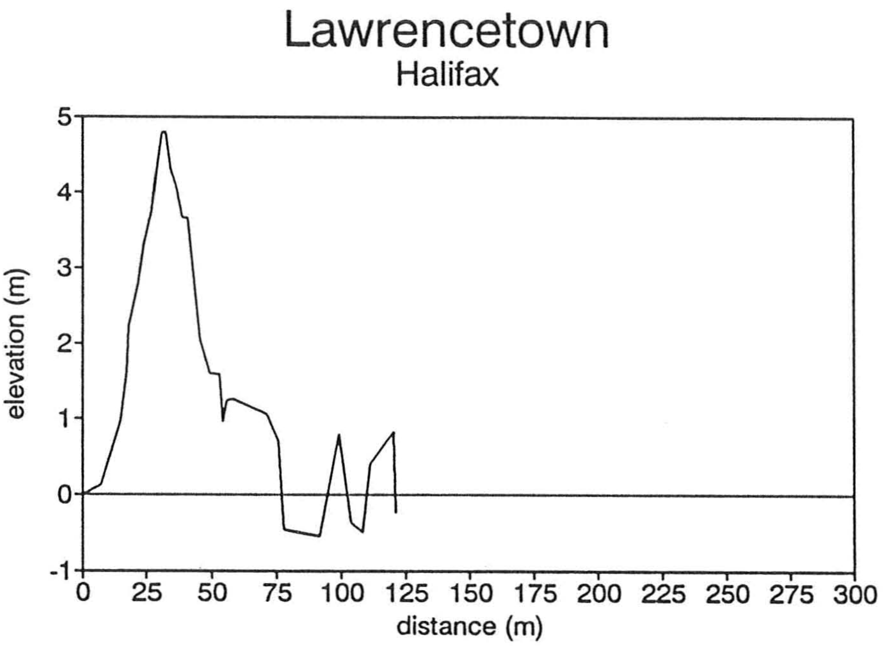


Figure 4.11. Lawrencetown dune system: map, profile and sediment sizes.



Lawrencetown

Sediment at transect		
location	mean	sorting
foreshore	1.86	0.36
backshore	1.43	0.49
ramp		
crest		

Figure 4.12. Lawrencetown Provincial Park. Note eroding drumlin in distance.

Figure 4.13. Hirtles beach. Note eroding drumlin and pond behind barrier.

Tombolos and Bay Mouth Barriers with Islands:

Tombolos built by drumlin sediment supply are found on the shore of Southeast Cape Breton Island. Most of those classified as tombolos are in fact bay mouth barriers which are attached to islands at some point along their length. The dune systems of this area differ from those of the rest of the Atlantic Shore in that they consist primarily of coarse grained sand, and are subject to overwash, as is indicated by the fact that the crest material may be coarser than the beach sediment. The dunes at Rorys Pond, Framboise, Fourchu and the southwest side of Point Michaud consist of single ridges comprised of a dune cap on top of barriers of coarser material. All four of these have been mined at sometime in the past, with the possible exception of Rorys Pond, a low bay mouth influenced by overwash (Fig. 4.15). However, given its proximity to the community of St. Esprit, it seems unlikely that it would have escaped.

Framboise is a 2.25 km long system, divided into three parts by eroding till bluffs (Fig.4.16). The western section has been badly damaged by mining and has virtually no dune deposits left, while the centre section has a dune cap on a gravel barrier subject to washovers, and the eastern section is accumulating sand in a series of low dunes.

Fourchu is the longest system in this area, over 13 km, culminating in a double tombolo at Winging Point (Fig..17). The dune deposit reaches its greatest extent at the western side of Winging Point, but is discontinuous on the eastern

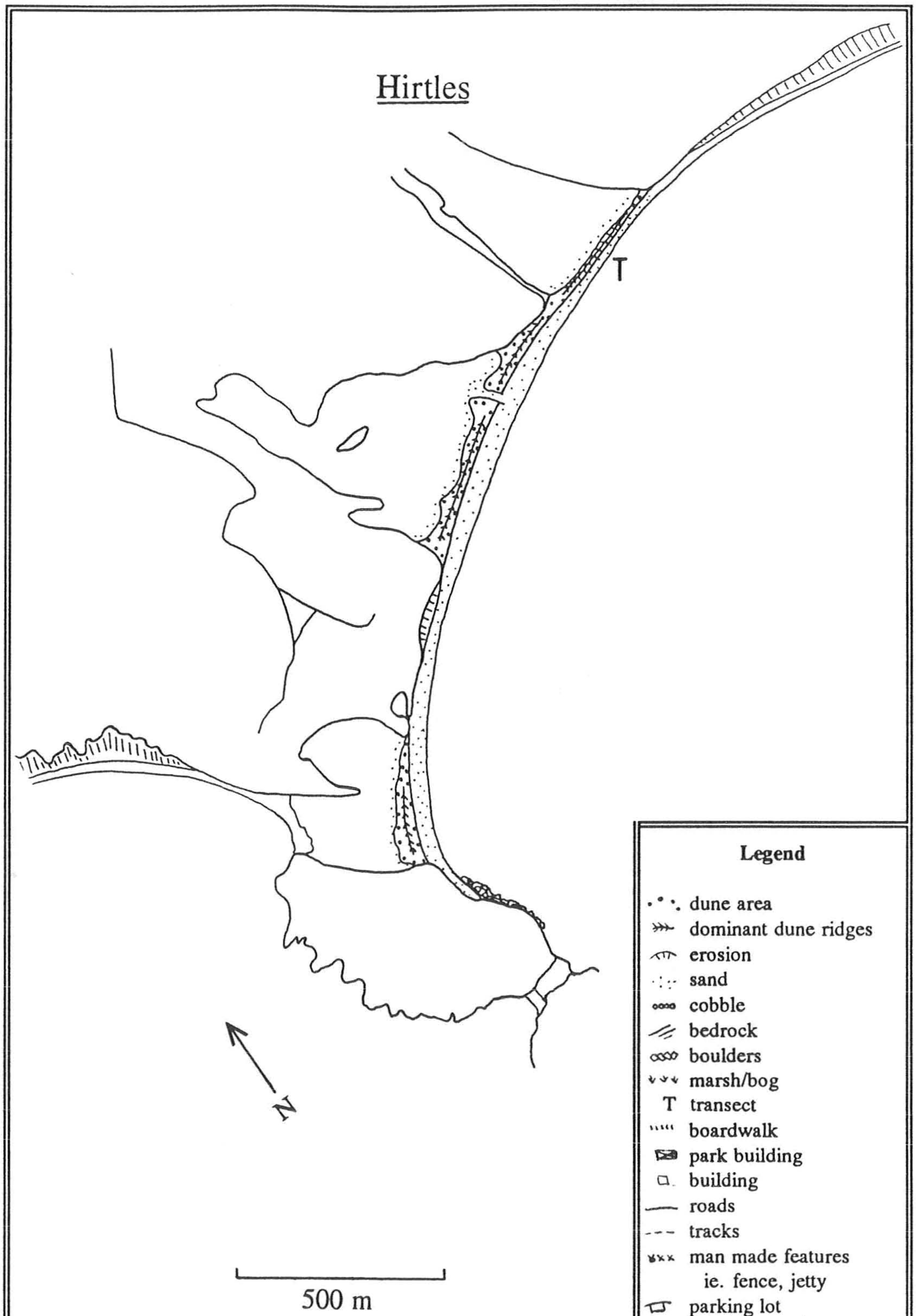
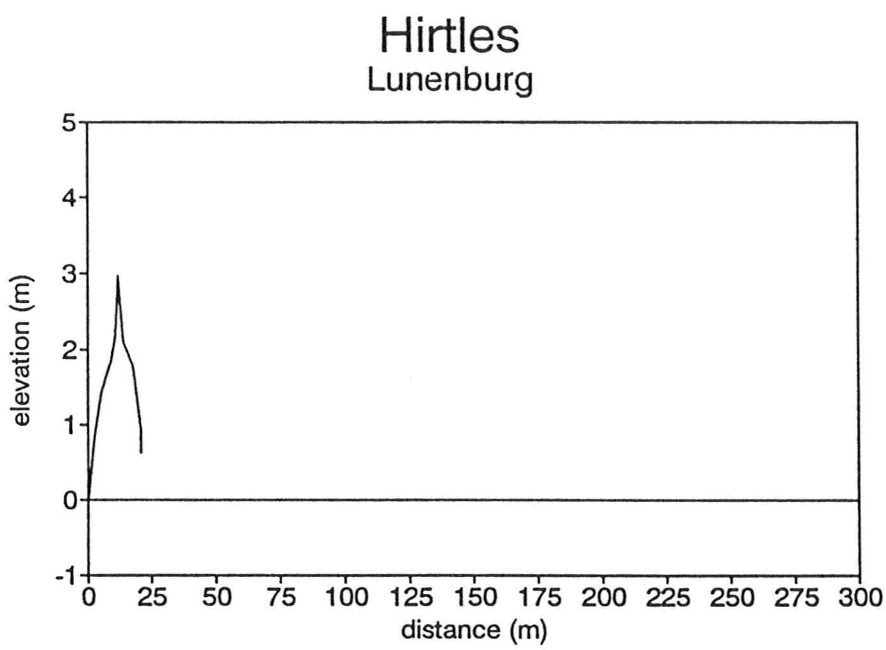


Figure 4.14. Hirtles dune system: map, profile and sediment sizes.



Hirtles

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.07	0.35
backshore	2.18	0.28
ramp	2.16	0.28
crest	2.23	0.29

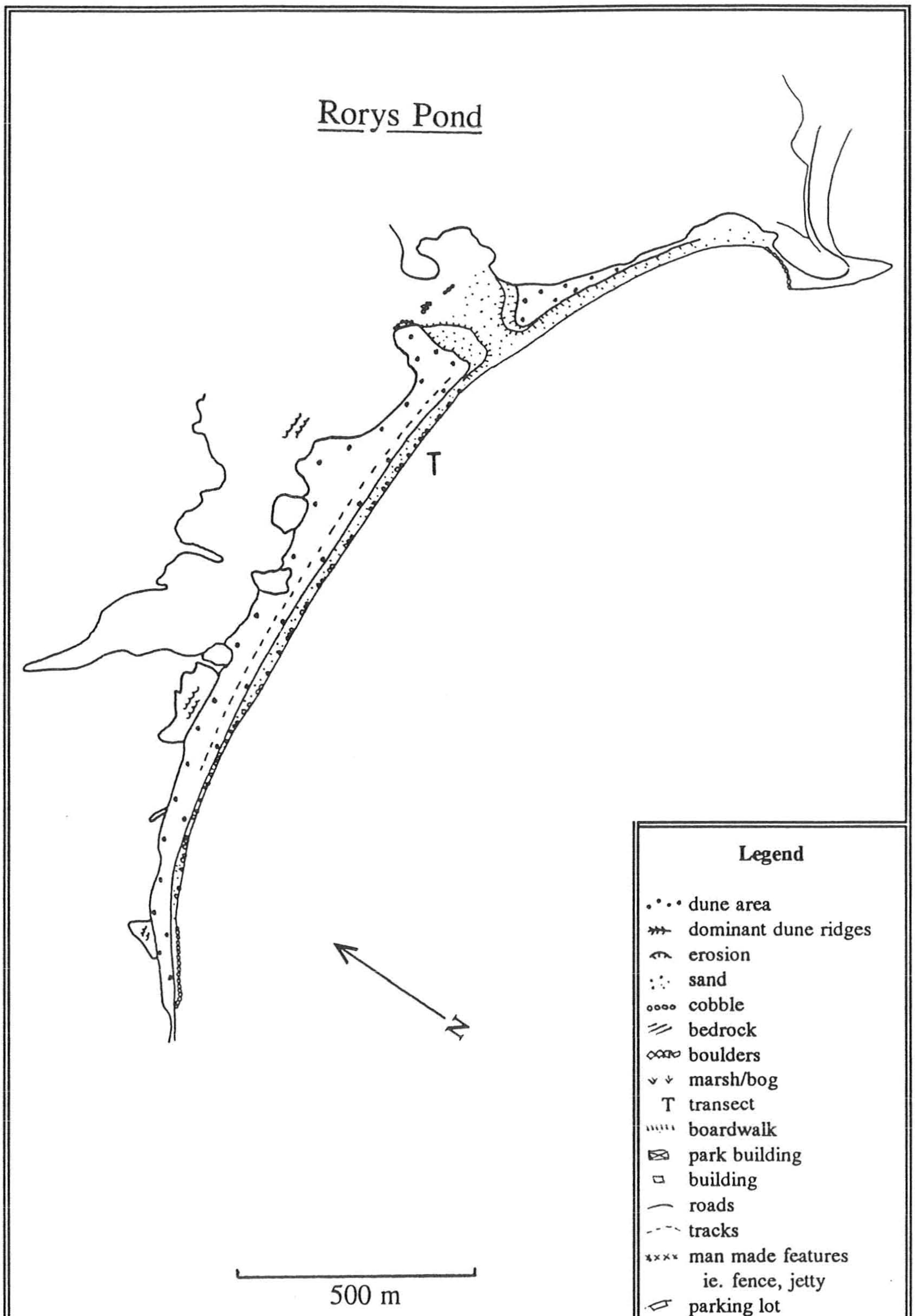
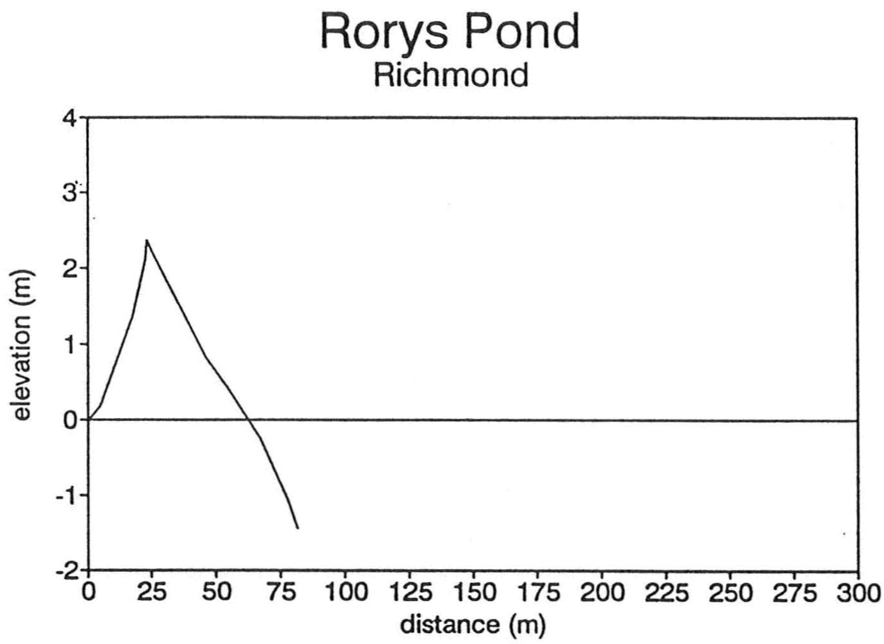


Figure 4.15. Rorys Pond dune system: map, profile and sediment sizes.



Rorys Pond

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	-0.56	0.97
backshore	-1.47	0.91
ramp	0.31	1.04
crest	-0.17	0.95

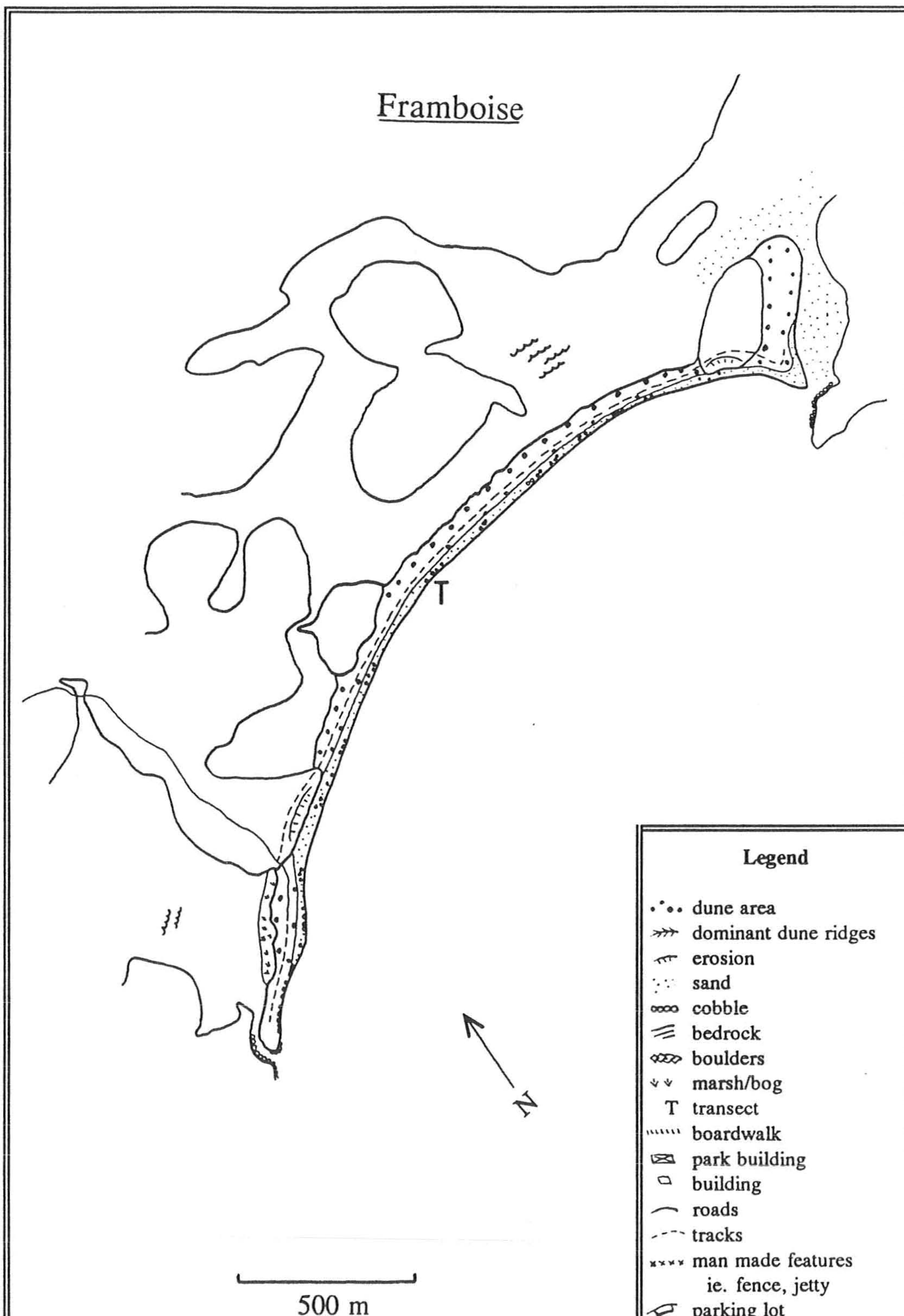
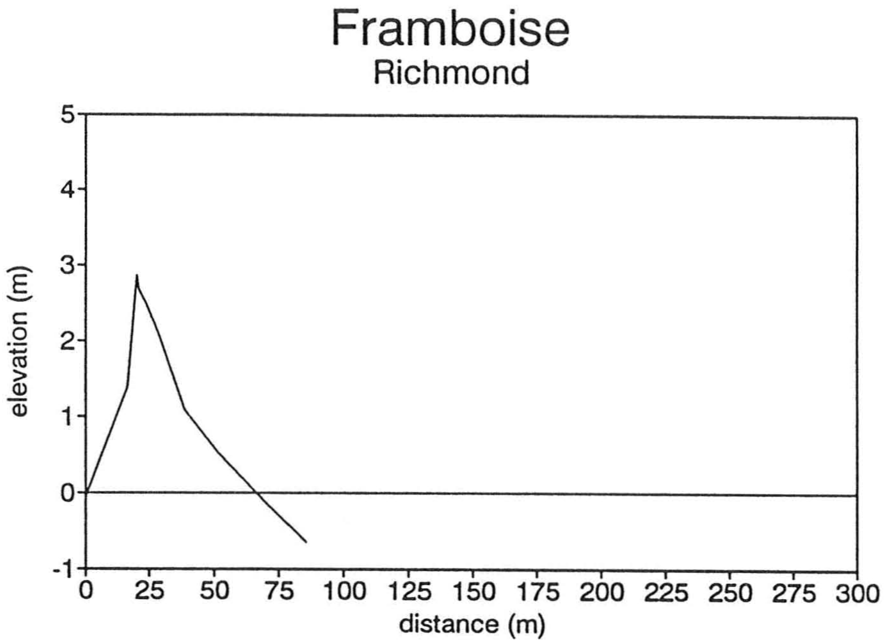


Figure 4.16. Framboise dune system: map, profile and sediment sizes.



Framboise

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	-0.63	1.95
backshore	0.71	0.74
ramp	0.75	0.60
crest	0.56	

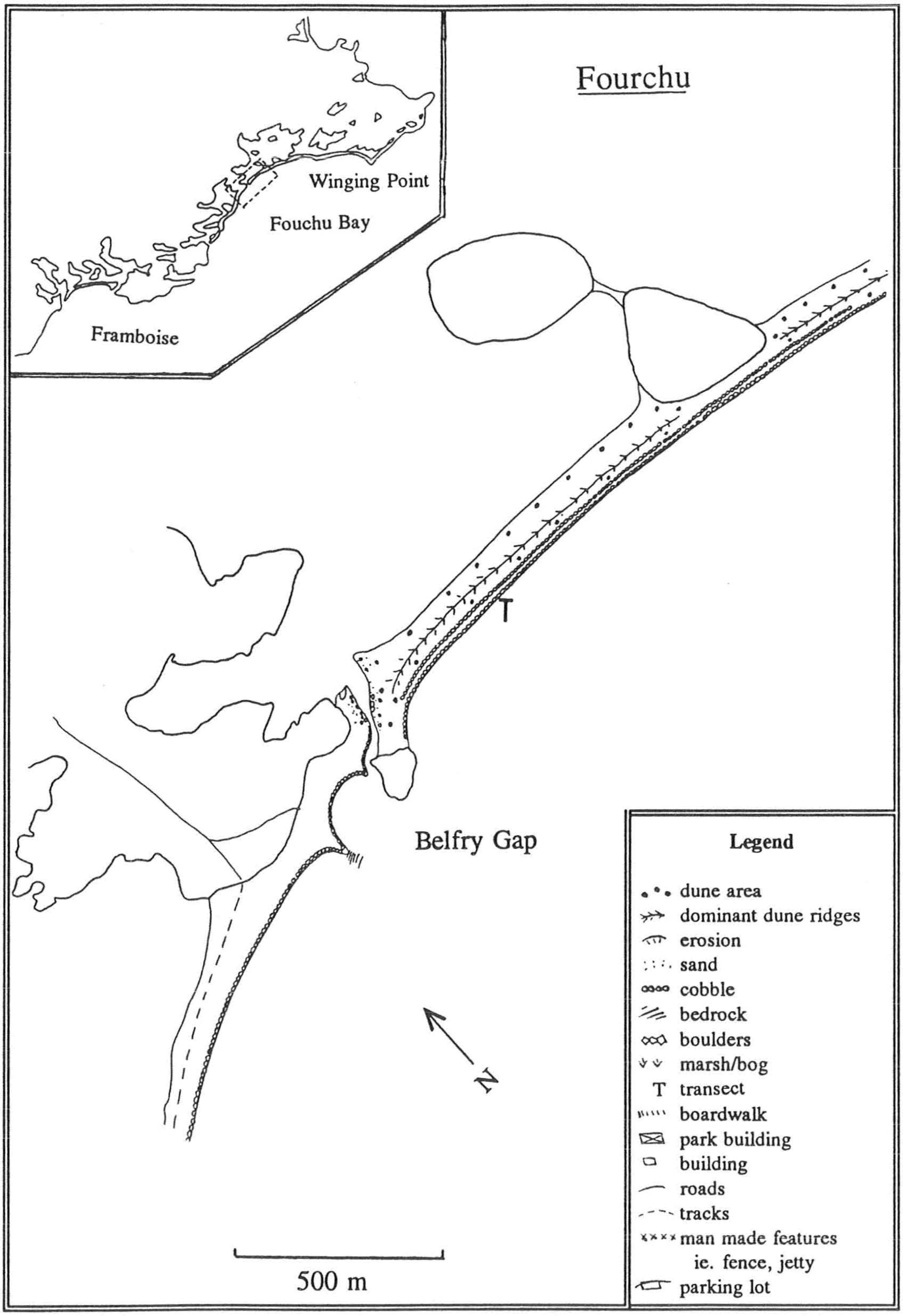
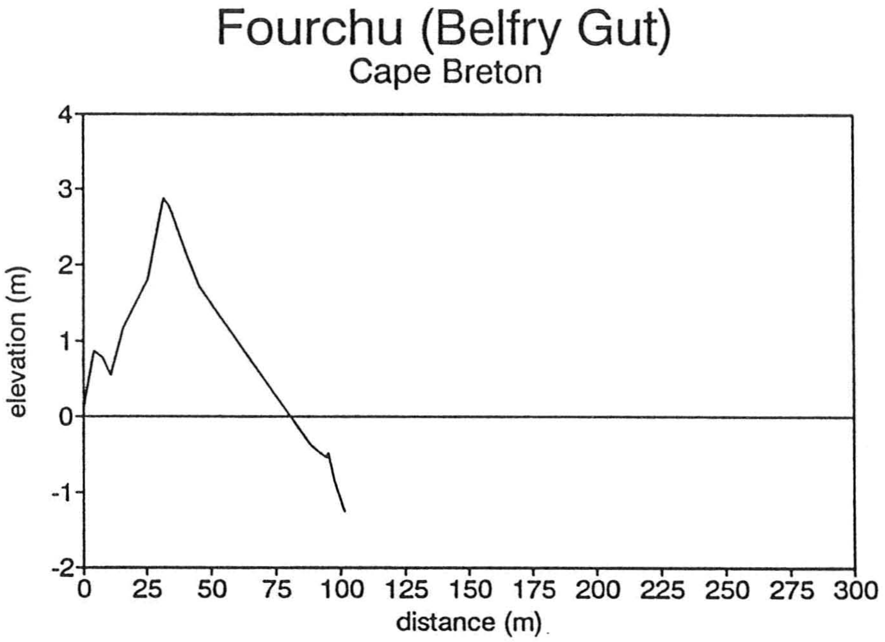


Figure 4.17. Fourchu dune system: map, profile and sediment sizes.



Fourchu

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	0.36	0.84
backshore	-0.81	0.93
ramp	0.18	1.25
crest		

side and in other areas of the system. To the east of Belfry Gap, the barrier seems to have been heavily mined, leaving a flattened gravel ridge. The barriers at Fourchu Bay appear to be strongly controlled by washover events, with only a thin cap of aeolian deposits (Fig.4.18).

Point Michaud is a double tombolo attached to a rock island (Fig.4.19). The western side is similar to those described above, but the eastern side is different from other systems of Southeast Cape Breton Island. It is sheltered by Point Michaud and the Basque Islands, consists of fine grained sand, has a wide, gently sloping beach, and has more than one dune ridge. The dunes are low, and hummocky, supporting a variety of plant species, including a forest association, which suggests that this system is fairly stable. The most eastern end was mined (Bowen et al., 1975), creating the area now used as a parking lot. The system probably developed as a single tombolo attached to Point Michaud and the Basque Island, which failed and retreated with rising sea level to its modern position (Bowen et al., 1975). Both sides of the tombolo have tracks along them. The western track provides access to the wharves on Point Michaud and is not damaging the system so long as the track adjacent to the marsh is used. The eastern side, on the other hand, is prohibited to vehicles, although offroad vehicles were observed on the dunes where they can cause extensive damage.

Sand dunes may exist at other locations along Southeast Cape Breton Island, such as at St. Esprit Lake and Black Point, but they were inaccessible. Dunes may have once existed at L'Archeveque.

Figure 4.18. Fourchu Bay, east of Belfry Gap. Thin dune cap on coarse clastic barrier.

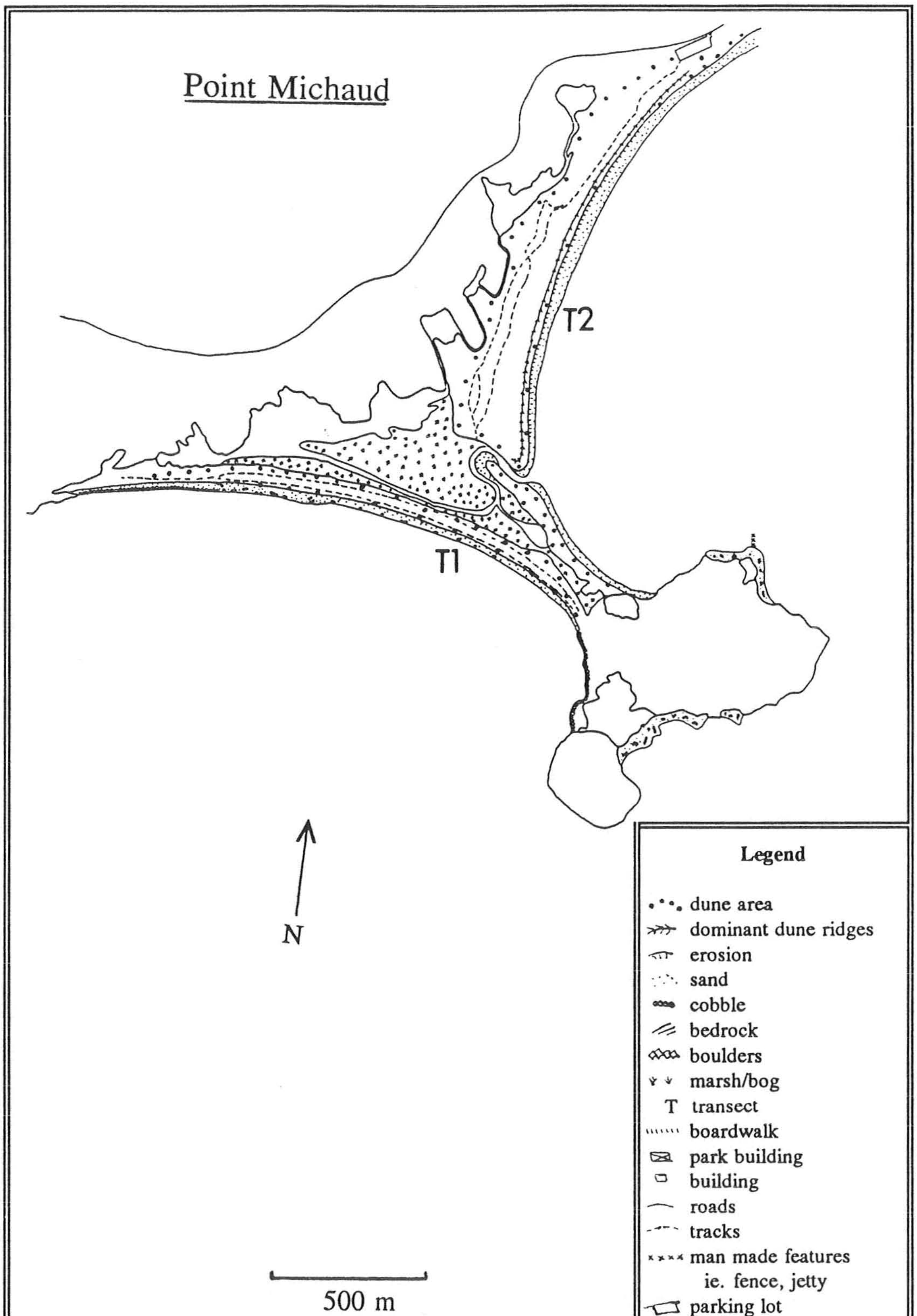
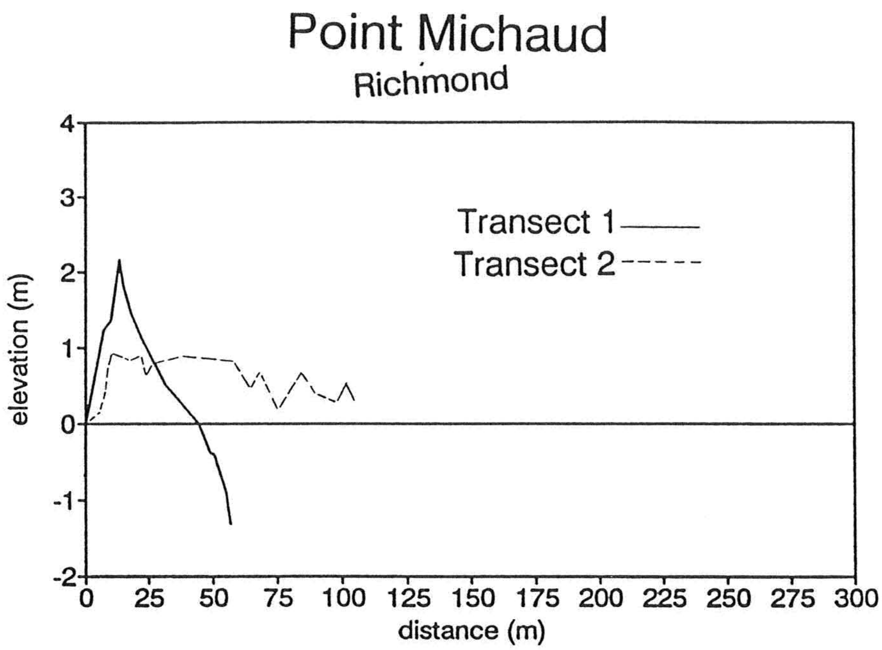


Figure 4.19. Point Michaud dune system: map, profile and sediment sizes.



Point Michaud

Sediment at transects 1 and 2				
location	T1 mean (O)	T2 mean (O)	T1 sorting (O)	T2 sorting (O)
foreshore	0.26	2.11	1.39	1.19
backshore	0.33	2.40	1.05	0.50
ramp	0.64	2.68	0.90	0.39
crest	0.90	2.65	0.82	0.40

4.3.2.2 Sand Dunes Associated with Bedrock and Thin Till

Sand dunes along the majority of the Atlantic Shore are comprised of relict beach deposits and are receiving very limited inputs of modern sediment. These dune systems can be divided into several categories according to their morphological setting, bay head barriers, bay mouth barriers, with or without islands attached, and beaches. Further categorization can be made depending the substrate of the barrier (see Fig.4.9)

Bay Head Barriers:

Bay head barriers with multiple ridges exist at only two locations on the Atlantic Shore, Summerville beach and Rissers beach. These two systems occupy similar positions across small bays created by river mouths, at the head of much larger bays. They are also relatively short and wide compared to most systems along this coast, and have been the focus of much recreational activity. Summerville has an unusual profile in that it consists of a few low, wide ridges backed by a high centre ridge of eroded dunes (Fig.4.20). The embankment of the railway line, which once ran the length of the barrier to the bridge at the far end, is responsible for the strange profile of the back of the highest ridge, with its flattened section and steepened slopes. The dunes adjacent to the old railway are unnaturally high, due to sand accumulation around a fence that once existed along the ridge, and the frequent blowouts in this ridge are the result of a well used trail along the fence (Bowen et al.,1975). The barrier is now a Provincial Park, and since people were prevented from camping on the dunes and from driving trailers on to the dunes via the old railway bed, the system has become well vegetated and is prograding (Bowen et al., 1975; Taylor et al., 1985).

Although Rissers beach has most likely received material from drumlins to the southwest, as is suggested by the red colour of the beach, its morphology and the sand deposition at the western end indicate that longshore transport is from the east, therefore restricting sediment input from the drumlins (Fig.4.21). Rissers beach is a provincial park, with a campground and day use area. A breakwater at the far end, originally built during the 1940s and replaced a few years ago, is successfully trapping sand, as is the sand fencing along the foredune. The existence of sand fencing suggests that the foredunes were once in a degraded condition, however they are now well vegetated and accumulating sand, with the exception of an area of erosion along the ramp at the distal end. Backing the foredune ridge are several steep ridges and forest vegetation. Much of the centre area of the barrier at the land end is occupied by park facilities. The rest of the area is forested, with a salt marsh along the landward shore of the barrier.

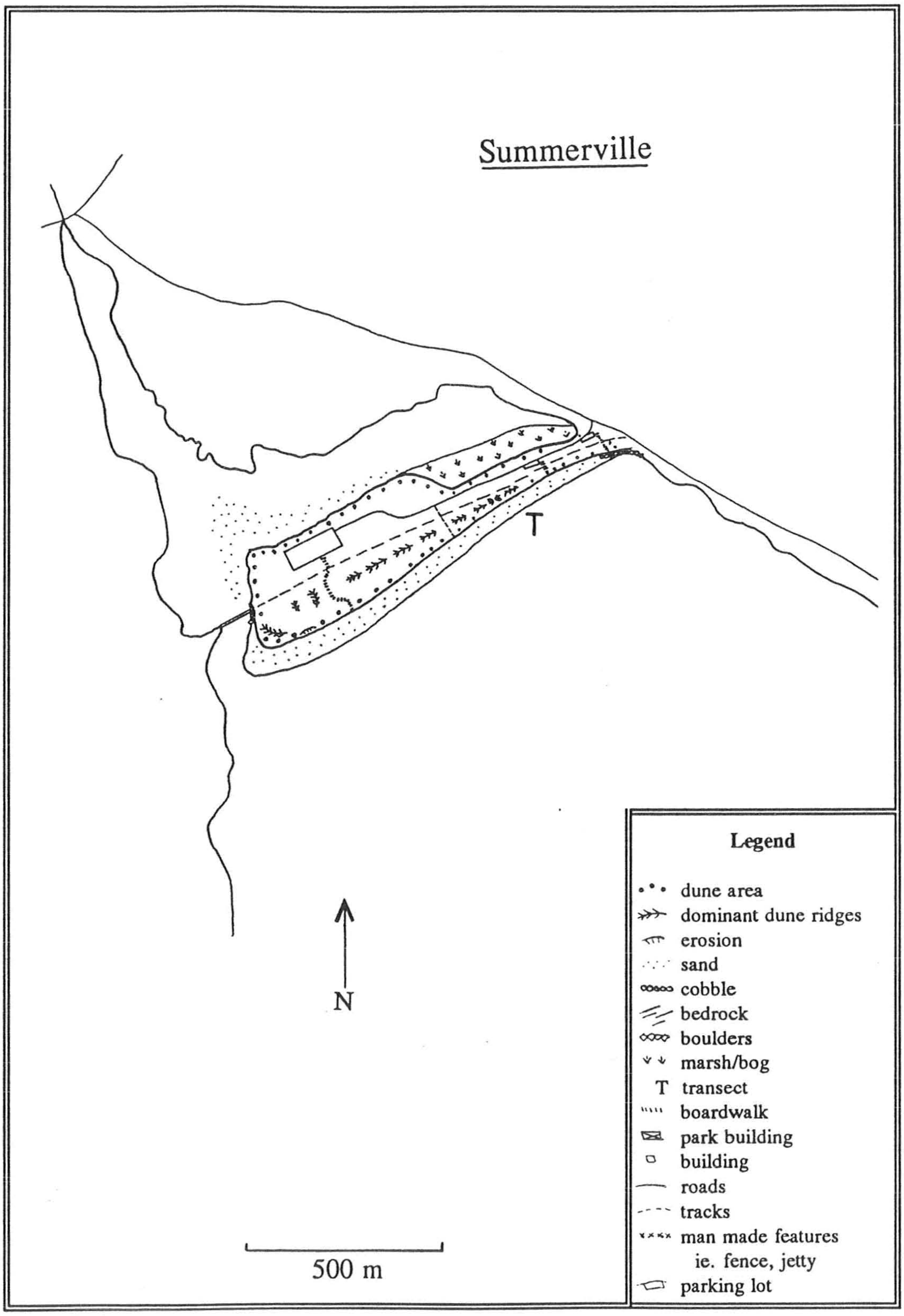
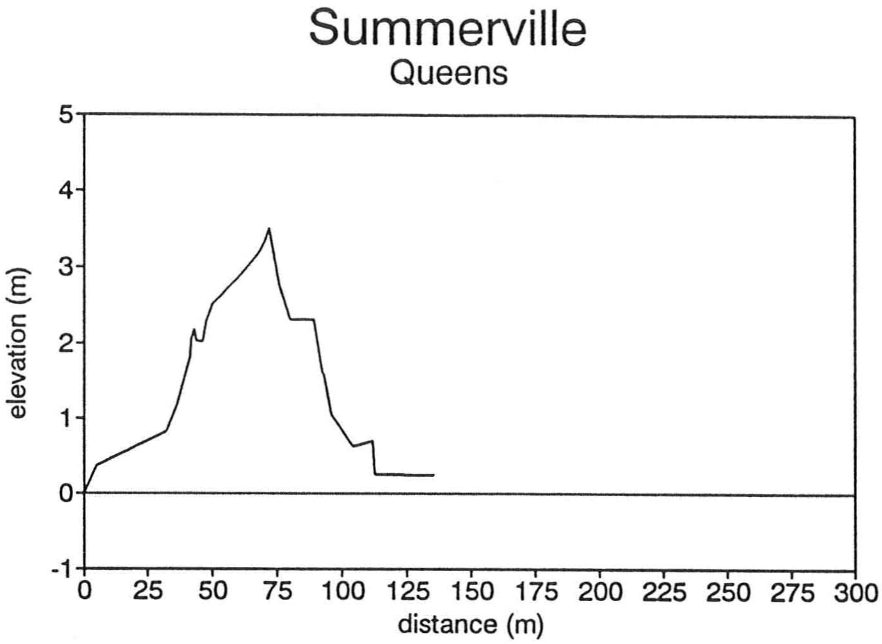


Figure 4.20. Summerville dune system: map, profile and sediment sizes.



Summerville

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.70	0.31
backshore	2.69	0.31
ramp	2.72	0.28
crest	2.27	0.66

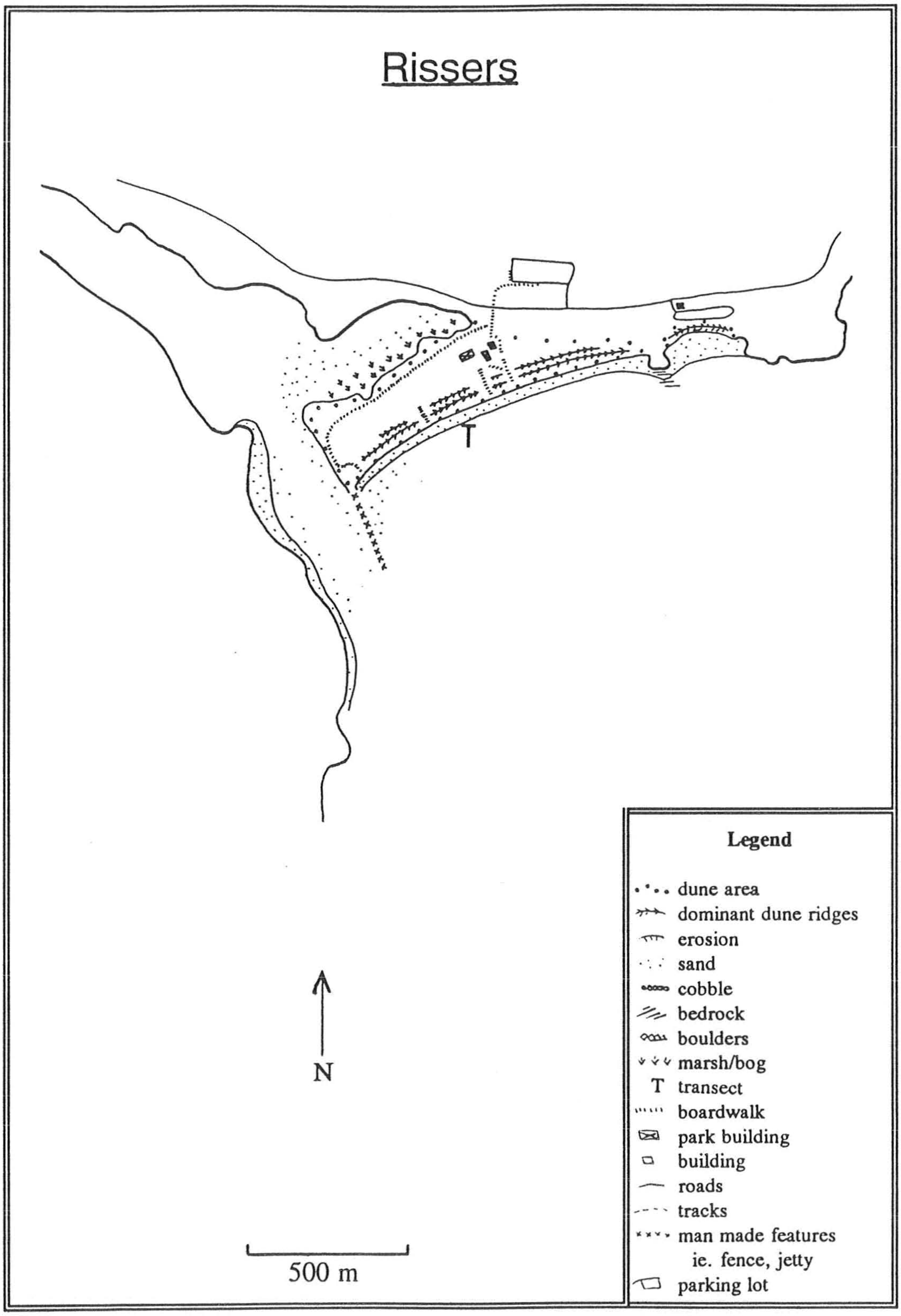
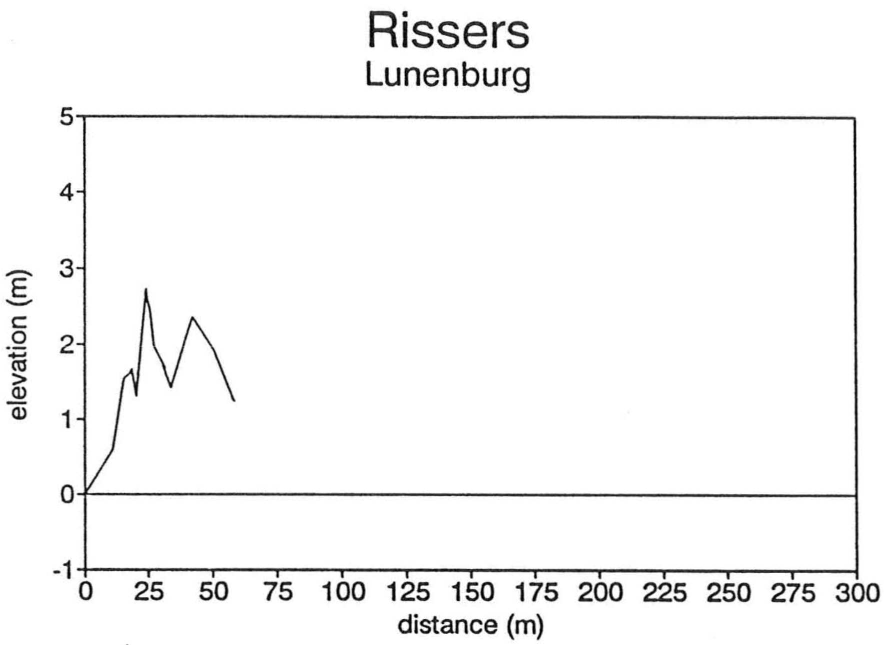


Figure 4.21. Rissers dune system: map, profile and sediment sizes.



Rissers

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.43	0.41
backshore	2.43	0.34
ramp	2.12	0.49
crest	2.49	0.34

Bay Mouth Barriers (coarse clastic material):

Bay mouth barriers are the most common geomorphological feature associated with sand dunes in Nova Scotia. On the Atlantic Shore, unlike any other place in the province, these barriers most often consist of a gravel ridge of well rounded cobble sized rocks, with sand, ranging from a thin sand cap to thick dune deposits, on top. Many of these systems are attached to islands at some point along their length. Although the internal structure of these systems was not investigated, cobbles were seen armouring the ramps and beneath the vegetation in the lee of the dune on beaches such as Baccaro, Red Head, St.Catherines River and Fox Bar, suggesting a cobble substrate. Barriers of coarse clastic material are very common along this coast, and the combination of bare cobble barrier and sand dunes on beaches such as Black Point and Cherry Hill, suggest that such formations may exist at other locations, with sand dunes covering the whole barrier (Fig. 4.22).

Baccaro and Red Head beaches consist of a single, continuous dune ridge, with a steep ramp and a wide, gentle stoss slope (Fig. 4.23, 4.24, and 4.25). Both systems have tracks running along the back of the barrier, and unless they cross the dune ridge, they appear to be doing little harm. According to local residents these beaches are lightly used in the summer, although all terrain vehicles can be a problem during this season, and are primarily used as access to hunting areas.

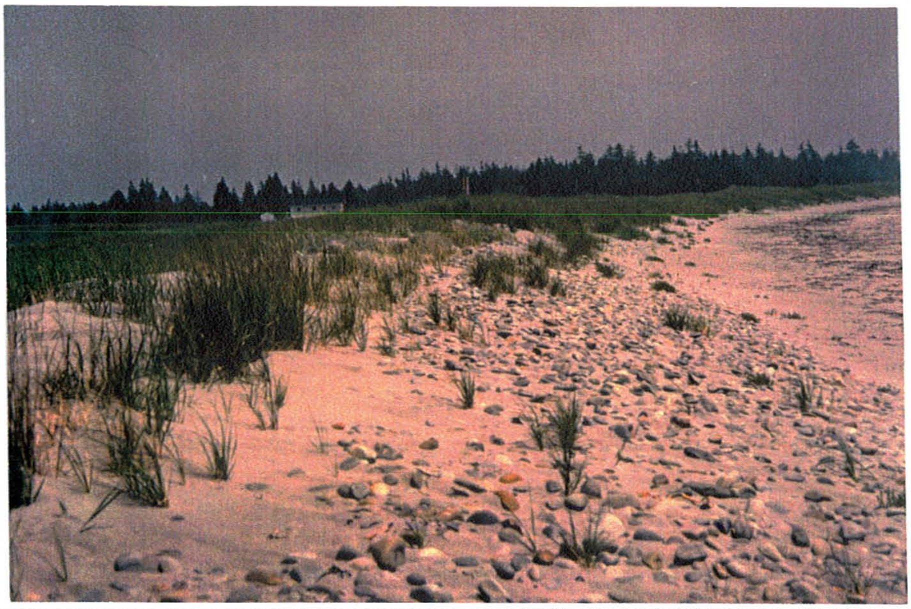


Figure 4.22. Cherry Hill. Cobbles on ramp become a cobble barrier behind photographer.

Figure 4.23. Baccaro. Typical steep ramp and wide, gentle stoss slope.

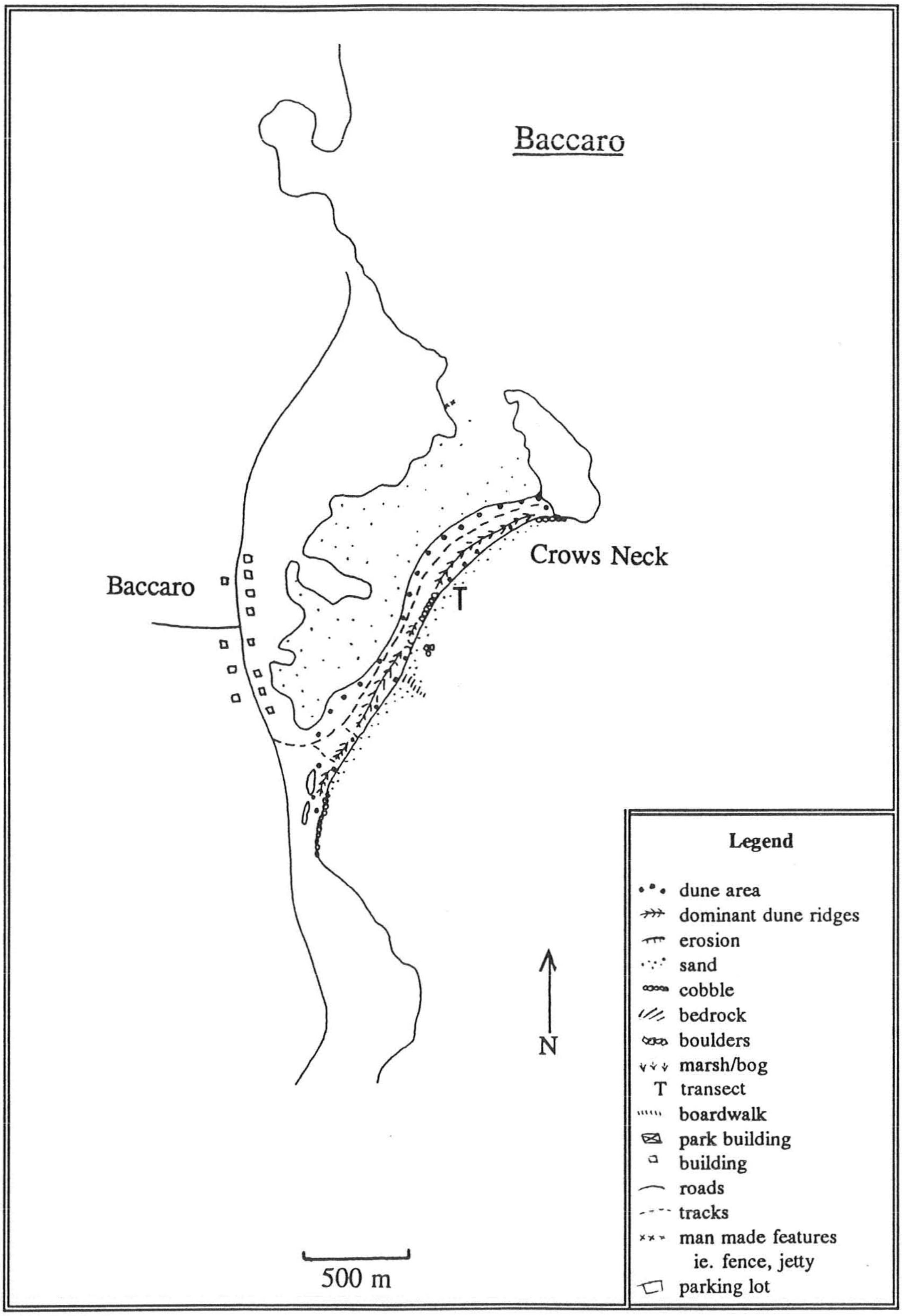
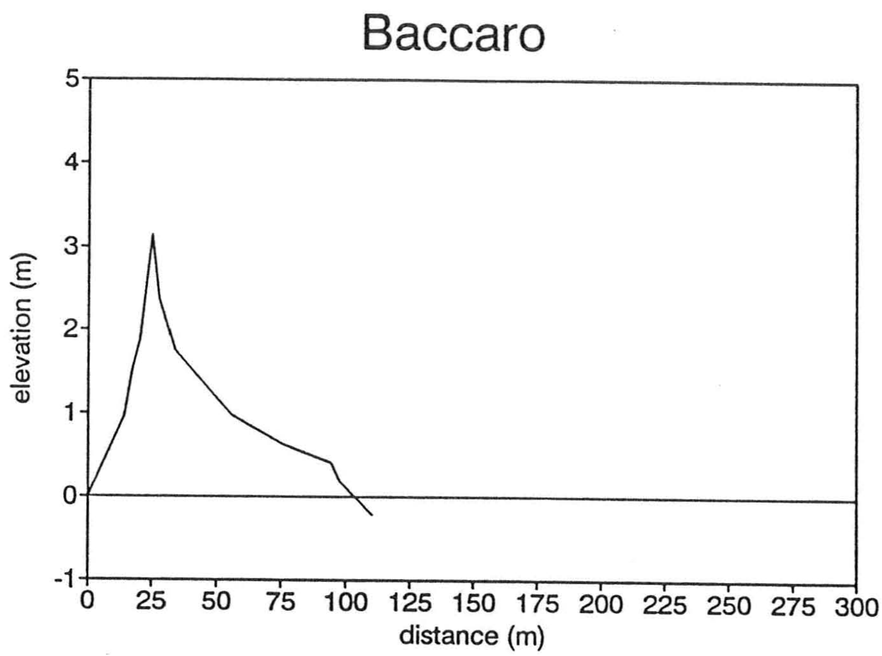


Figure 4.24. Baccaro dune system: map, profile and sediment sizes.



Baccaro

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.51	0.49
backshore	1.85	0.54
ramp	2.01	0.52
crest	2.29	0.45

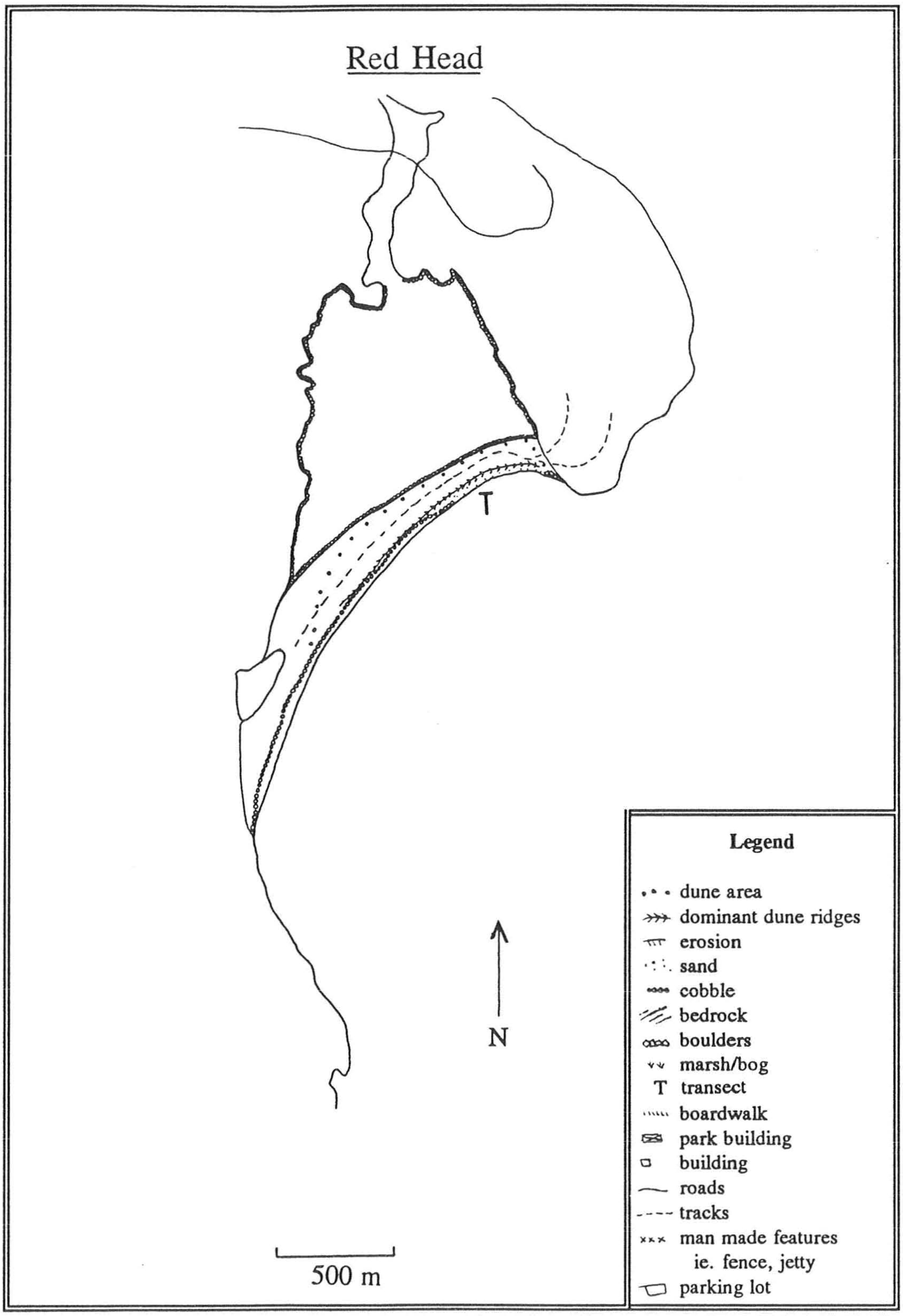
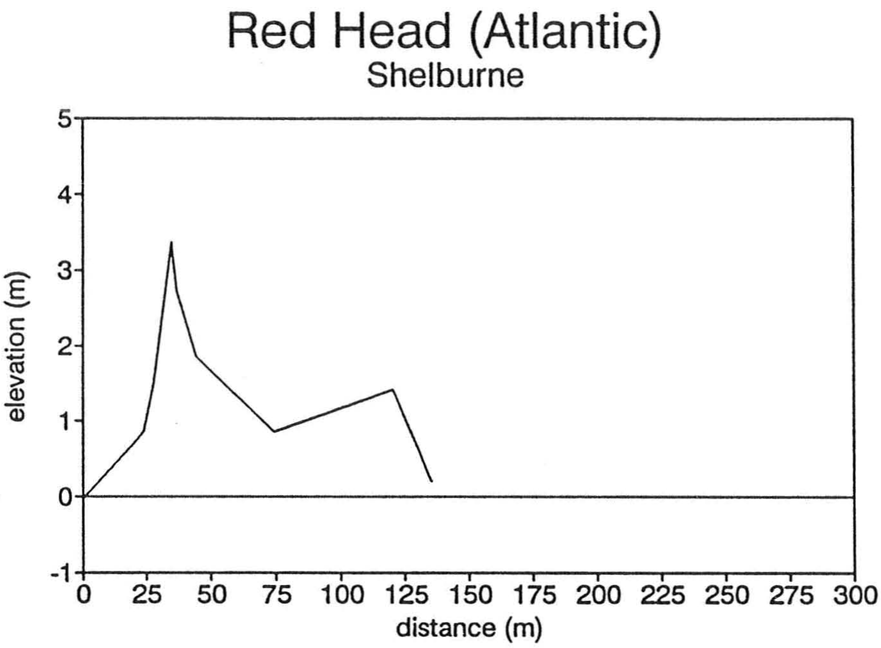


Figure 4.25. Red Head dune system: map, profile and sediment sizes.



Red Head

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.13	0.62
backshore	2.28	0.31
ramp	2.40	0.32
crest	2.39	0.34

The dune systems at Fox Bar and St. Catherines consist of ridges on both sides of the barrier, with a low area of hummocky dune deposits in between. On Fox Bar, the seaward ridge consists of old, partially eroded dunes with a new foredune at their base, while the other ridge is cobble (Fig. 4.26). Although tracks exist, the system does not appear to be heavily used. At St. Catherines River beach, the ridges on both sides are sand dunes, with the landward ridge consisting of old sand dunes (Fig. 4.27). The area was used to pasture cattle until the early 1980s, an old post is still visible in the base of an old dune, and control structures once existed in the inlet and along the marsh (Greg Kenney, pers. comm.; Bowen et al., 1975). Control of the area was acquired by Environment Canada in 1985, and officially designated as part of Kejimkujik National Park in (Farrier et al., 1991). Although the foredune area is not as densely vegetated as most other systems along this coast the vegetation is vigorous, and sand is accumulating along the ramp. At present the relative inaccessibility of the barrier, along a 3 km trail and a further 2 km along the shore, has prevented heavy use of the dunes, and consequently they appear to be in good condition. However, aerial photographs from 1927, 1955, and 1976 show that the barrier is retreating and the lagoon is filling with sediment, most likely from the dunes. Increased activity on these dunes would quickly result in loss of vegetation and sand erosion. Given the limited availability of new sand to the system, serious erosion of the dunes could result in the ultimate loss of the whole dune system. The second barrier in Kejimkujik Seaside Adjunct, across

Little Port Joli consists of a single dune ridge and is even more difficult to access.

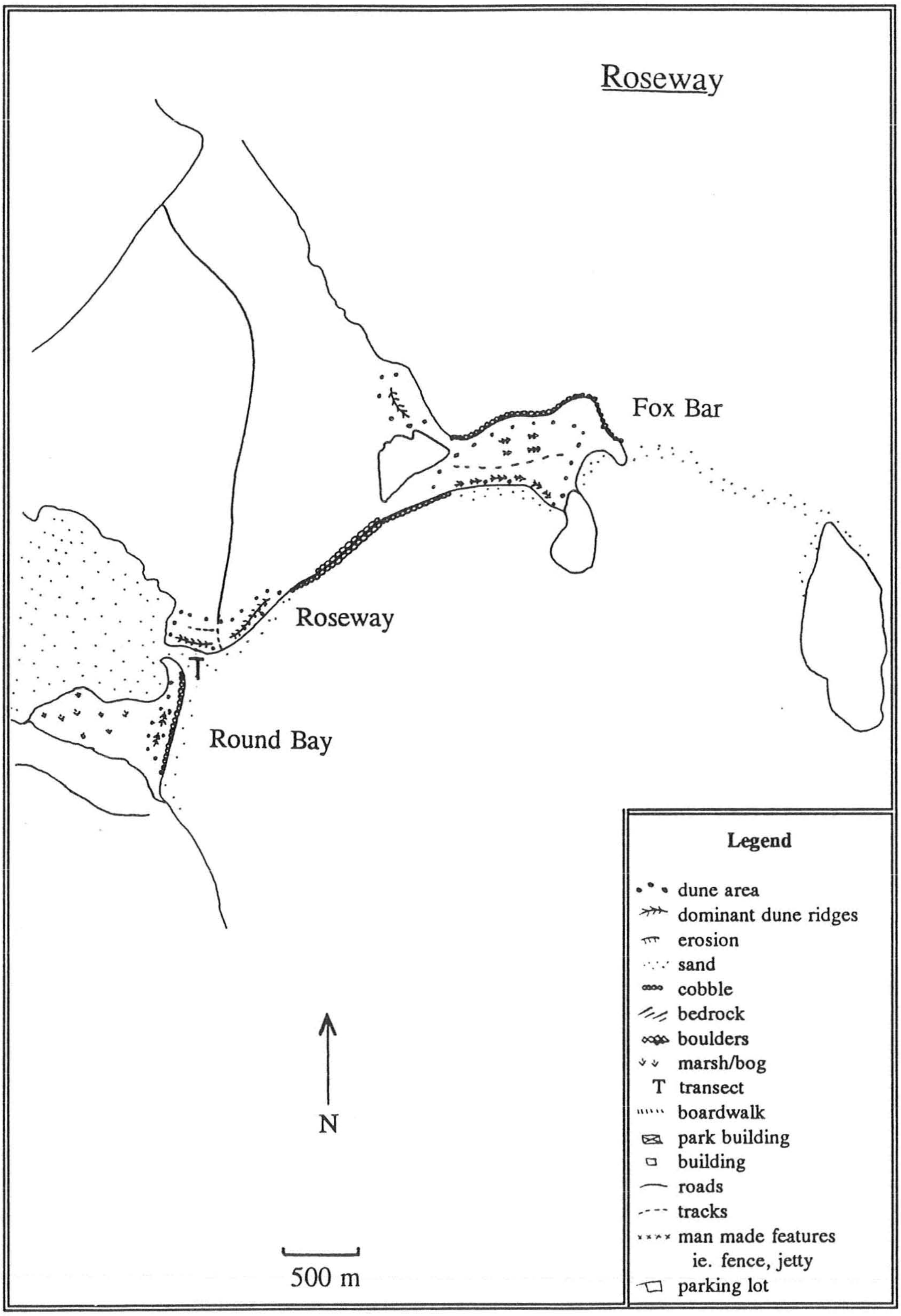
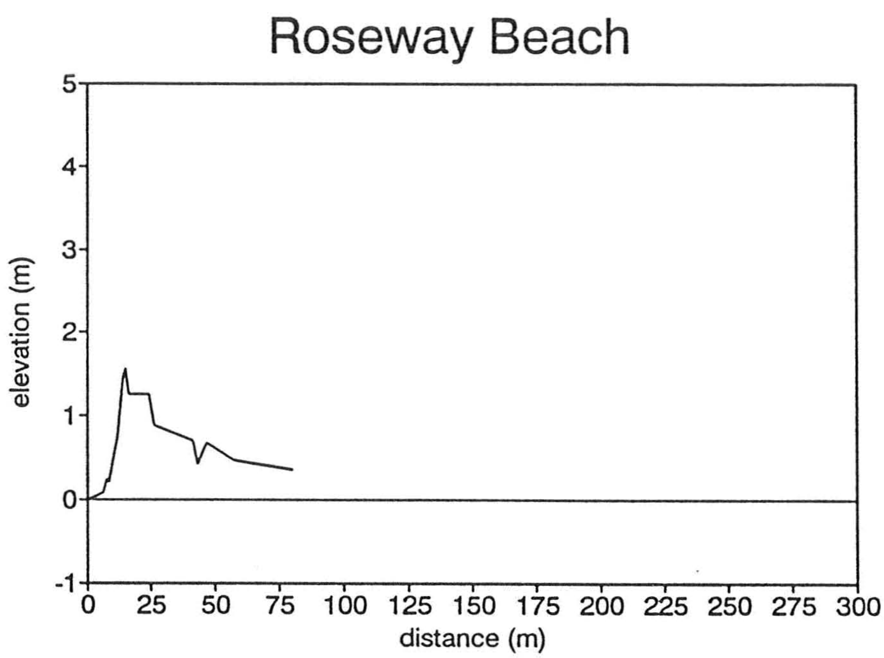


Figure 4.26. Roseway, Fox Bar and Round Bay: map, profile and sediment.



Roseway

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.38	0.48
backshore	2.49	0.40
ramp	2.71	0.33
crest	2.72	0.34

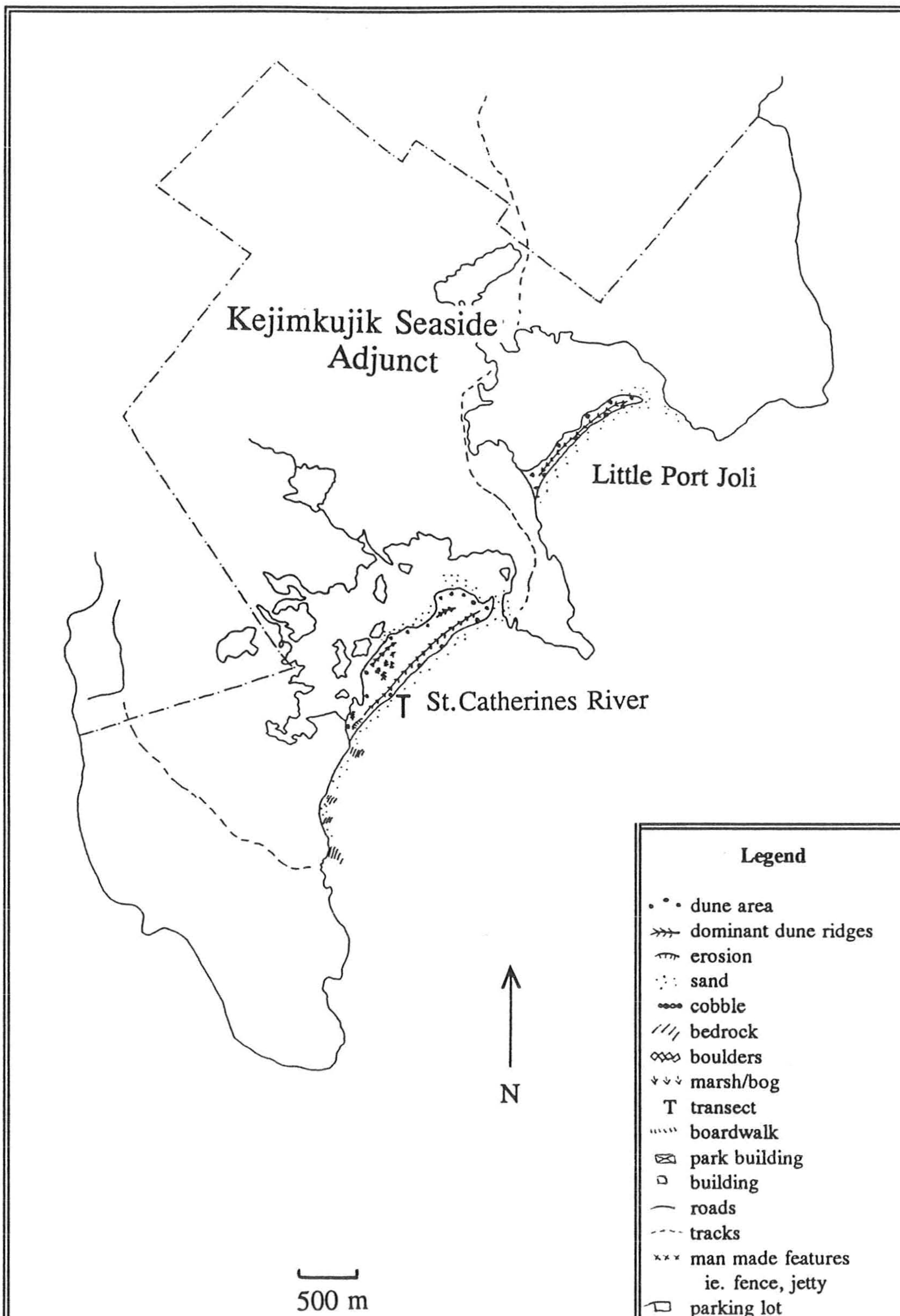
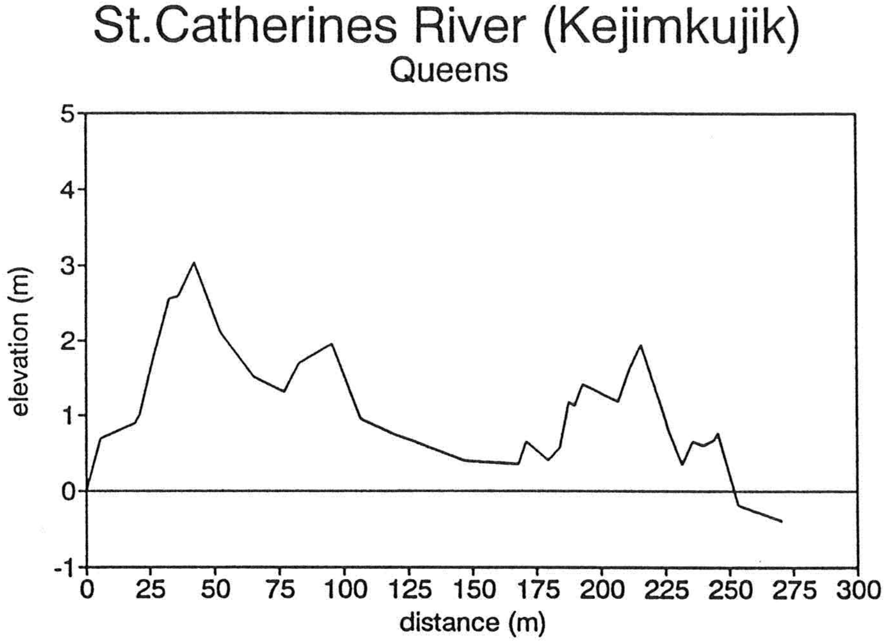


Figure 4.27. Kejimkujik dune systems: map, profile and sediment sizes.



St. Catherines

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	1.86	0.42
backshore	1.78	0.48
ramp	2.24	0.35
crest	2.02	0.46

The bay mouth barriers of Cherry Hill and Black Point both have bare cobble bars in the centre section, with sand dunes at each end, and wide sand flats or marshes behind. The sand dunes of both systems are in good condition, however there are several trails cutting across the dunes at Cherry Hill, the more heavily used of the two (Fig. 4.28). Although a track runs along the back of the Black Point Barrier, providing access to Little Harbour Lake, it appears to be doing no damage to the system since it is on cobble most of the way (Fig. 4.29).

This type of system, a combination of a bare cobble barrier and sand dunes, may represent the second stage in a developmental sequence, which starts with cobble barrier with a continuous sand dune cap, as occurs at Baccaro and Red Head (Fig.4.30). The third stage would be a bare cobble barrier backed by dunes, a situation similar to that of Round Bay, where a cobble barrier backed by dunes and sand flats exists. The final stage would be a the destruction of all the dunes and the development of extensive sand flats and salt marsh formations. Such a situation exists at Cow Bay, also known as Silver Sands, which used to have high sand dunes and was a popular recreation area (Taylor et al., 1985). In this case, the system was commercially mined, resulting in severe disturbance of the dunes and their vegetation cover, causing the eventual destruction of the dunes.

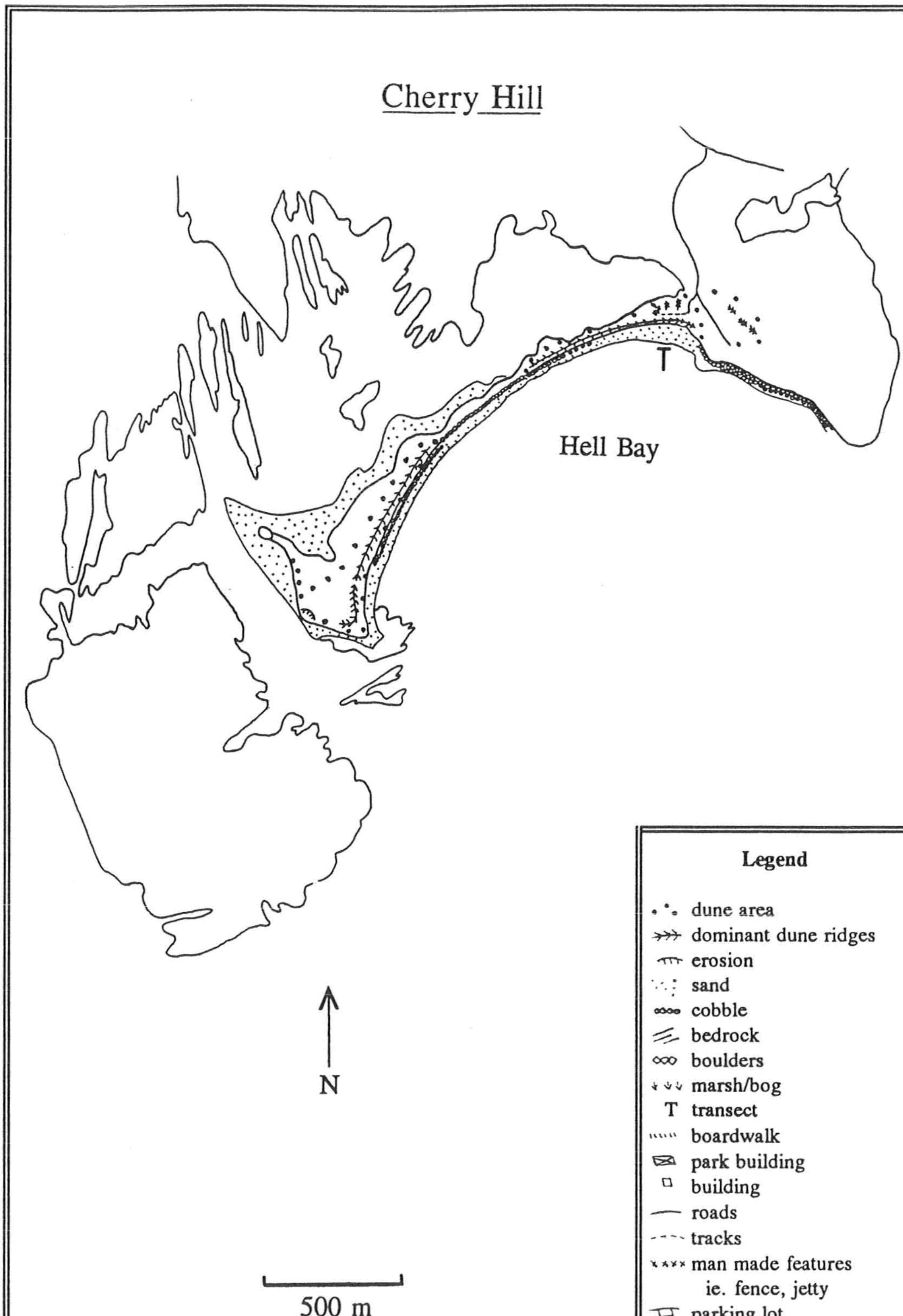
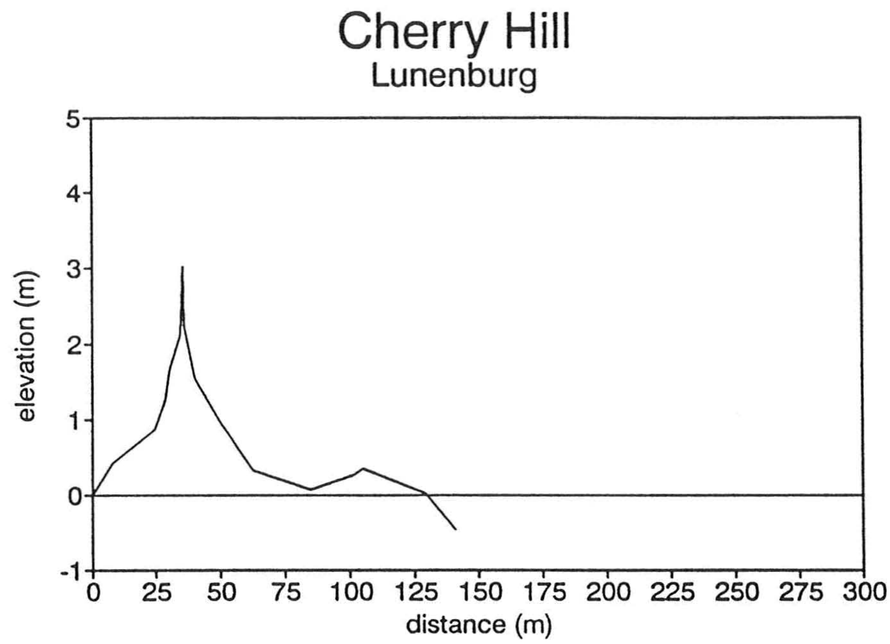


Figure 4.28. Cherry Hill dune system: map, profile and sediment sizes.



Cherry Hill

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.24	0.37
backshore	2.34	0.29
ramp	2.35	0.29
crest	2.36	0.33

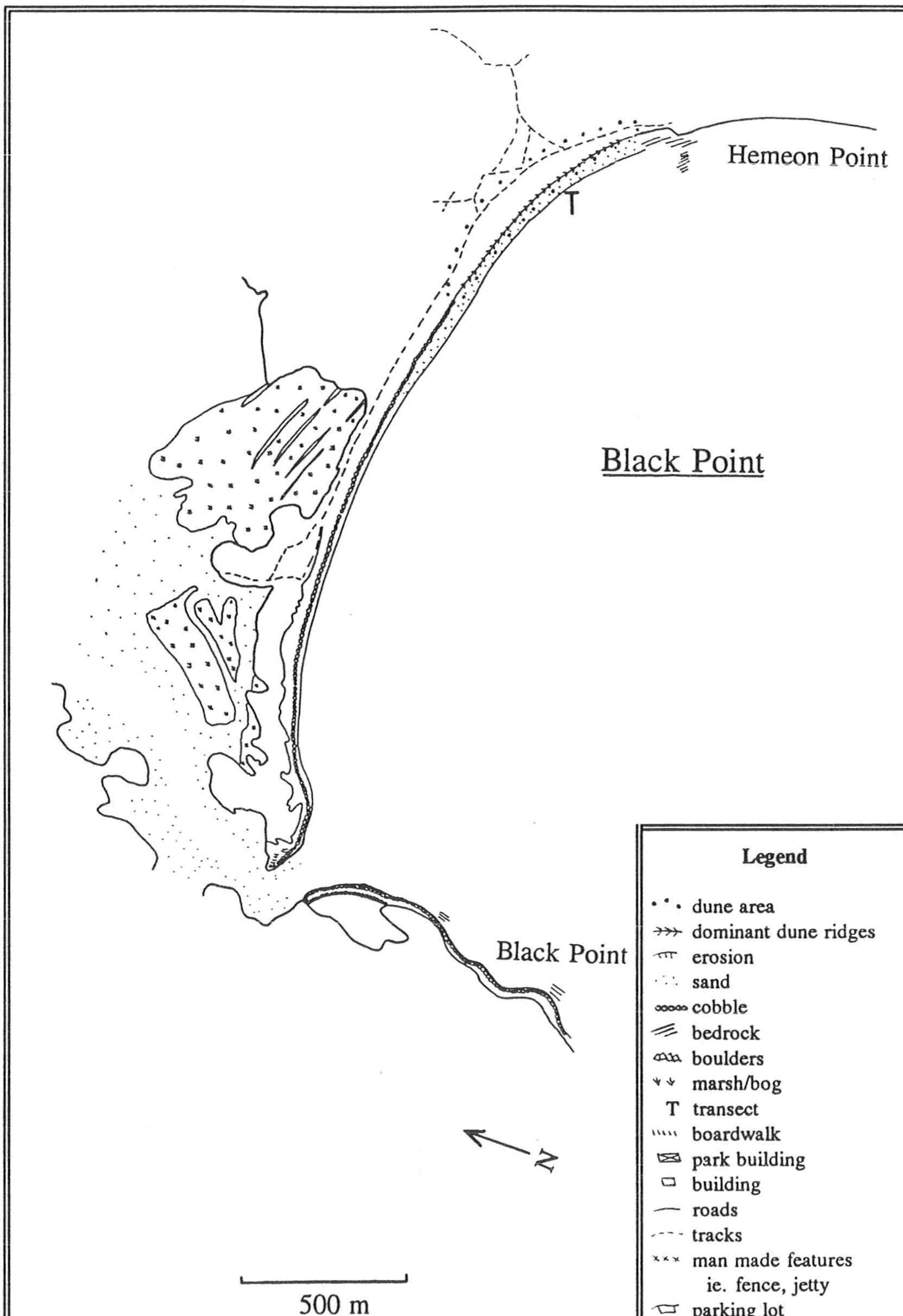
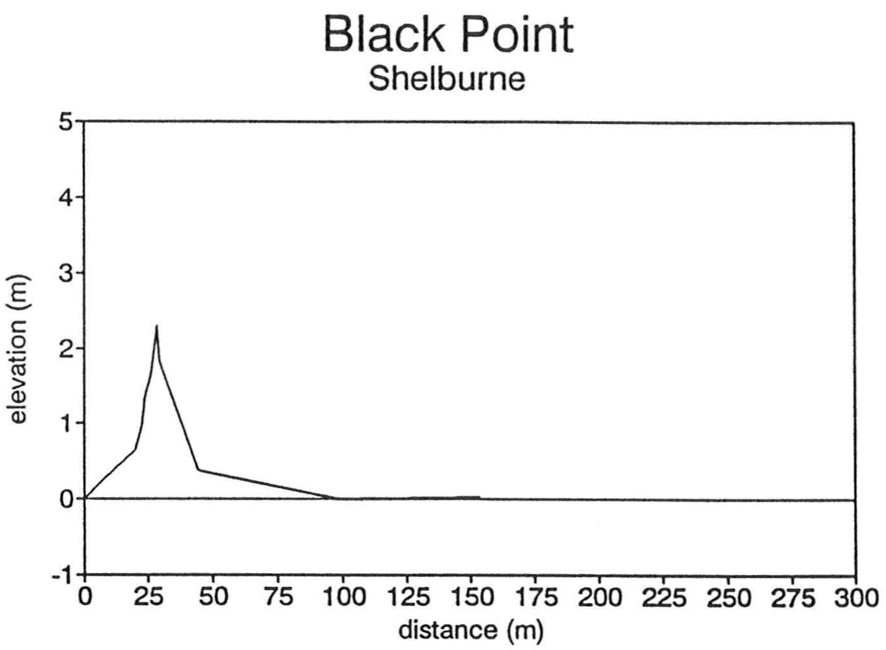


Figure 4.29. Black Point dune system: map, profile and sediment sizes.



Black Point

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.67	0.37
backshore	2.66	0.27
ramp	2.69	0.24
crest	2.62	0.26

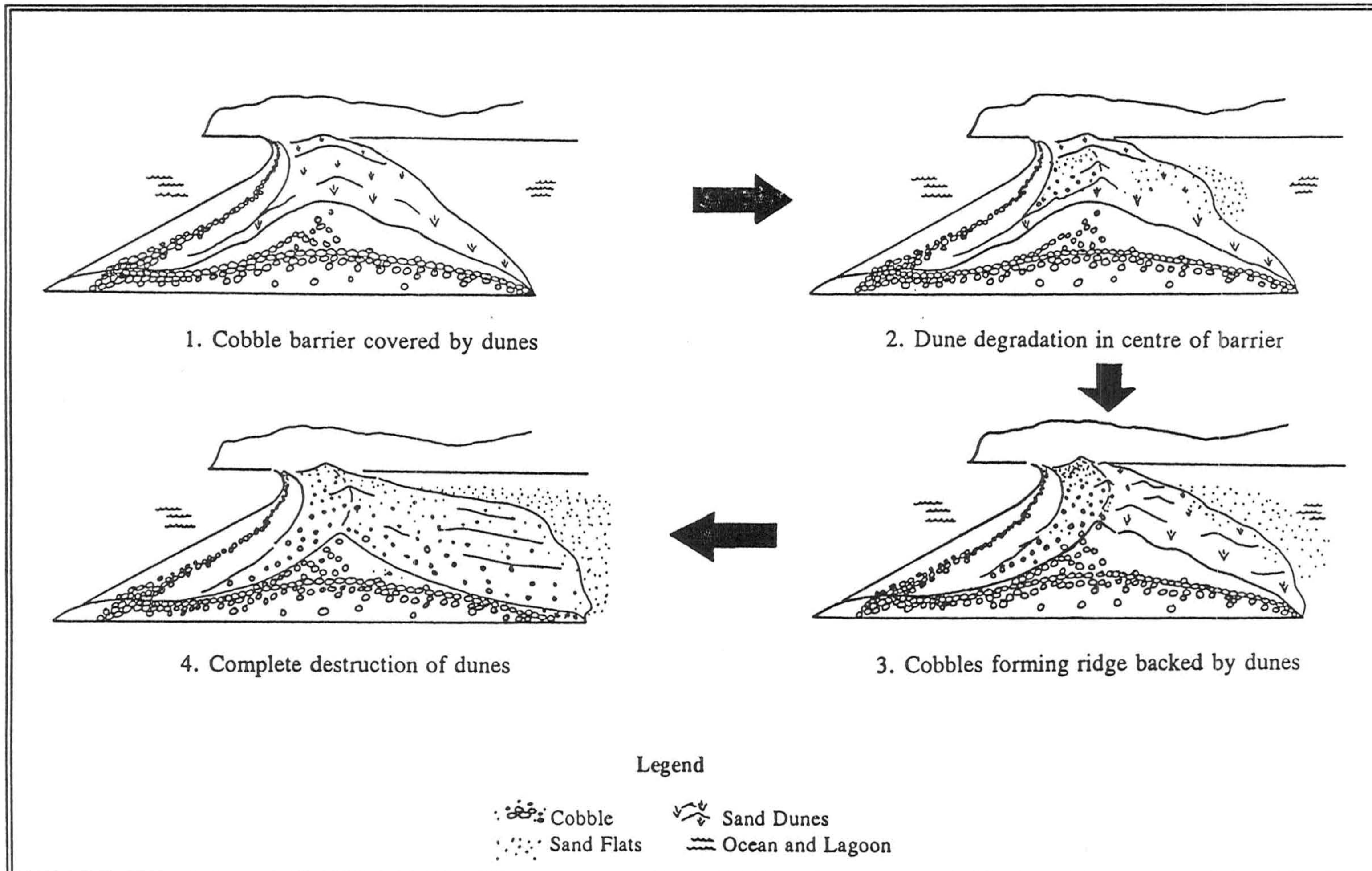


Figure 4.30. Model of the degradation of sand dunes capping a cobble barrier.

Bay Mouth Barriers (sand):

Bay mouth barriers, consisting entirely of sand are more rare, but are found at Cape Sable Island, Crescent, and Martinique. The dune morphology on these barriers is the same as on those formed of coarse clastic material, with a single ridge, a steep seaward slope and a gentle lee slope. Like the other systems, the sand barriers are usually also attached to islands at some point along their length. Crescent is a true tombolo, connecting Bush Island of the LaHave Island, to the mainland, and has a paved road running the length of the barrier. The dunes of this system are very badly eroded, with high dunes, over 2 m, remaining only at the southern end of the barrier (Fig. 4.31). A large salt marsh also occurs at the southern end, directly behind the largest dunes. The remaining dune ridge is very broken, with boulders filling the gaps (Fig. 4.32). A wooden retaining wall protects the windward face of the dunes, creating a strange ramp profile. Despite numerous attempts to repair the system, the barrier is becoming narrower as beach and dune material is transferred to the marsh behind. The first known repair work was done in 1905 following a winter storm, and since then the barrier has been reinforced with car bodies, posts, rocks, trees, and a seawall (Bowen et al., 1975). Crescent beach would have failed and retreated before now if not for the anchoring effect of the road. It is a popular recreation area, and is the only place in the province that cars were observed driving and parking on the beach. The speed limit, twenty-five km/h, was imposed when attempts to keep

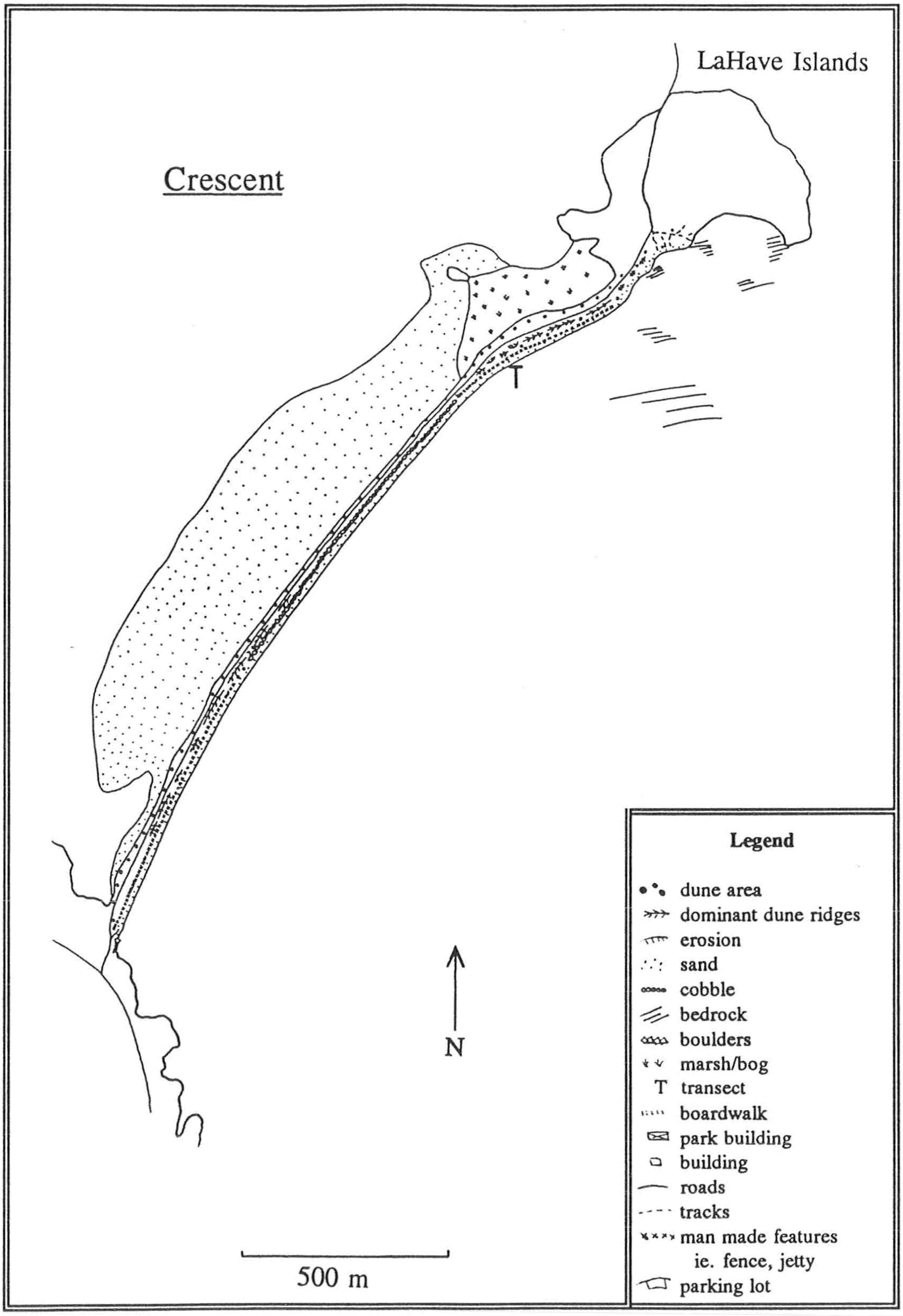
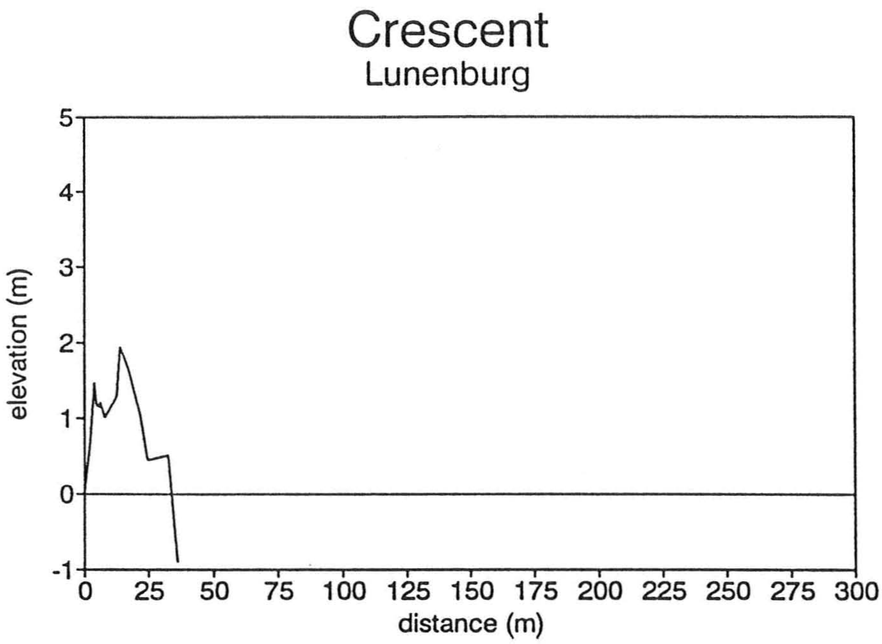


Figure 4.31. Crescent dune system: map, profile and sediment sizes.



Crescent

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.61	0.29
backshore	2.48	0.33
ramp	2.65	0.30
crest	2.65	0.30

Figure 4.32. Crescent, Lunenburg County. Note the narrow width of the barrier, the road along the back, and the high wooden wall along the front of the dunes.

vehicles of the beach failed in the early 1970s (Bowen et al., 1975).

Martinique beach is another that is threatening to fail (Fig. 4.33). The eastern end of the barrier, attached to Flying Point Island, has been breached and rebuilt, and an estimated 9 m of dune was lost of the front of the ridge between 1976 and 1981 (Taylor et al., 1985). The barrier consists of one dune ridge that is widest at the western end, and gets narrower and steeper towards the east. The highest dunes, also the most eroded and narrowest, occur just to the east of a rocky shoal, approximately 2 km along the beach. This shoal appears to be holding the barrier in place, and once the beach moves landward of the influence of the shoal, the centre of the barrier will stretch, narrow and eventually separate from Flying Point Island. During the winter of 1991 - 1992, the most vulnerable area of the dunes, that just east of the shoal, was eroded by wave action along both the front and along the back. Snow fencing along the front of this area had accumulated sand in the past, but much of the fence and the sand were removed during the winter. Martinique has been a provincial park since 1971, vehicle tracks across the dunes are now well vegetated, and the only area where sand removal occurred for local use, at the western end, has recovered.

Cape Sable Island, forming the western shore of Barrington Bay, has numerous dunes, usually a single ridge of 1 to 2 m in height, along its eastern coast (Fig 4.34). They form a series of barriers connecting small islands, with ponds or marshes behind them. The systems at Clam Point, Bakers beach, and from South Side to Hawk Point were visited, with profiles done at Clam Point

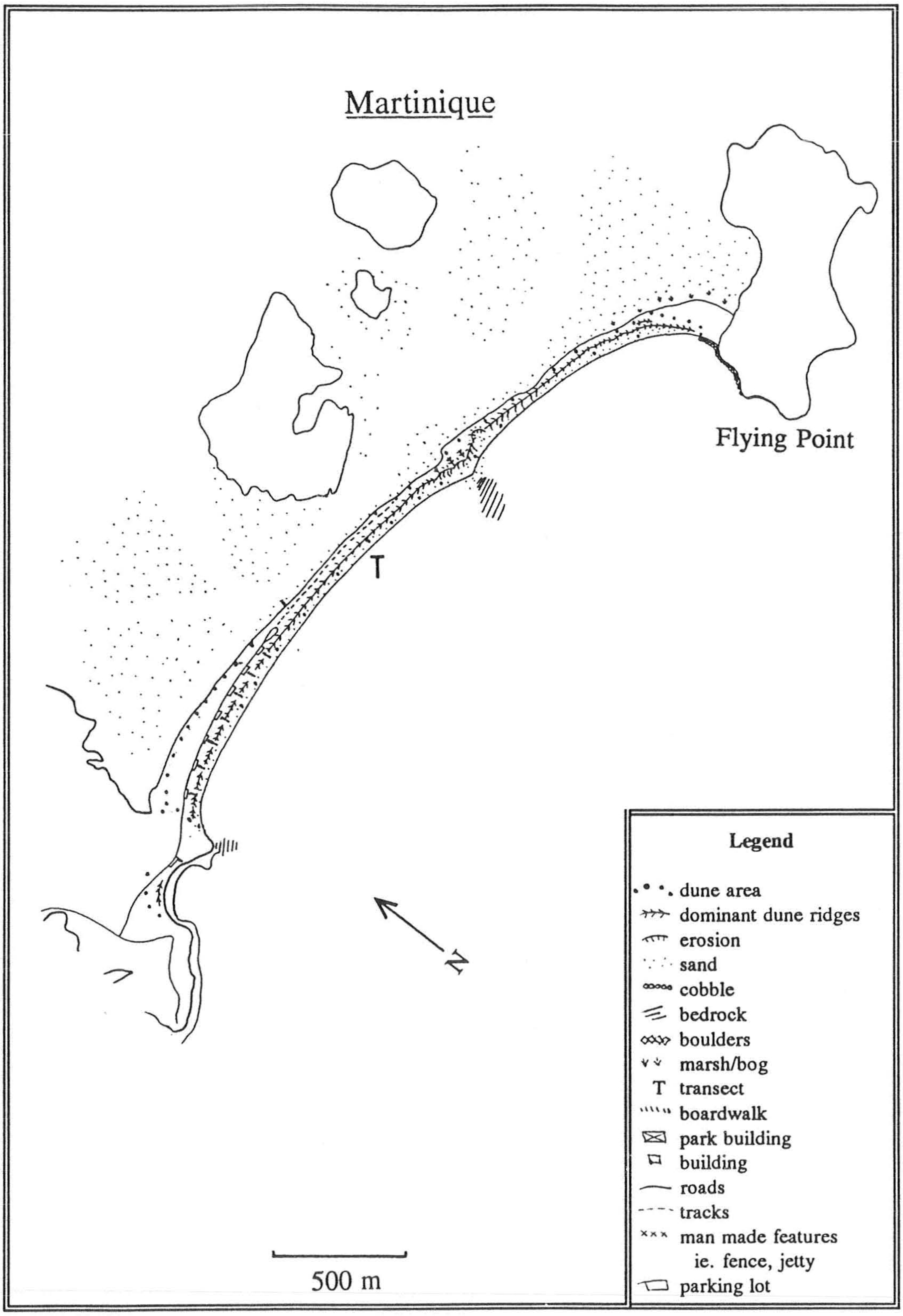
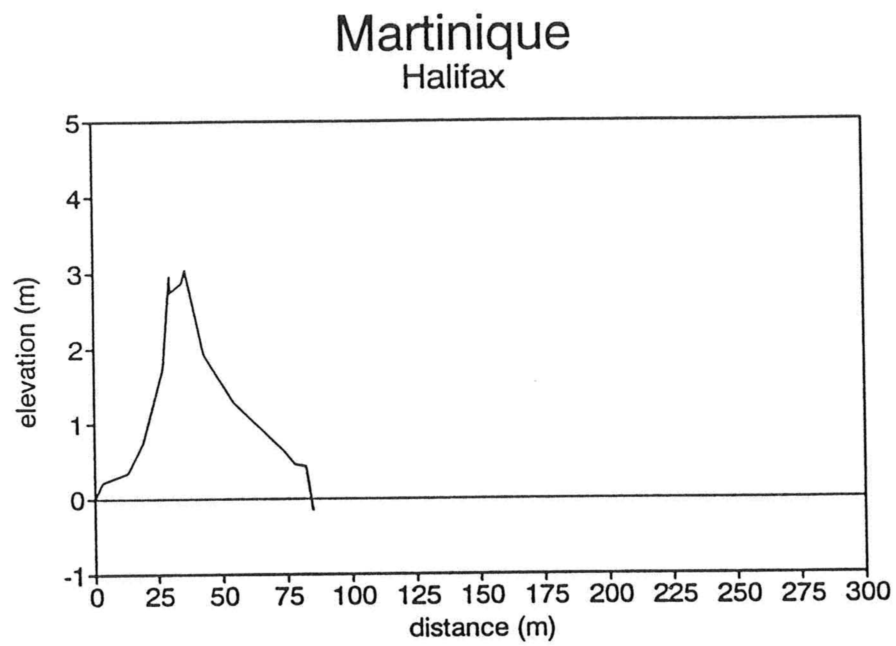


Figure 4.33. Martinique dune system: map, profile and sediment sizes.



Martinique

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.45	0.34
backshore	2.44	0.32
ramp	2.54	0.30
crest	2.53	0.35

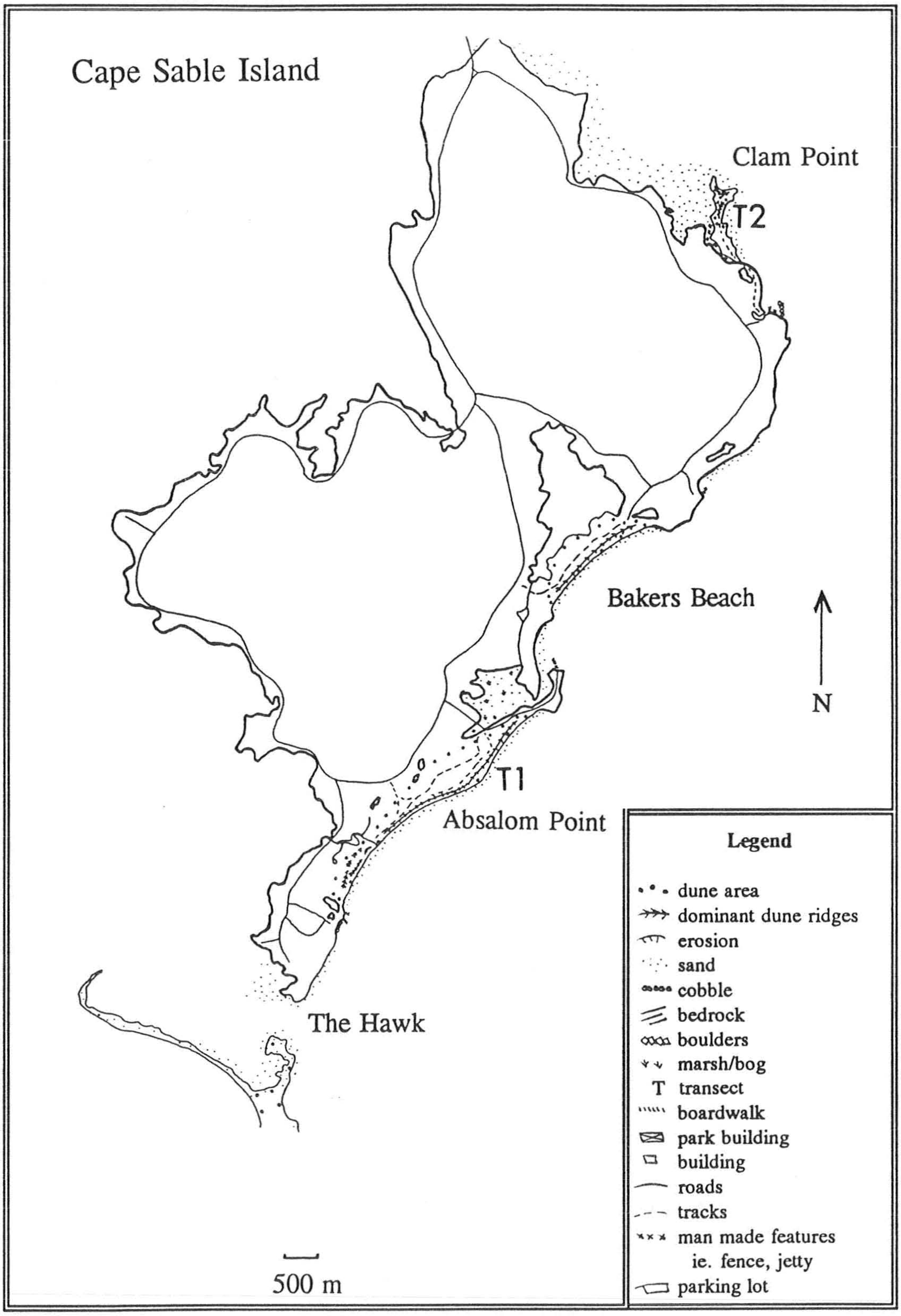
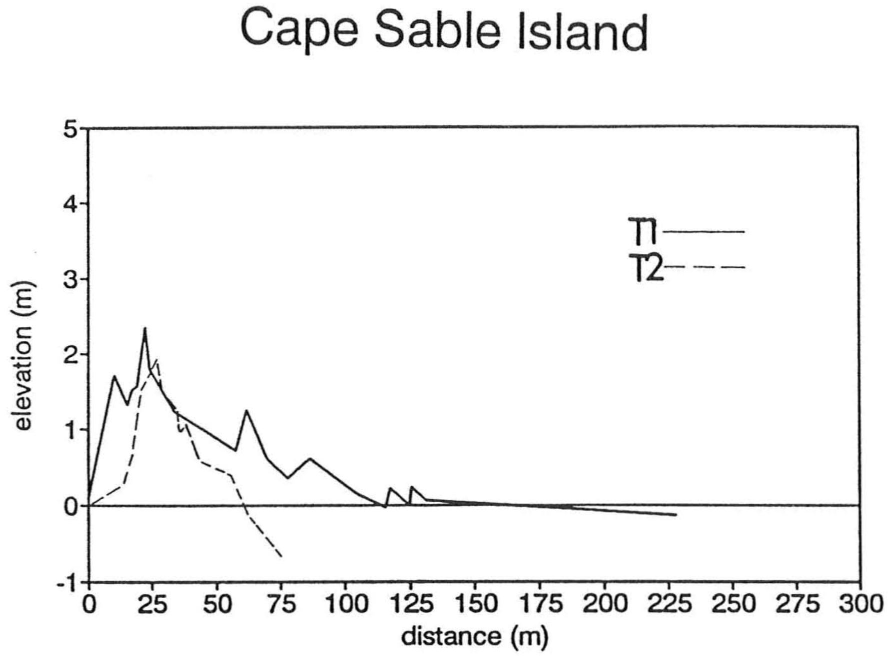


Figure 4.34. Cape Sable Island dune systems: map, profile and sediment sizes.



Cape Sable Island T1 = Absalom Point, T2 = Clam Point

Sediment at transects 1 and 2				
location	T1 mean (O)	T2 mean (O)	T1 sorting (O)	T2 sorting (O)
foreshore	2.49	2.35	0.33	0.69
backshore	2.42	2.65	0.33	0.32
ramp	2.28	2.43	0.46	0.55
crest	2.08	2.49	0.43	0.44

and Absalom Point. The Hawk, an island off the southern end, has large sand dunes on it according to local provincial parks personnel, but was inaccessible without a boat. Clam Point is a system of several small barriers between bedrock islands. The barriers consist of a low, wide, single dune ridge, which is well vegetated and appears to be prograding. A single track exists along the back of the first barrier, and the second has been quite badly cut up by vehicles. According to local residents, all terrain vehicles are heavily used during the autumn, and are doing serious damage to most of the sand dunes on the island. The dune ridge at Bakers beach is also degraded by vehicle tracks, and garbage is common both on and in the dunes (large bits of metal observed sticking out of the dunes). At Absalom Point the dunes, which back a beach rather than a barrier, exceed 2 m in height and there is often more than one ridge. Near Hawk Point there is a prograding foredune ridge, backed by a discontinuous eroding older ridge. The whole system appears to be very active and vulnerable to disturbance, especially by vehicles. Old car bodies were observed in the inlet near Lower Clarks Harbour.

Sand dunes on the eastern side of Barrington Bay occur at Sand Hills Provincial Park. The park consists of a rapidly prograding spit, a barrier with older dunes, now protected behind the spit, and a rapidly eroding set of dunes backing a beach (Fig. 4.35). The major dunes of the area were once those of the beach, however altered conditions in Barrington Bay, following the construction of the causeway to Cape Sable Island, has resulted in severe erosion of these dunes and the subsequent growth of the spit. The dunes of the barrier consist of two ridges, are well vegetated and in good condition. At least one track runs across them and several trails. The dunes of the spit are very low and still subject to washovers. The southern end of the system has only the remnants of much wider, higher dunes, and now consist of one dune ridge, which gives the impression of having been cut in half along its length by wave erosion. The area has a long history of non-native use, starting as the possible site of Fort La Tour built by the French in the mid 1600s. The Acadians settled the area in the 1800s and since then the dunes have been used as pasture and the salt marsh drained for agriculture. Cranberries were commercially grown in the low area behind the dunes until the late 1940s (Bowen et al., 1975).

Beaches:

Sand dunes associated with beaches are only found along the Atlantic Shore of Nova Scotia. Some, such as Sandy Bay, Carters and Tor Bay consist of several bay head beaches connected to small islands. Others, such as Louis Head and Beach Meadows, are associated to a spit formed across the mouth of a river.

Bay Head Beaches:

Sandy Bay, the future site of a provincial campground, is presently isolated due to the fact that it is accessible only by dirt road and a rough track.

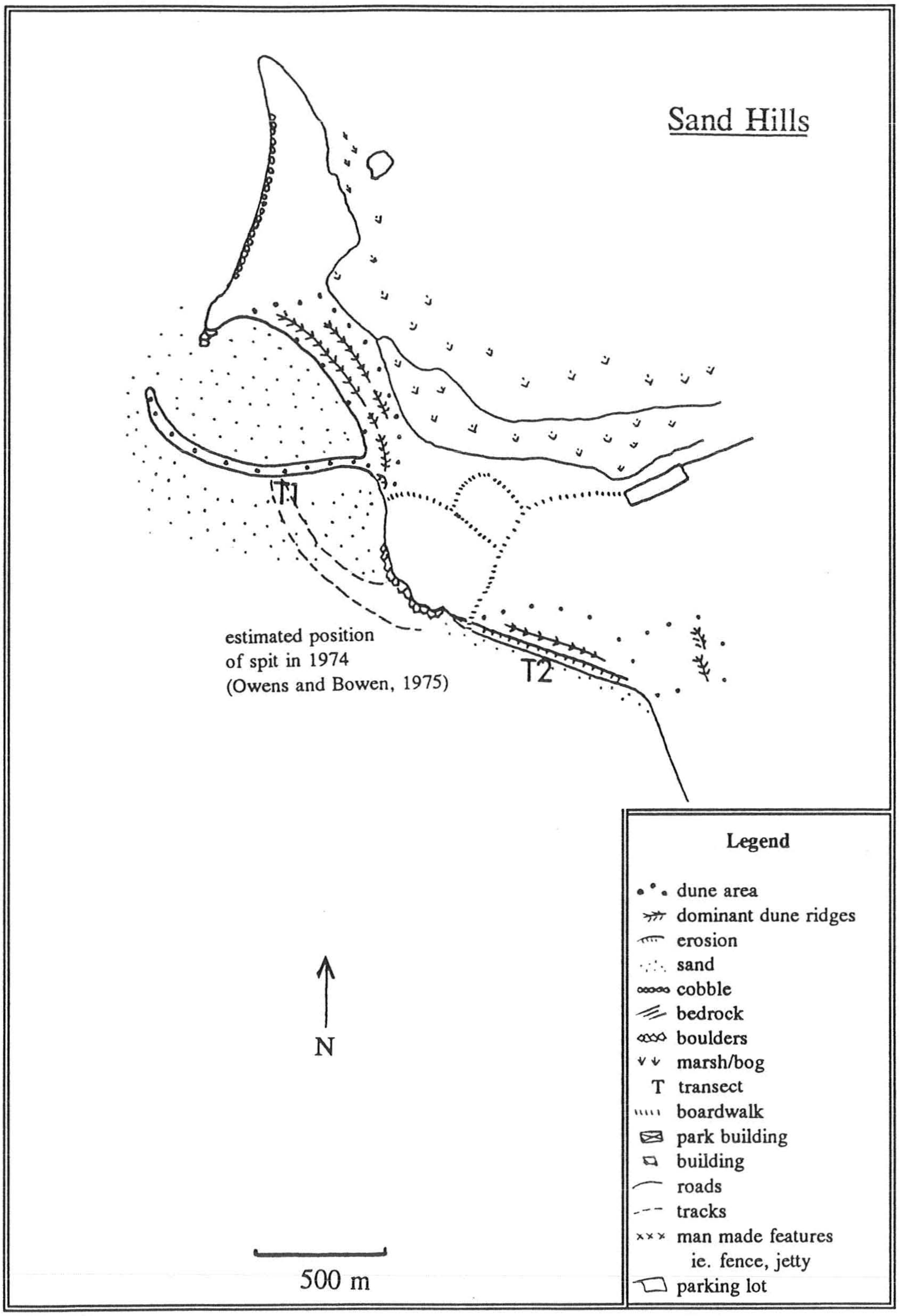
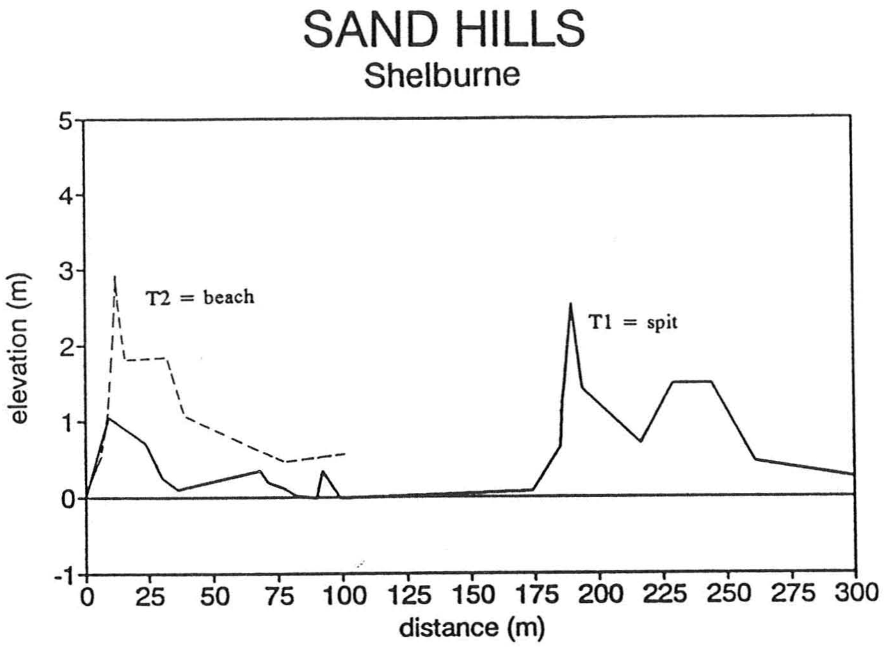


Figure 4.35. Sand Hills dune systems: map, profile and sediment sizes.



Sediment at transects 1 and 2				
location	T1 mean (O)	T2 mean (O)	T1 sorting (O)	T2 sorting (O)
foreshore	1.40		0.82	
backshore	2.15	2.03	0.36	0.74
ramp				
crest	2.04	2.25	0.40	0.35

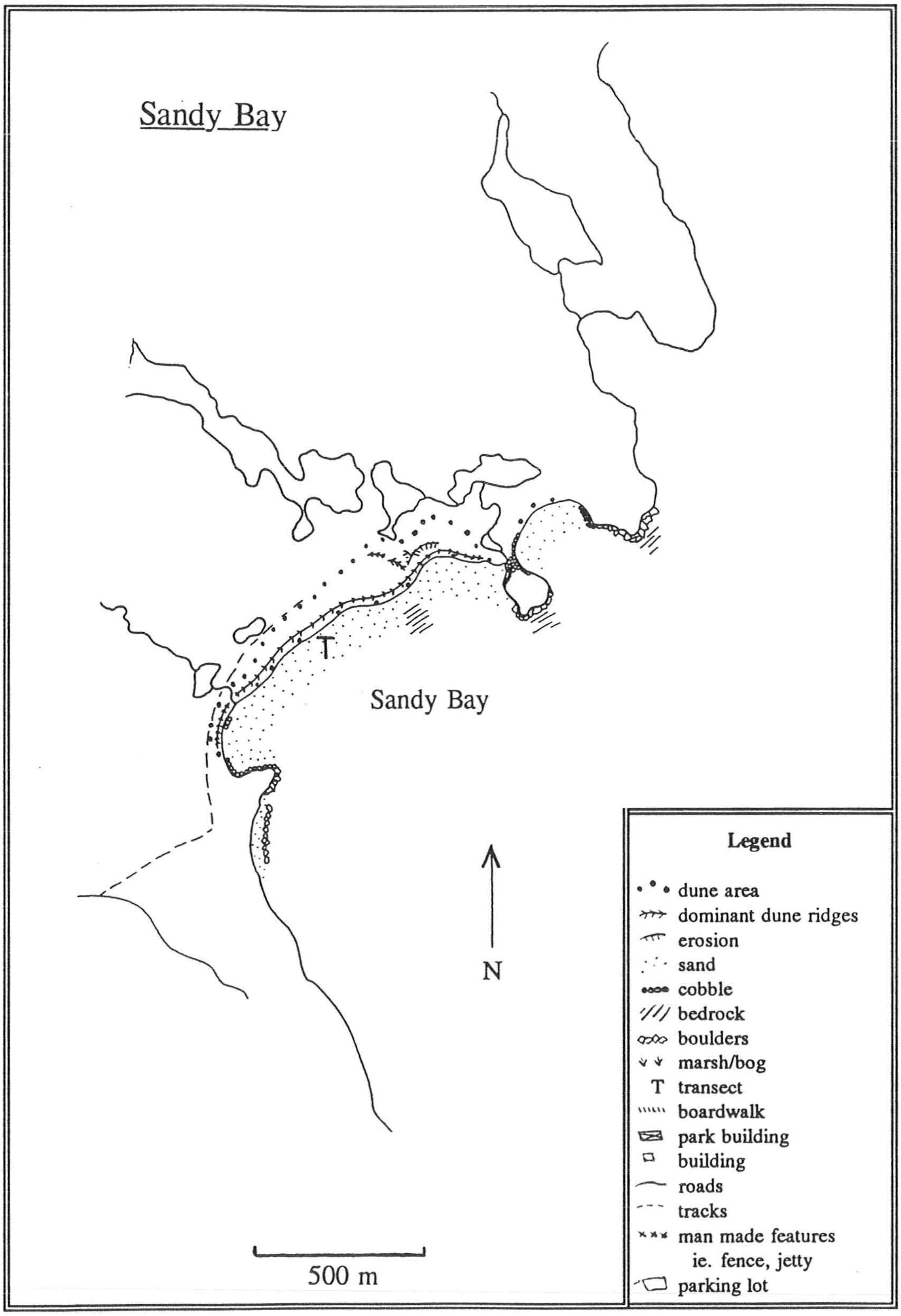
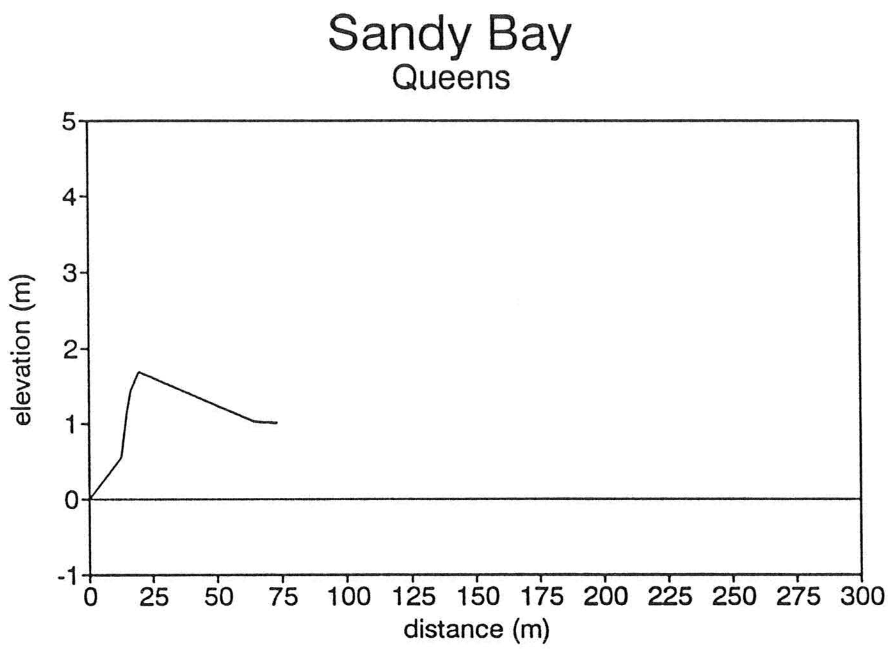


Figure 4.36. Sandy Bay dune system: map, profile and sediment sizes.



Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.27	0.48
backshore	2.42	0.41
ramp	2.08	0.42
crest	2.49	0.52

The dunes occur as low ridges backing three of the four pocket beaches which make up the bay (Fig. 4.36). On the largest beach the dune ridge is approximately 1.5 m above the mean high tide line, and large old dunes exist at the eastern end. These have large blowouts in them, containing the remnants of parties (Fig. 4.37). Other than the blowouts in the large dunes, the low dune ridge is well vegetated, and relatively undisturbed. A track runs the length of the system, adjacent to the forest which backs the dunes. Behind the beach are several ponds, suggesting that once the beach may have been more isolated from the mainland. Ponds also occur behind the beaches at Carters, Tor Bay and Kingsburg.

Carters beach, located on the southwestern shore of Port Mouton, consists of three pocket beaches connected to two small islands (Fig. 4.38). The centre beach is backed by a series of dune ridges of deceasing height, while the other two beaches have fewer, lower ridges (Fig. 4.39). The southern end of the centre beach appears to be prograding, likely at the expense of the large old dunes to the south of the beach. The dunes backing the beach are well vegetated, and are in good condition despite the numerous tracks across them, however the old dunes are very badly eroded by vehicle tracks and the shrub vegetation only remains in patches. This system is the most degraded by all terrain vehicles in Queens County. The sand dunes carry on into the next bay, South West Port Mouton, were the large old dunes continue and the dune ridge which backs the beach is being eroded by wave activity.

Figure 4.37. Sandy Bay. Old dunes with blowouts and remains of an old forest.

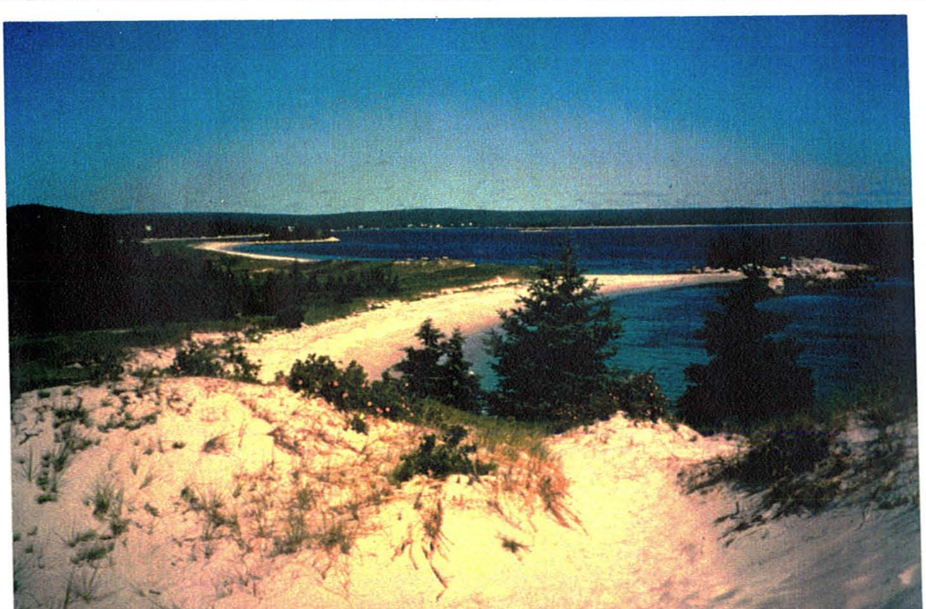


Figure 4.38. Carters Beach. From high dunes towards low dunes backing beach

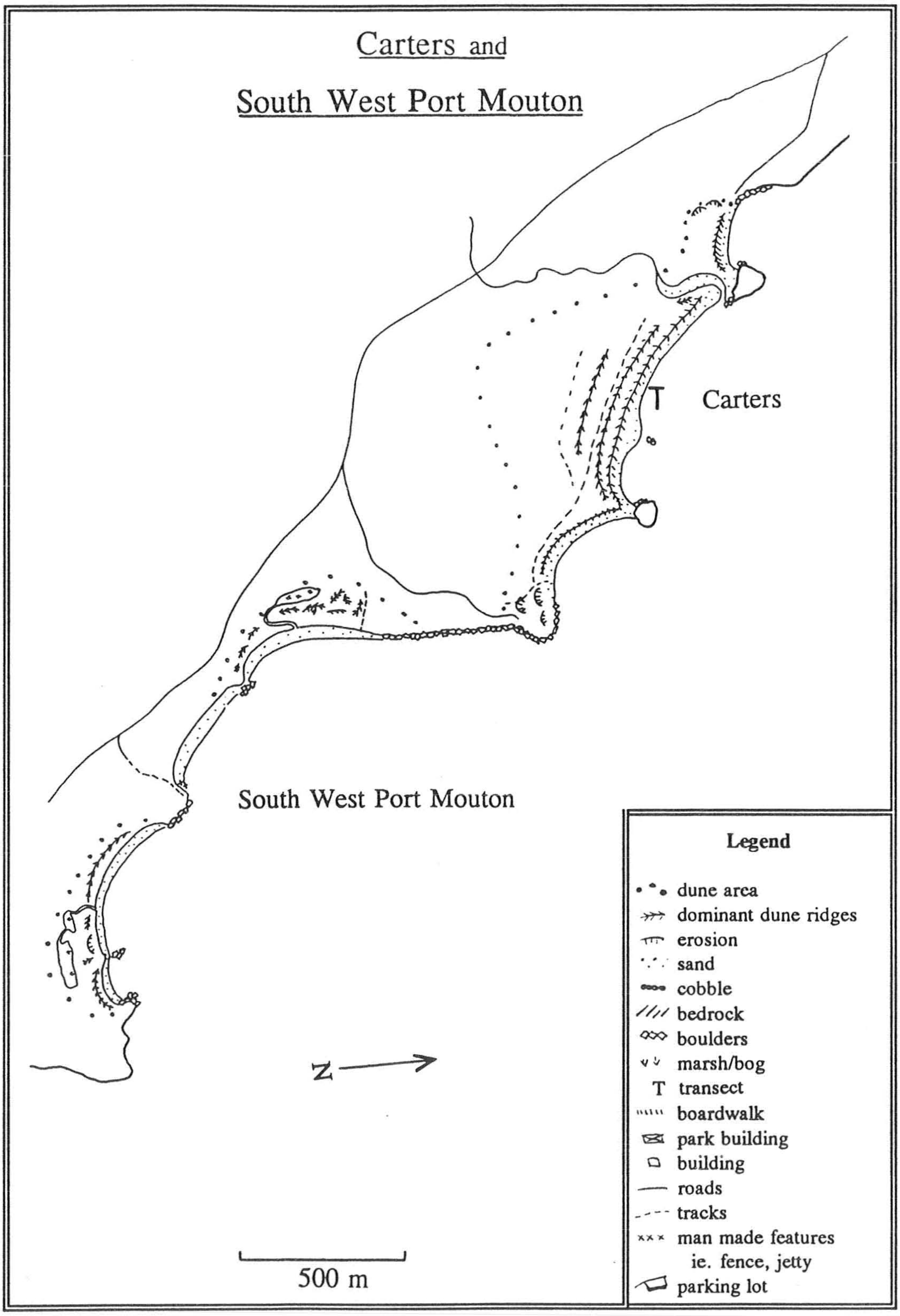
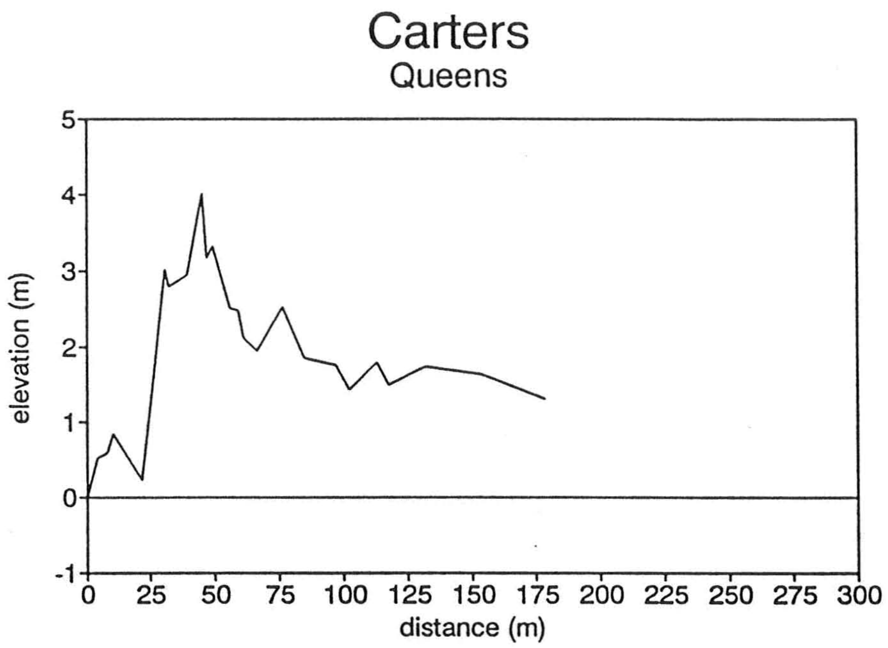
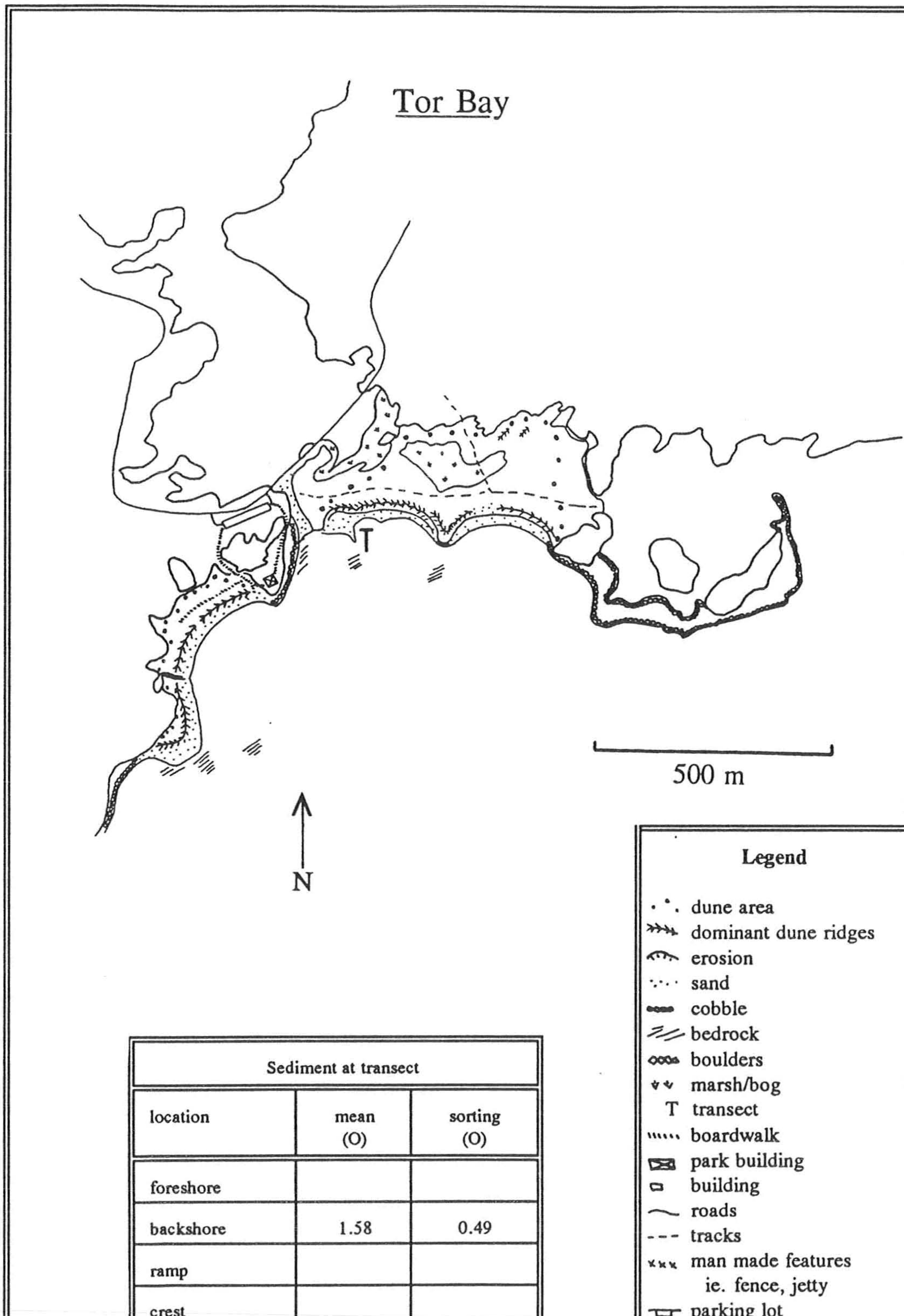


Figure 4.39. Carters and South West Port Mouton: map, profile and sediments.



Carters

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.42	0.41
backshore	2.48	0.35
ramp	2.44	0.35
crest	2.97	0.35



Sediment at transect		
location	mean (O)	sorting (O)
foreshore		
backshore	1.58	0.49
ramp		
crest		

Figure 4.40. Tor Bay dune system: map.

Tor Bay Provincial Park consists of three crescentic beaches backed by a dune ridge which has lower hummocky ridges behind the eastern two beaches (Fig. 4.40). The centre beach is a tombolo, joining a small island to the mainland. Boardwalks connect the parking area to the western beach and dunes, and to the interpretive centre on the rock outcrop separating the western and central beaches, and tracks exist behind the other foredune ridges. The park is not as heavily used other beach parks, and consequently the dunes are intact, with the exception of a breach in the foredune ridge on the eastern beach. Backing this ridge is an area of shrubs and cranberry bogs.

The beach at Kingsburg is the exception to the fine sand beaches of the Atlantic Shore, with medium grained sand on the backshore, ramp and crest. Although the surficial material of the numerous ridges, which extend back into old pastures, is aeolian deposits, the underlying material may be wave deposited beach ridges. It is not possible to determine the formation of the ridges without studying the internal structure. Unlike the neighbouring barrier and dune system of Hirtles beach, Kingsburg does not appear to be supplied by sediment from eroding drumlins, but from rock outcrops and the overlying till. This system probably originated as a barrier, on which the community of Kingsburg is located, and a tombolo, connecting Zinck Head to the mainland (Fig. 4.41). A road exists along the back of the wide stoss slope of the main dune ridge, and a track runs along the crest on this ridge. Several tracks also cut across the dune to the beach. The dunes are well vegetated between the tracks and deposition is

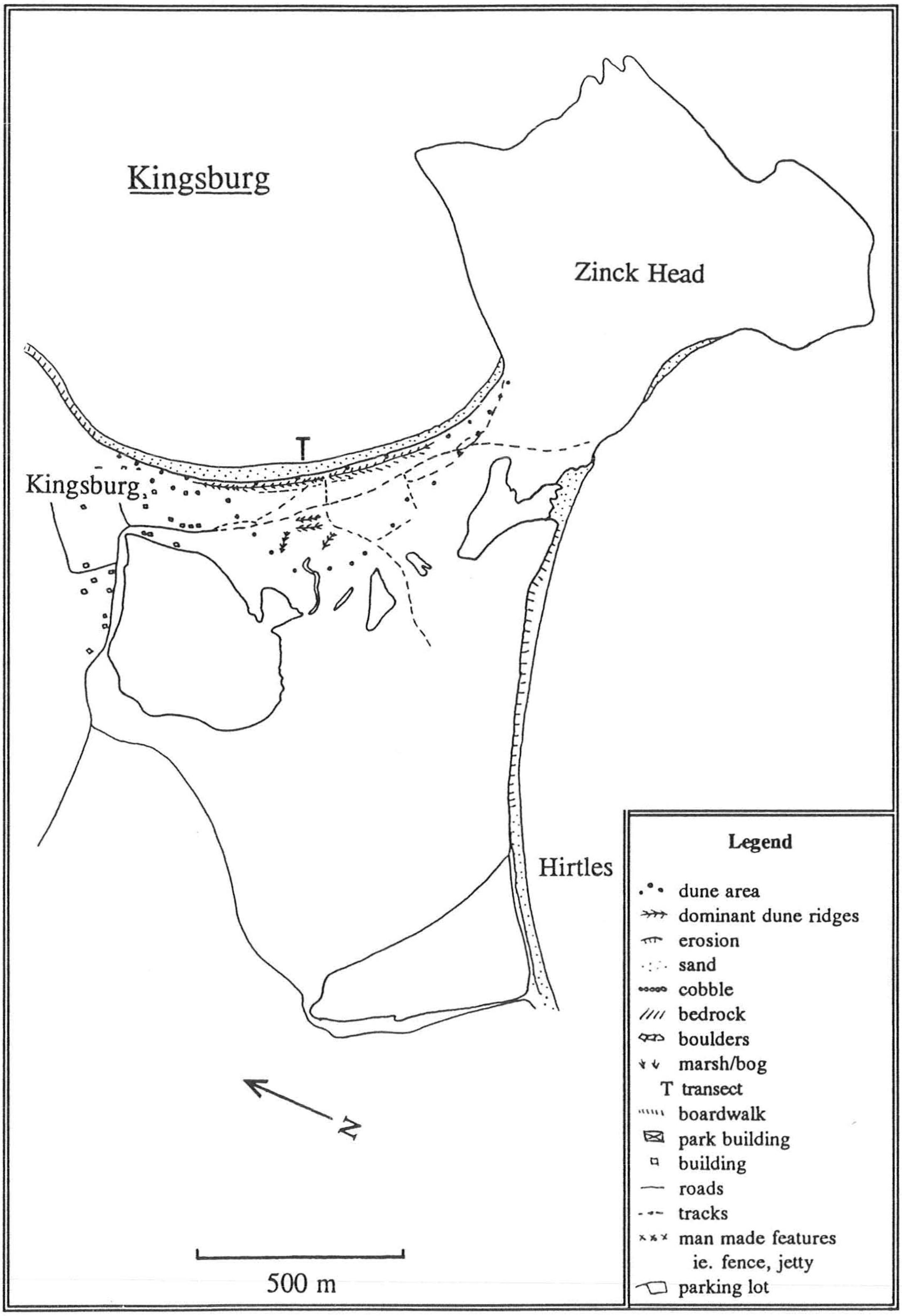
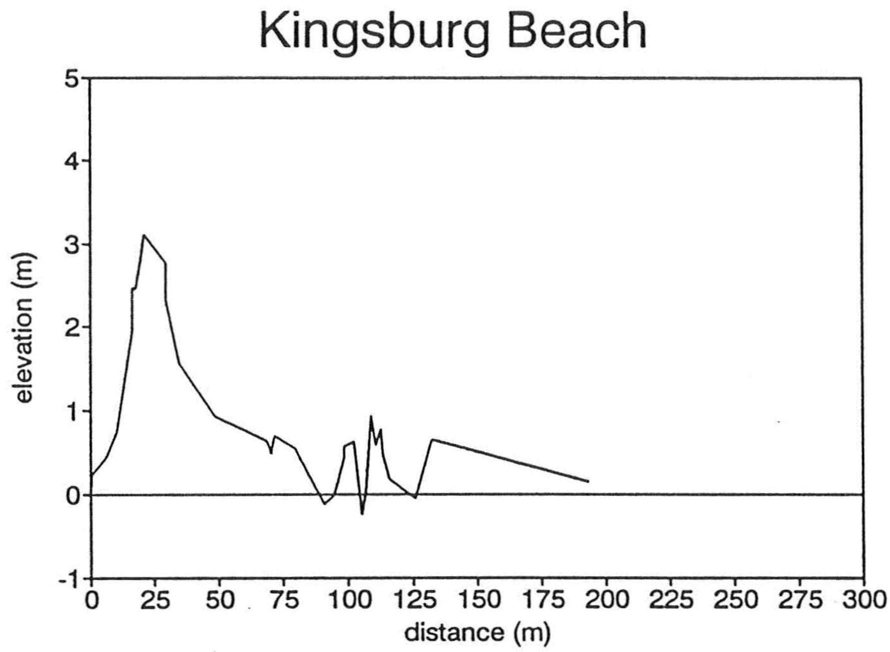


Figure 4.41. Kingsburg dune system: map, profile and sediment sizes.



Kingsburg

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.43	0.42
backshore	1.73	0.70
ramp	1.46	0.46
crest	1.68	0.47

occurring along the ramp. Landward of the main ridge are several lower ridges, separated by moist hollows. These are also well vegetated and support a variety of wild life, including a fox den.

Beaches with Spits:

Louis Head is a popular beach with the local residents, some of whom set up trailers immediately behind the beach. The single, low dune ridge, which exists the length of the beach, is backed by forest and a dirt road. The eastern end of the beach becomes a barrier across Sable River, attached to John Island at the back (Fig. 4.42). According to a local resident John Island has only recently become attached, and there used to be high dunes at the eastern end which eroded during the 1940s. At present, deposition is occurring along the ramp of the eastern half of the beach, while erosion is taking place at the western end, leaving a small, 1 m bluff at the back of the beach. The removal of sediment from the western end by wave activity has exposed the remains of a forest below high tide line, proving that sea level was once much lower.

Beach Meadows, partially privately owned and partially a municipal park, consists of two or three dune ridges to the west of the main car park, with the highest dunes being at the very western end (Fig. 4.43). A privately owned path of mown grass cuts through these dunes, causing erosion only on the front ridge. East of the main parking lot the dunes become a single ridge, culminating in a small spit across a river. The dunes in this location are eroding, as are the back and front of the spit, and deposition is occurring on the far bank of the river. With the exception of those on the spit, the dunes at Beach Meadows are in good condition, well vegetated and protected from excessive damage by foot traffic by seven boardwalks connecting parking lots to the beach.

Roseway Beach, located on the northern side of Round Bay, is a small beach backed by low dunes (see Fig. 4.26). Higher dunes exist in the middle of the beach, adjacent to the road access, and have tracks cut across them. The communities of Roseway and Round Bay were once connected by a bridge across the channel. Round Bay was also much deeper than it is today, deep enough for boats and used as a harbour during the 1800s, according to the local newspaper. Given this sort of activity in the area, it is likely that the dunes were used for recreation and as a readily available source of sand. According to a local resident, horse races were held along the beach, then wide sand flats, not the cobble and rock it is today, from Roseway to Fox Bar in the 1920s.

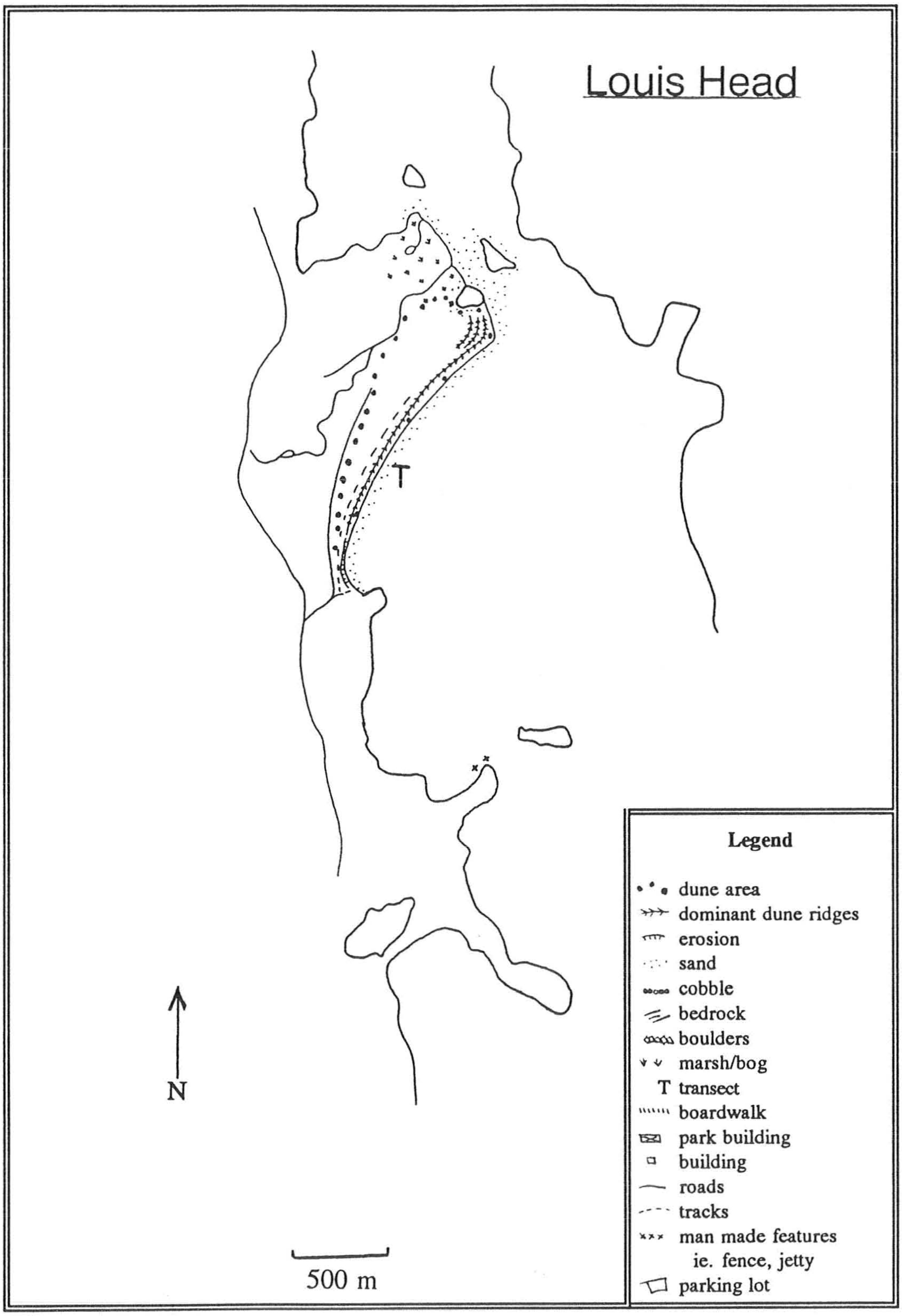
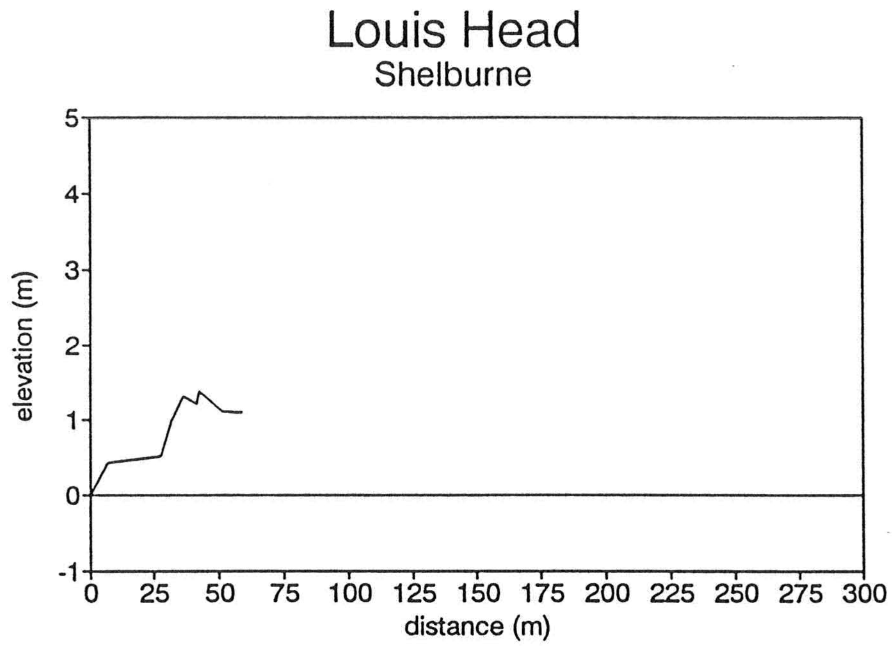


Figure 4.42. Louis Head dune system: map, profile and sediment sizes.



Louis Head

Sediment at transect		
location	mean (O)	sorting (O)
foreshore		
backshore	2.23	1.01
ramp	2.64	0.52
crest		

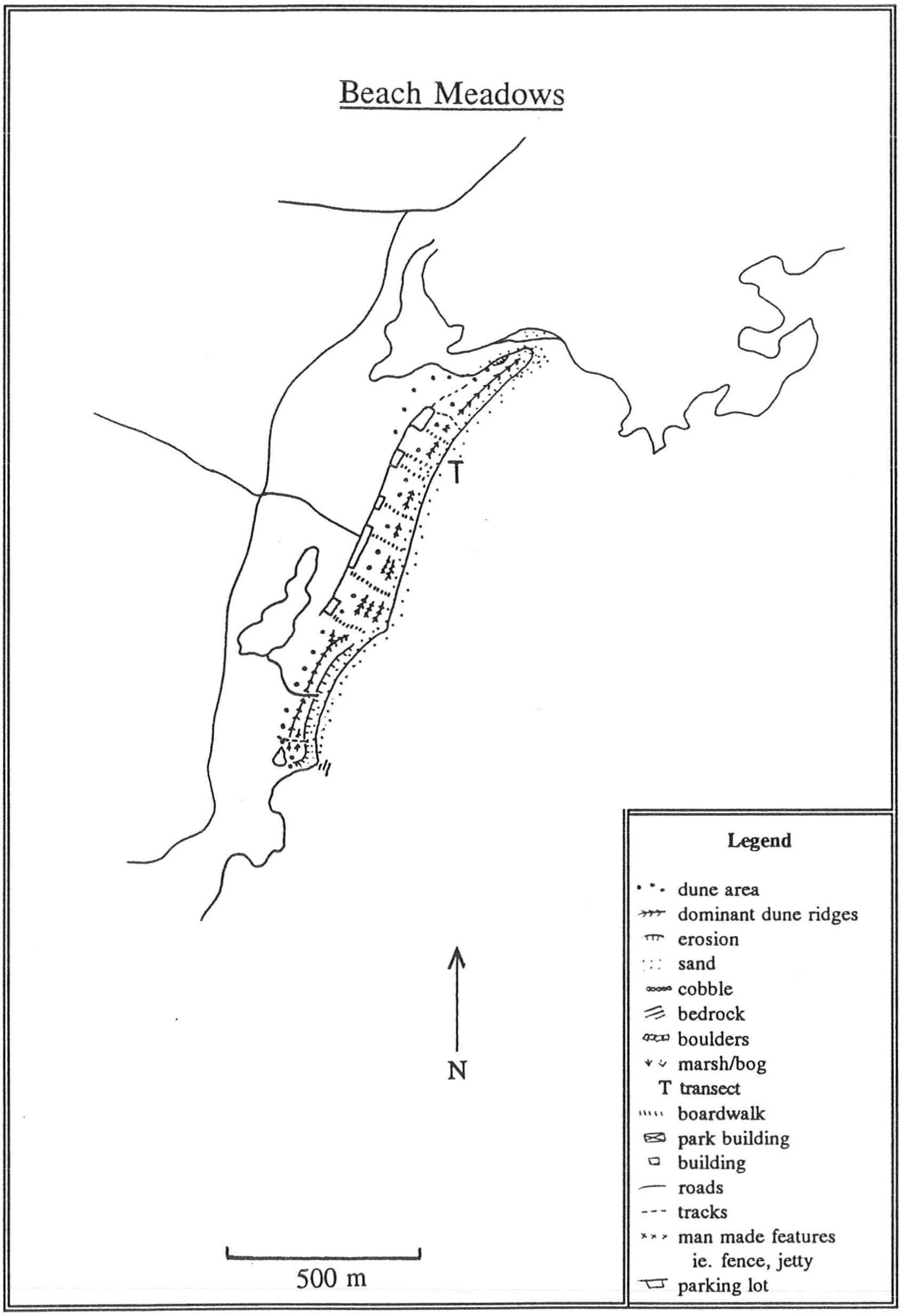
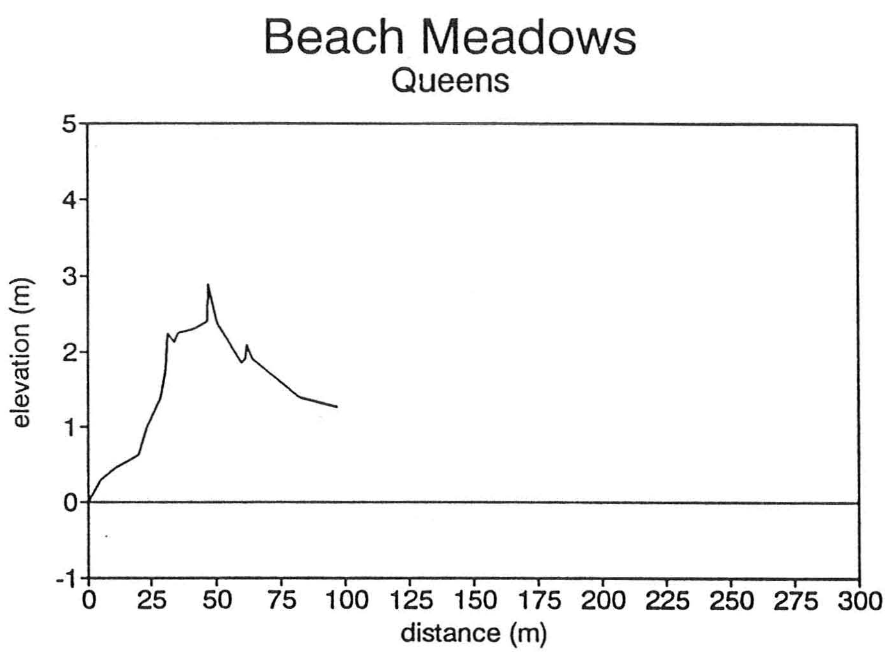


Figure 4.43. Beach Meadows dune system: map, profile and sediment sizes.



Beach Meadows

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.20	0.49
backshore	2.08	0.47
ramp	2.38	0.34
crest	1.98	0.61

4.3.3 Old Sand Dunes

Large old sand dunes occur at several locations on the Atlantic Shore, all of which are south of Halifax and in the areas without modern supplies of sediment (Fig. 4.44). These old dunes, which exceed the height of any other dunes in the province, are often found well back of the current beach in sheltered locations. The old dunes at Sand Hills, estimated to be 8 - 10 m in height by Bowen et al. (1975), are located in the trees at the eastern end of the system, as are those at Cherry Hill (Taylor, pers. comm.). At Sandy Bay and St. Catherines River beach the large old dunes are located immediately behind the modern ones. North of Fox Bar high dunes occur well back of the beach in an area where there are no substantial modern dunes. In some cases, erosion of the old dunes is supplying the sediment required for the growth of the new dunes, as is occurring at Carters beach (Fig. 4.45). The large old dunes at each end of Carters beach, exceed 10 m in height, are part of a larger system which extended south along the beach at South West Port Mouton, where some large old dunes still exist. Large dunes also occur on the northwestern end of Port Mouton Island, directly across the channel from those at Carters beach.

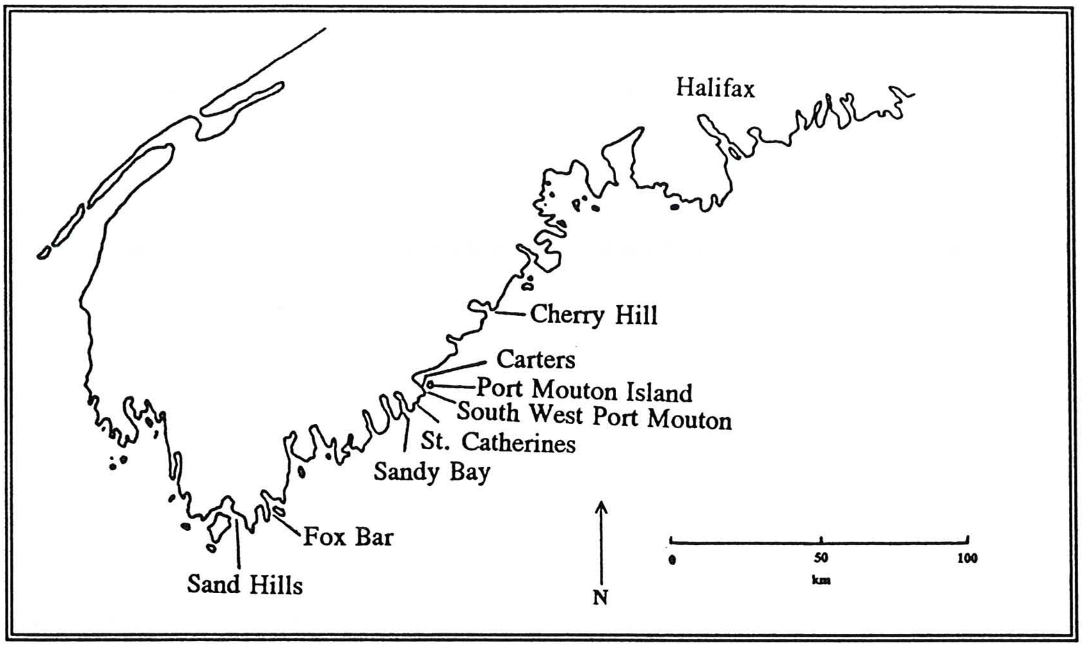


Figure 4.44. Location of old dunes south of Halifax.

Figure 4.45. High old dunes at Carters. Note person on first low ridge on right.

CHAPTER 5

SAND DUNE DESCRIPTION: NORTHERN NOVA SCOTIA

5.1 Introduction

The sand dunes of the northern part of Nova Scotia may be classified into three regional groups, East Cape Breton Island, Northeast Cape Breton Island, and the Northern Shore (see Fig. 4.1, p.51). These three groups only account for thirteen of the forty-two dune systems over 1 km in length studied (Fig.5.1). As in chapter 5, the environment of each region, the sediments, the dune morphology and the dune condition will be discussed.

5.2 East Cape Breton Island

The coastline of eastern Cape Breton Island is cut by long narrow embayments, which follow the regional structure of the bedrock, Carboniferous sandstones, siltstones, shales and coal of the Pictou Group. The area is covered by a till veneer, either a continuous sandy till of 2 - 4 m thick, or a discontinuous sandy, stoney till of less than 2 m in depth (Grant, 1988). The embayments are

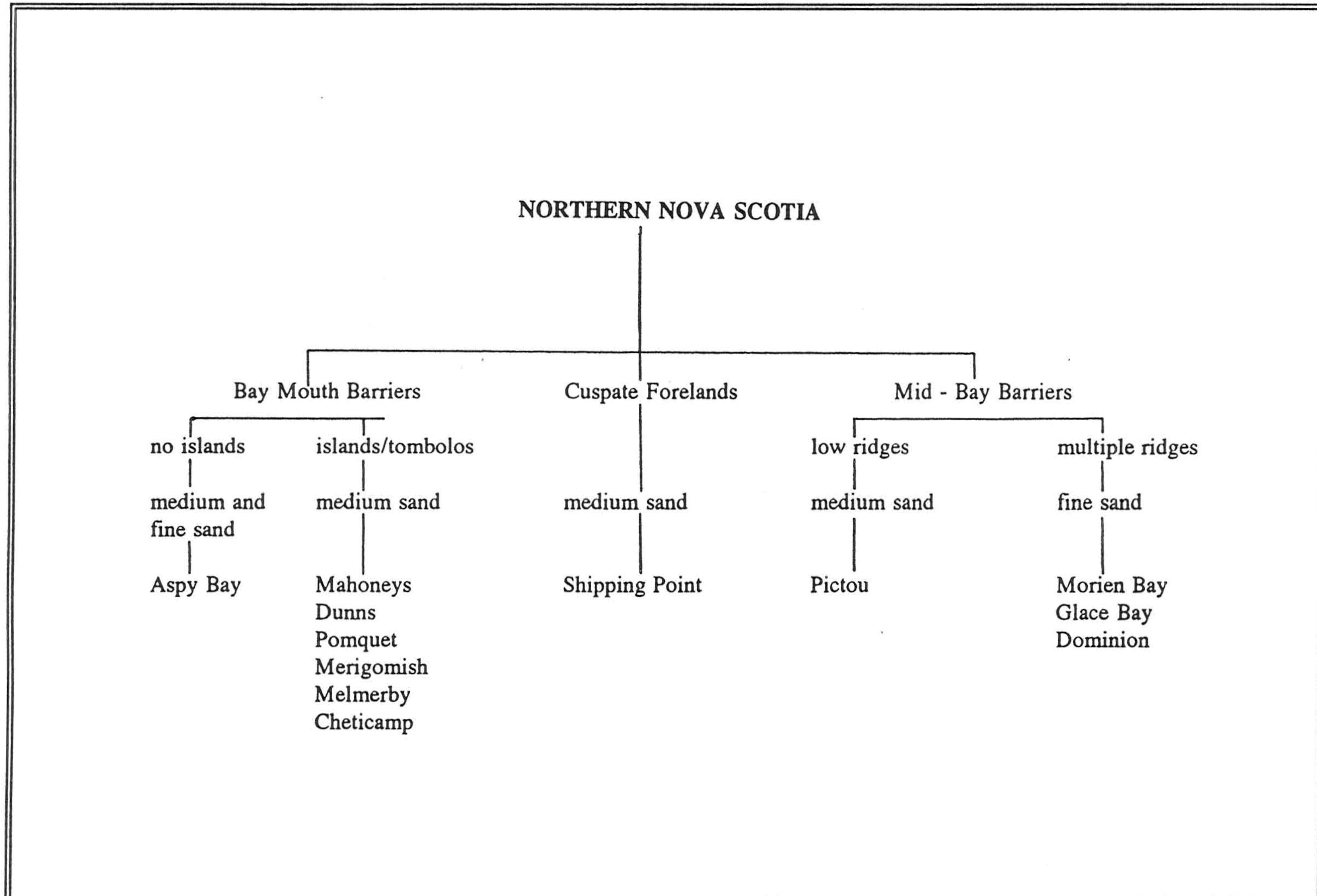


Figure 5.1. Divisions of northern Nova Scotia based on morphology and sediment size.

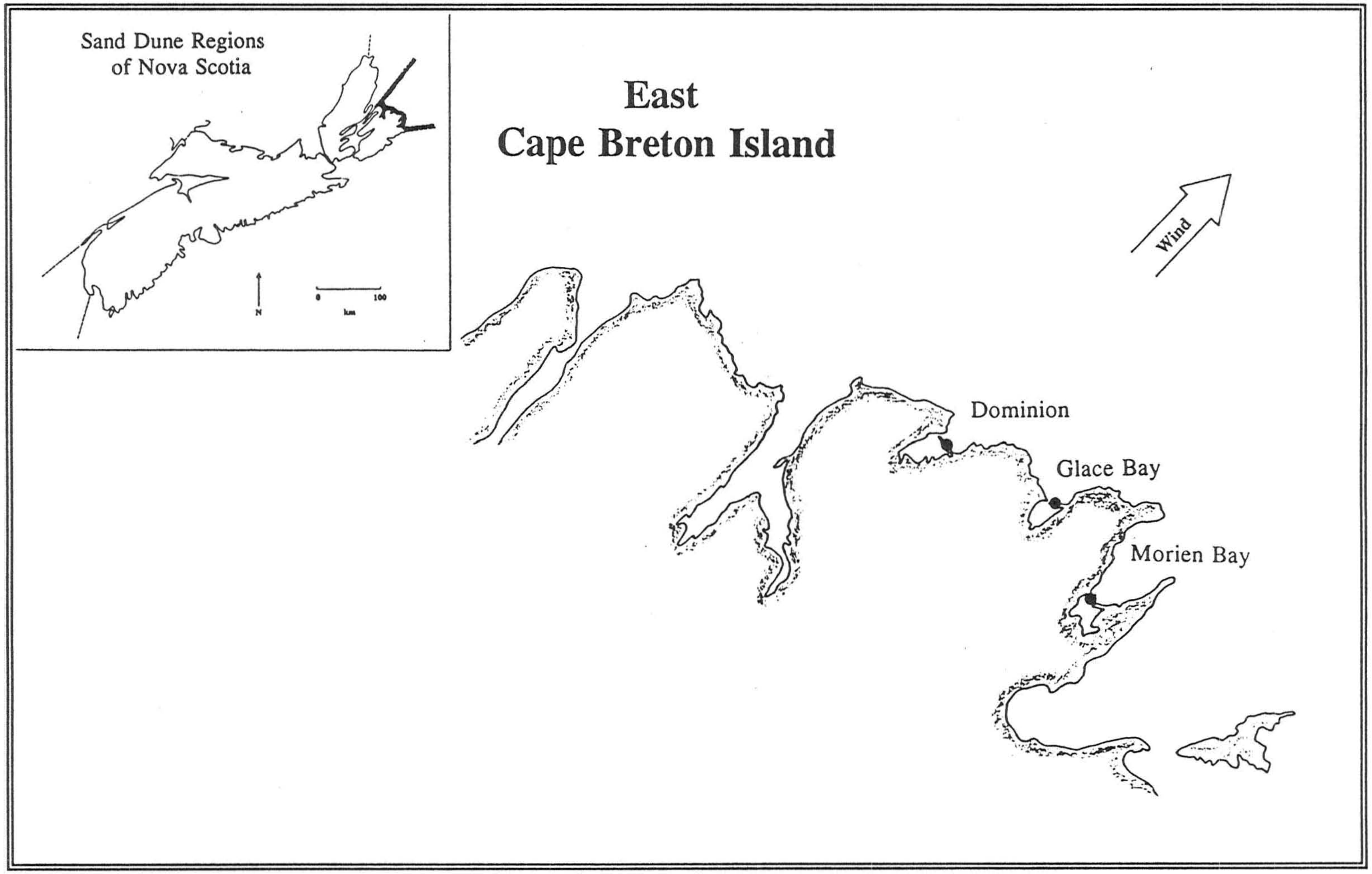


Figure 5.2. Sand dunes of East Cape Breton Island.

exposed to the northeast, but sheltered from waves out of the south and east.

Sandy barriers exist at four locations along the coast, Florence, Dominion, Glace Bay and Morien Bay; of these only the latter three are greater than one kilometre in length. The barrier at Florence, 750 m long, may once have had a continuous dune ridge, but is now badly eroded, with large rocks filling breaks in the dunes and a railway along the back of the barrier. The other three systems are mid-bay spits across Indian Bay, Big Glace Bay and Morien Bay (Fig. 5.2). These spits attach to the mainland at the transition point between continuous and discontinuous till.

5.2.1 Sediment

The dunes of East Cape Breton Island consist of fine sand, with the exception of medium sand on the backshore area of Dominion and on the crest at Morien Bay. The beaches have a bimodal sediment distribution, with pebble to cobble size material found at the landward end of all three spits, where it forms a ridge on Dominion and Glace Bay, and a steep backshore at Morien Bay. Coarser material is also found armouring the dune ramp on all three beaches. The finer material toward the far end of the spits suggests a northwestern transport of sediment along Dominion and Glace Bay, and a southeastern movement along the northeastern spit of Morien Bay. The primary source of littoral sediment is the bedrock cliffs, which are relatively unresistant and are

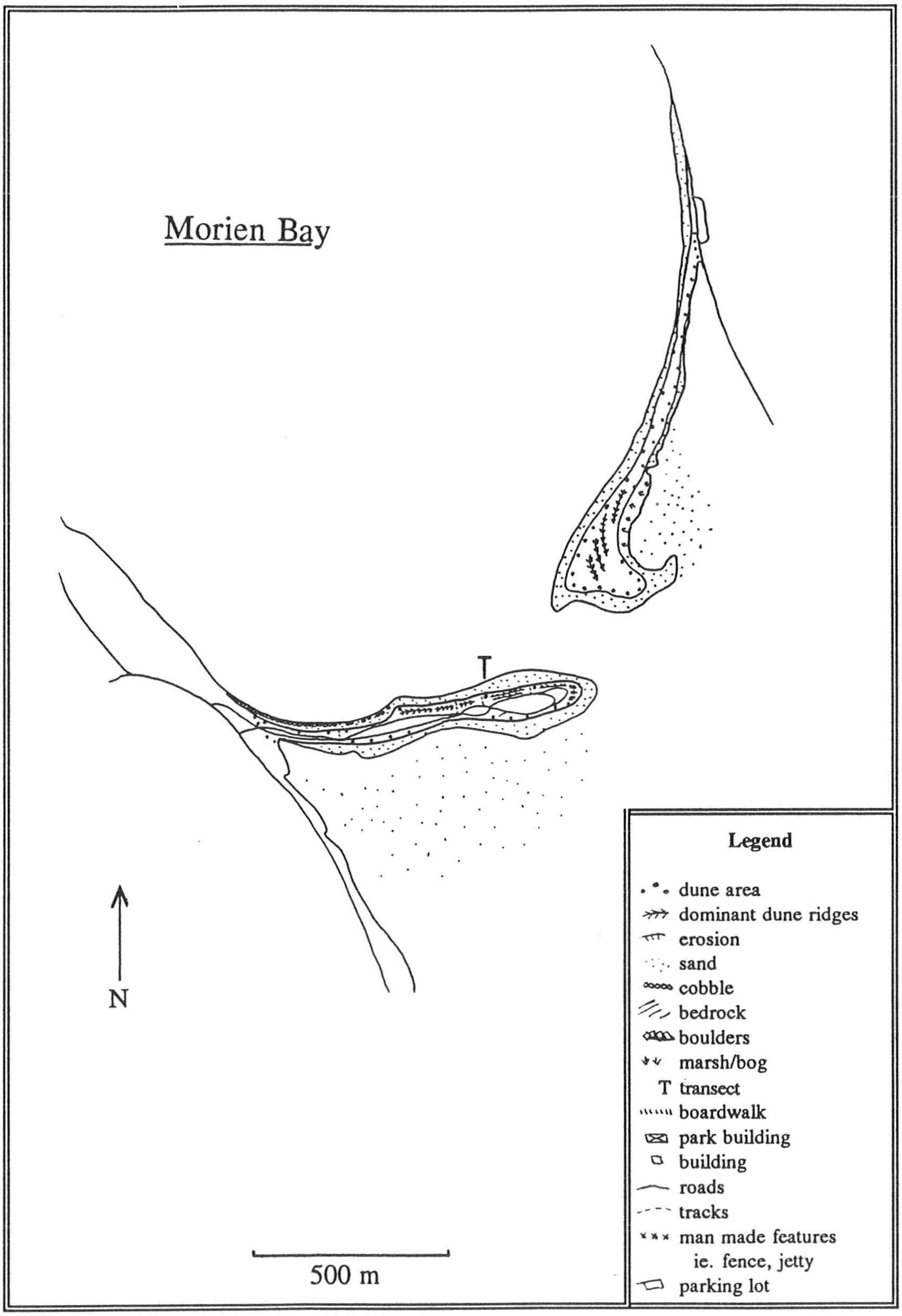
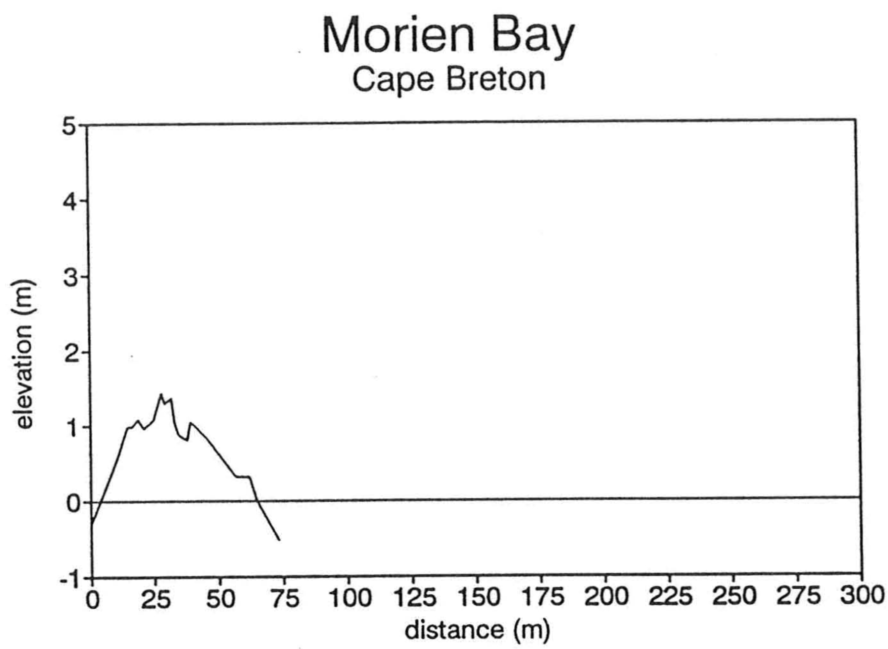


Figure 5.3. Morien Bay dune system: map, profile and sediment sizes.



Morien

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	-1.77	1.31
backshore	2.35	0.64
ramp	2.27	0.80
crest	1.78	1.16

eroding at a rate of up to 0.5 m/a (Bowen et al., 1975).

5.2.2 Sand Dunes

The distinguishing features of the sand dunes of East Cape Breton Island are their location on mid-bay spits, and the series of parallel ridges which range in height from 1.0 - 2.8 m above the high water line, with an average maximum height of 2.2 m.

The system at Morien Bay consists of two spits, each one approximately 1 km long and 60 to 70 m wide (Fig. 5.3). A low dune ridge, with a typical height of 1.4 m above high water line, exists along the length of the northern spit. A series of lower parallel ridges become more distinct toward the far end where they curve landward. The southern spit appears to have a similar morphology, with a series of parallel dune ridges at the distal end, however it is not easily accessible and consequently the dunes have not been degraded by human activity, and are higher, more intact and better vegetated.

The Glace Bay and Dominion dune systems differ from those of Morien Bay in that they consist of a dominant southern spit, with a small or no northern spit, and they are much larger in height, width and length (Fig. 5.4 and 5.5). The Glace Bay dunes have been very badly eroded and at present exist only as scattered remnants on a shingle-sand bar for the first 900 m of the spit (Fig. 5.6). Beyond this point larger, more continuous, but often badly eroded, dunes

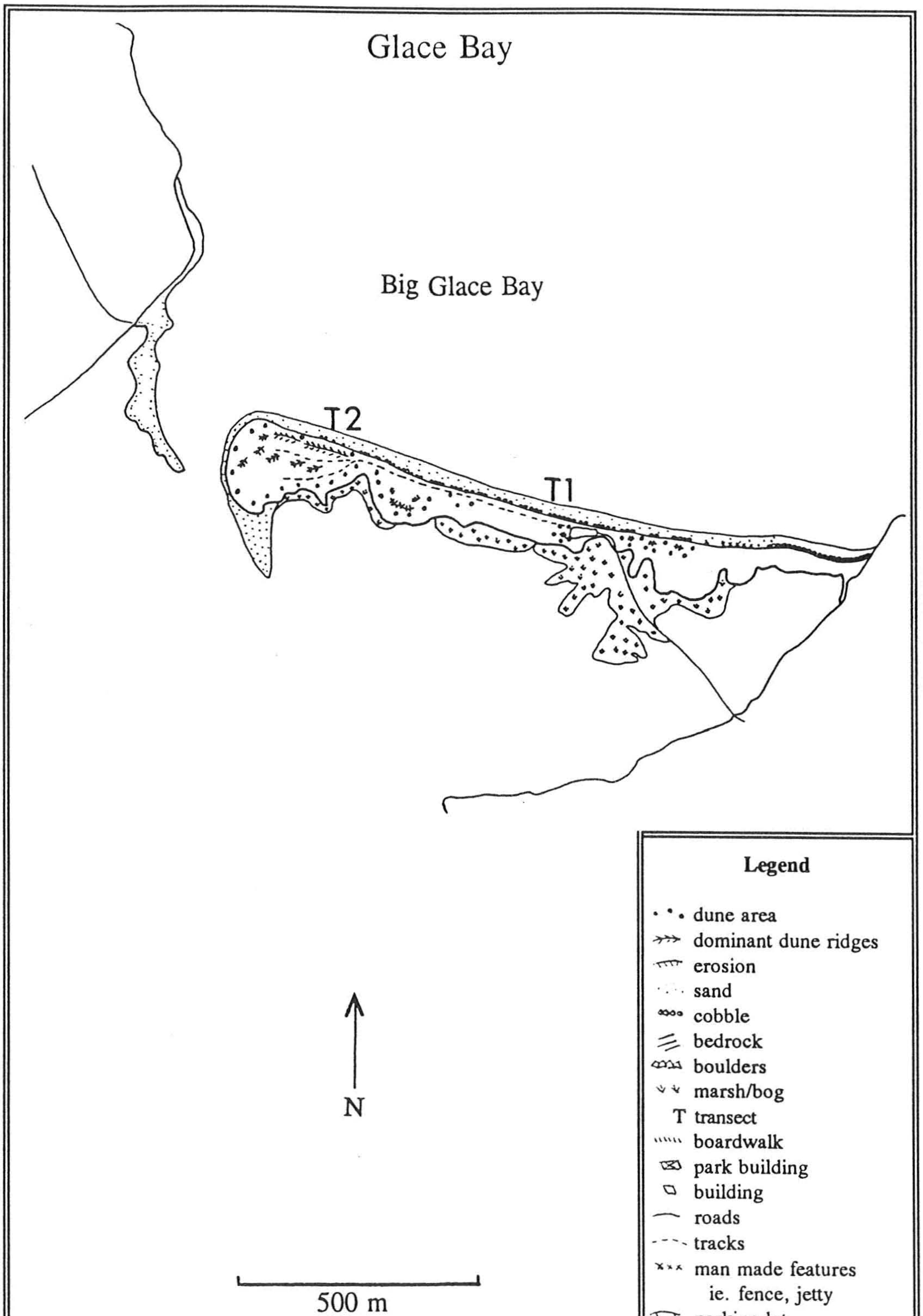
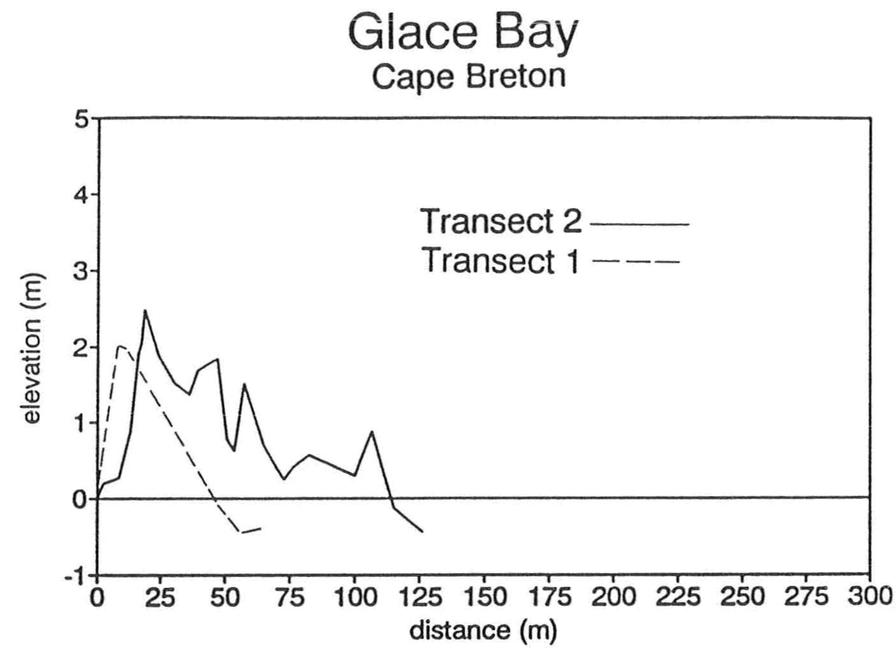


Figure 5.4. Glace Bay dune system: map, profile and sediment sizes.



Glace Bay

Sediment at transect 2		
location	mean (O)	sorting (O)
foreshore	2.39	0.33
backshore	2.40	0.41
ramp	2.26	0.40
crest	2.18	0.38

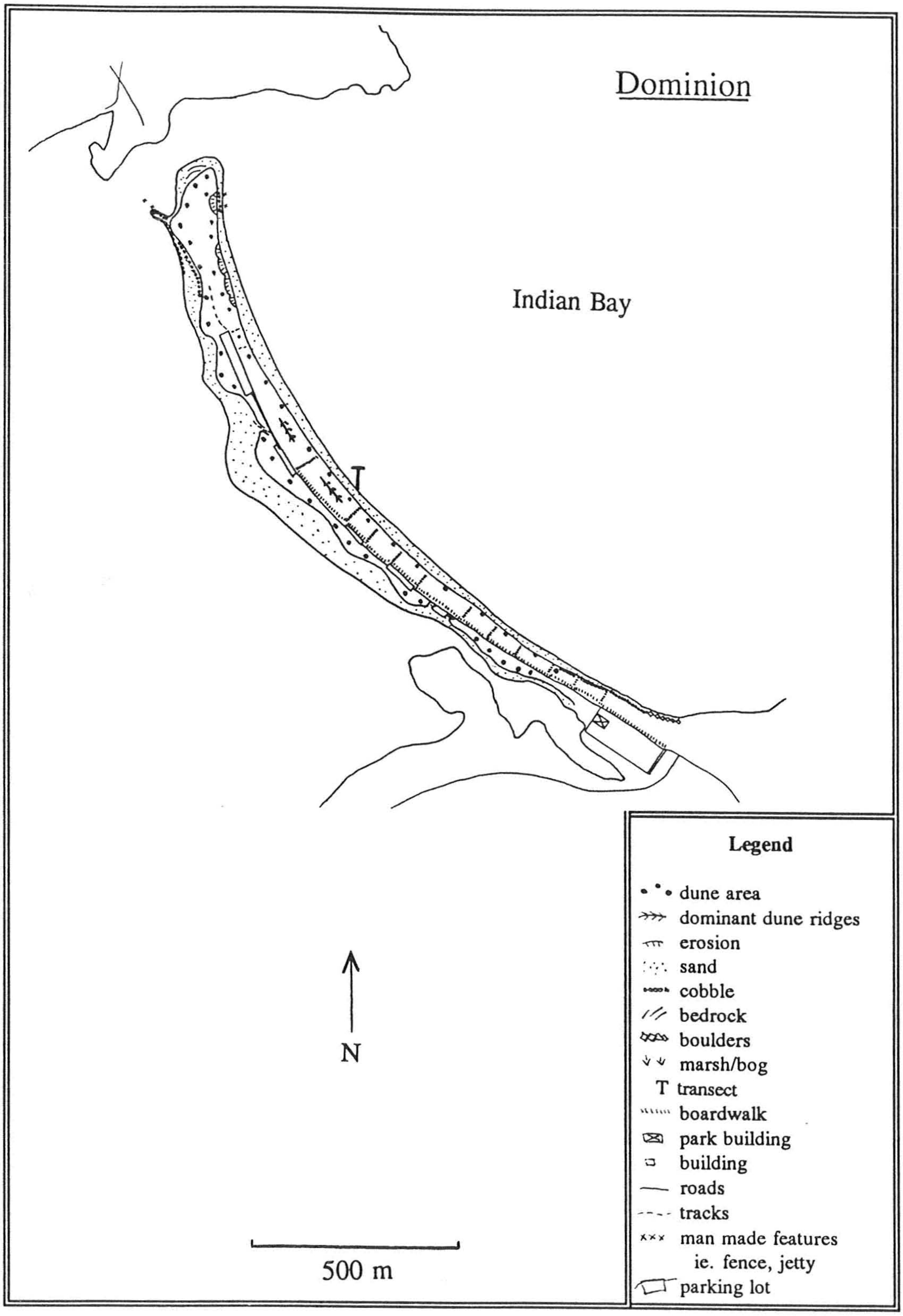
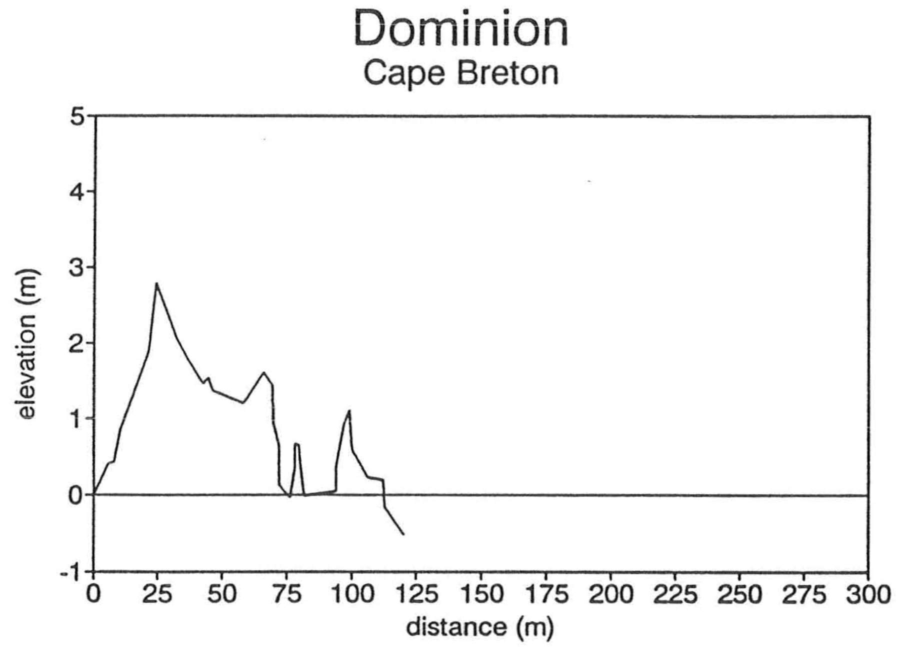


Figure 5.5. Dominion dune system: map, profile and sediment sizes.



Dominion

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	2.45	0.40
backshore	1.59	0.88
ramp		
crest	2.04	0.45

exist, with a typical maximum height of 2.5 m above high water line. These dunes are cut by several sets of vehicle tracks, and are thinly vegetated, with only thirty percent vegetation cover on the foredune ridges, and consequently are probably very mobile. The dune ridges become lower and more complex toward the distal end.

The sand dunes at Dominion Provincial Park are very similar to those of Glace Bay in that continuous dunes begin some distance along the spit, in this case 290 m, and the ridges become more complex toward the far end, with a typical height of 2.8 m above high water line. An unpaved road cuts through the length of the dunes, dividing the higher continuous seaward ridges from a lower discontinuous back ridge. Most of the road is level with the high water line, and consequently is vulnerable to flooding through the three breaks in the back ridge. The highest dunes at the north end of Dominion are being eroded at the seaward edge, indicative of the fact that this spit is migrating landward, as are those of Morien Bay and Glace Bay. Landward movement of sediment across the systems and through the tidal inlets is also suggested by the large sand flats which have accumulated behind each of these spits.

5.2.3 Dune Condition

All the sand dune systems of East Cape Breton Island have been very severely damaged by human activity. Vehicle tracks are currently causing serious damage on the Morien Bay system and Glace Bay, while the dunes at Dominion experienced degradation due to human activity until they were incorporated into a provincial park. Bowen et al. (1975) described Dominion as a line of poorly vegetated, isolated dunes, cut by numerous washovers and blowouts, the remnant of a much larger, higher continuous dune system, reported to have been 8 - 10 m high in the earlier part of this century. The situation has changed dramatically since the system became a provincial park, and, with the help of sand fencing along most of the system, the foredune ridge is once again continuous, with no active washovers. Most of the dunes, including old tracks, are now well vegetated, and numerous (nine, and one under construction) elevated boardwalks and the sand fencing help keep people off the dunes (Fig. 5.7).

The sand dunes at Glace Bay, as mentioned, are very degraded, and exist only as scattered remnants along much of the barrier. Vehicles are the most serious problem on this system, and possibly threaten the integrity of the thinly vegetated dunes at the distal end. The recovery of the dunes at Dominion suggests that a similar revitalization could occur at Glace Bay. Vehicles are also the worst problem on the sand dunes at Morien Bay, where several dirt roads make a series of loops extending the full length of the system. The dune vegetation had been recently burnt, leaving the surface sand vulnerable to erosion.

Figure 5.6. Glace Bay. Dunes eroded by vehicle traffic. Old wharf at waterline.

Figure 5.7. Dominion. Fencing and boardwalks protecting and rebuilding dunes.

5.3 Northeast Cape Breton Island

The coast of Northeast Cape Breton Island consists primarily of resistant Devonian metamorphic and igneous rock cliffs. Sand dunes greater than one kilometre in length are only found in Aspy Bay, which lies along the Aspy Bay fault (Fig. 5.8). The Aspy Bay lowlands are underlain by Carboniferous sandstones, limestones and gypsum, with surficial deposits of glaciofluvial and fluvial material along the North Aspy River and till deposits between the North, Middle and South Ponds. Aspy Bay is exposed to the high energy wave environment of the North Atlantic via the Cabot Strait. However, the potential impact of Atlantic waves is reduced because the prevailing winds are offshore, from the west, and ice exists along the shore during the four winter months (Owens and Bowen, 1977).

5.3.1 Sediment

Most of the littoral zone of Northeastern Cape Breton Island is sediment starved with the exception of a few bays, such as Aspy Bay, where till deposits exist along the shore. Modern sources of sand in Aspy Bay are limited to local accumulations of till between Dingwall Harbour and Middle Pond, and Middle Pond and South Pond. The outer shores of Aspy Bay provide little sand to the littoral zone since they consist of rubble talus slopes and cliffs of metamorphic

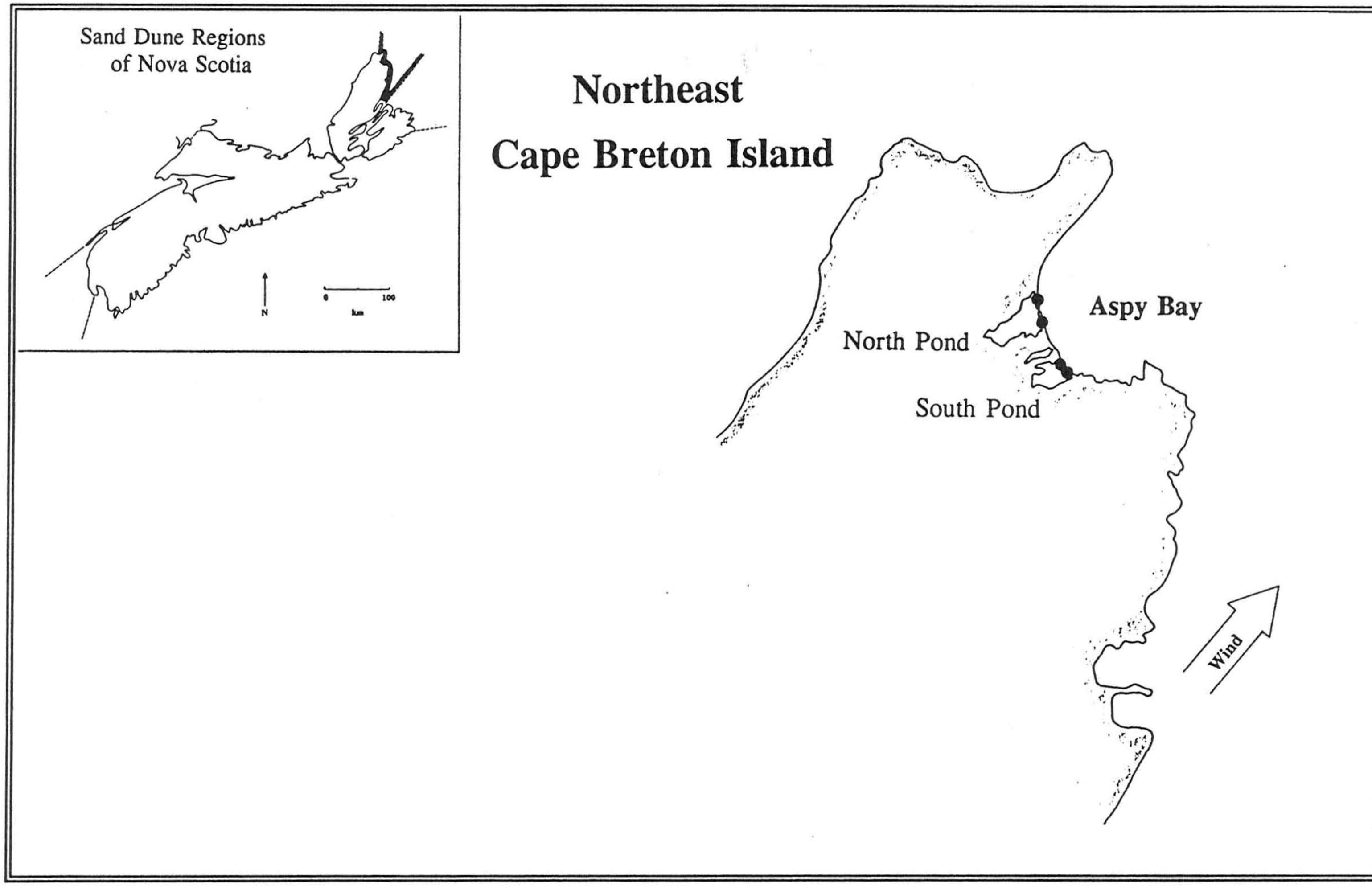


Figure 5.8. Sand dunes of Northeast Cape Breton Island.

rock to the north, and exposed igneous rock with pockets of till to the south. Some sediment may be provided by the North Aspy Bay River during periods of high discharge and westerly offshore winds. The sediment of both the north and south barriers is medium sand with fine sand on the foreshore. The occurrence of finer sand on the foreshore than on the crest suggests that washover deposition is an important process on these barriers.

5.3.2 Sand Dunes

The sand dunes of Aspy Bay are found on bay mouth barriers, which separate North and South Pond from Aspy Bay. The North Pond system is 3.5 km long, divided approximately in half by an inlet (Fig. 5.9). The South Pond barrier, 1.8 km, is also cut by an inlet, however the location of this inlet changes frequently (Fig. 5.10). At present it is roughly one third of the way along the barrier from the southern end, while fifty years ago it was at the southern end. The inlet is also periodically reopened by bulldozers (local residents; Taylor, pers. comm.). Smaller cobble barriers exist across Middle Pond and the small embayment south of South Pond.

The sand dunes are distinct because they have a low wide profile, with a long gentle lee slope, similar to that of a washover. These barriers are subject to frequent washover events, as indicated by the dry seaweed on the lee slope of the barriers, but also have a layer of medium grained aeolian sand deposits. The sand dune material is probably redistributed during every major storm with washover events. Washover channels occur on both barriers, and are found approximately every 50 m on the southern part of the North Pond barrier. Embryo dunes were seen forming in the seaweed line and around plants on both barriers. The only stable dunes exist at the north end of the southern barriers, where a well developed dune ridge is found along the back of the barrier, behind which exist a series of partially submerged beach ridges (Carter et al., 1989). Its location at the back of the barrier, with a flatter, lower dune ridge in front, suggests that the system has prograded at sometime, possibly related to an increase in the erosion of the till cliff located immediately to the north. At present this cliff partially protected from wave erosion by a cobble-boulder beach at its base.

5.3.3 Dune Condition

Of the Aspy Bay sand dunes, those at the northern end of the South Pond show the greatest diversity of plants (twenty one species identified), with a forest association existing on the older dune ridge. Despite its low profile, the landward section of the southern end of the South Pond barrier also has a wide range of plant species (seventeen identified), but never reaches a forest association. The lack of plant species (five identified) found on the Northern Pond barrier suggests that this system is the more active of the two.

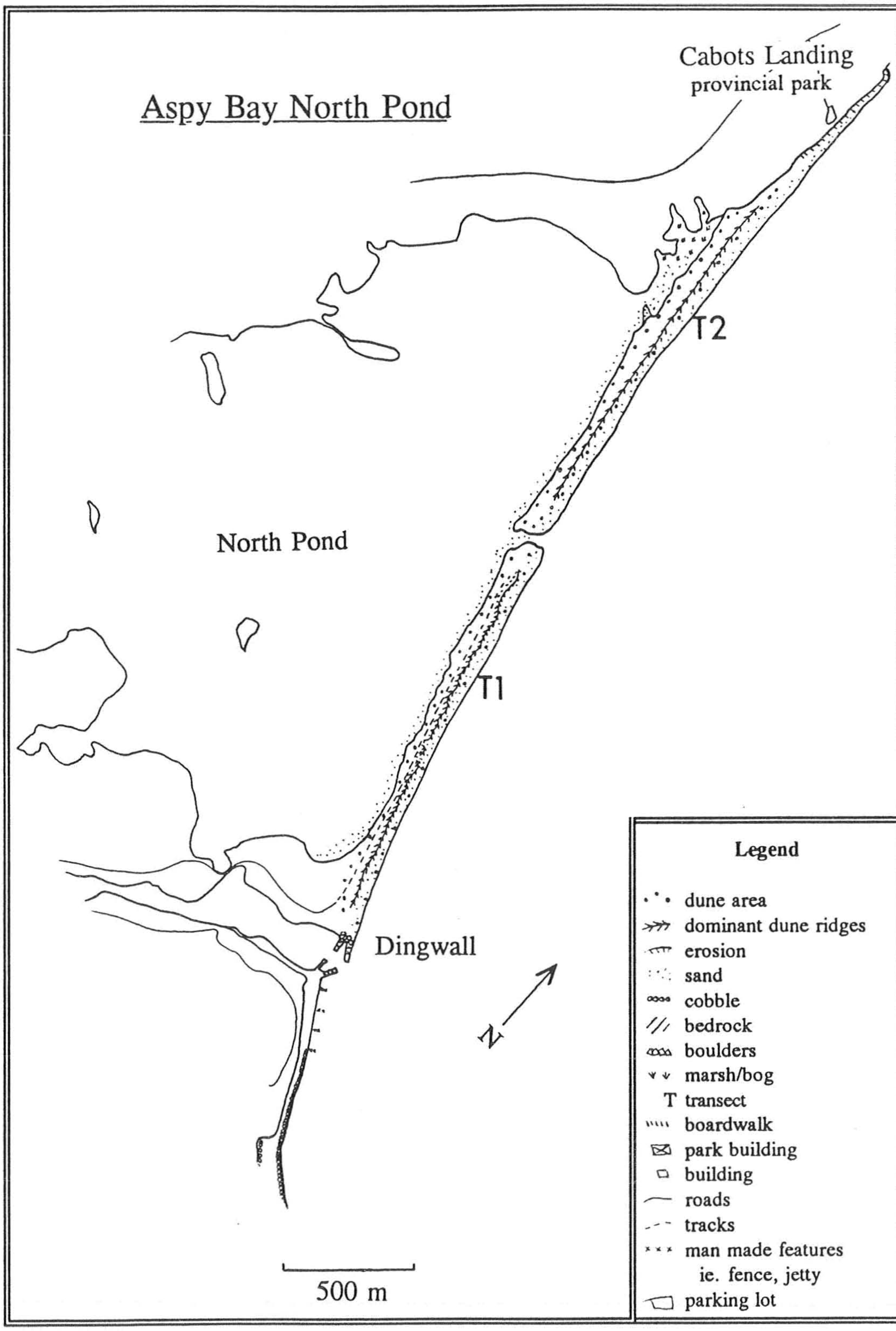
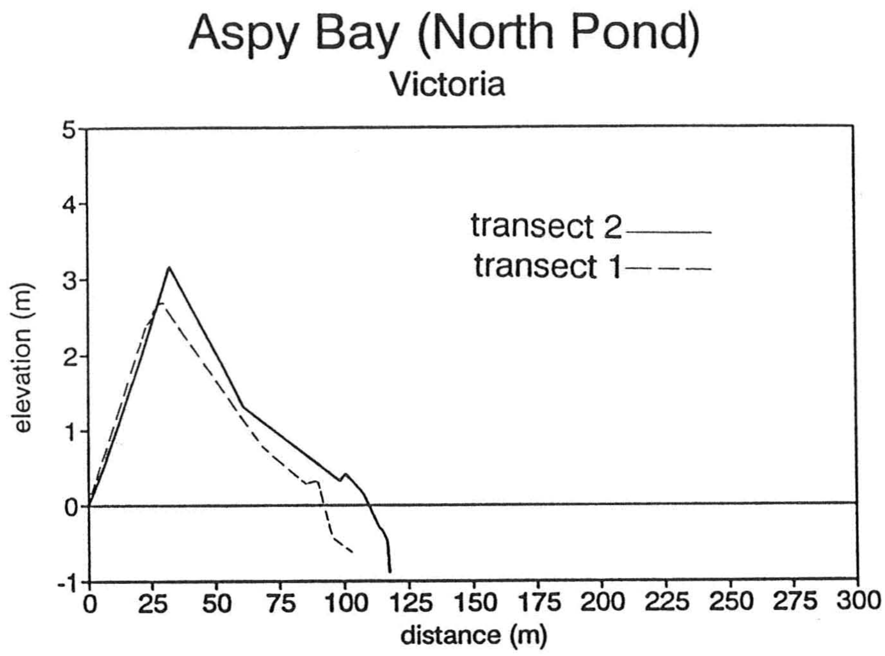


Figure 5.9. Aspy Bay North Pond dune system: map, profile and sediment.



Aspy North Pond T1 = s, T2 = n

Sediment at transects 1 and 2				
location	T1 mean (O)	T2 mean (O)	T1 sorting (O)	T2 sorting (O)
foreshore	2.21	2.10	0.62	0.44
backshore	1.24	0.94	0.86	0.77
ramp	1.30	1:05	0.92	0.73
crest	1.11	1.22	0.83	0.67

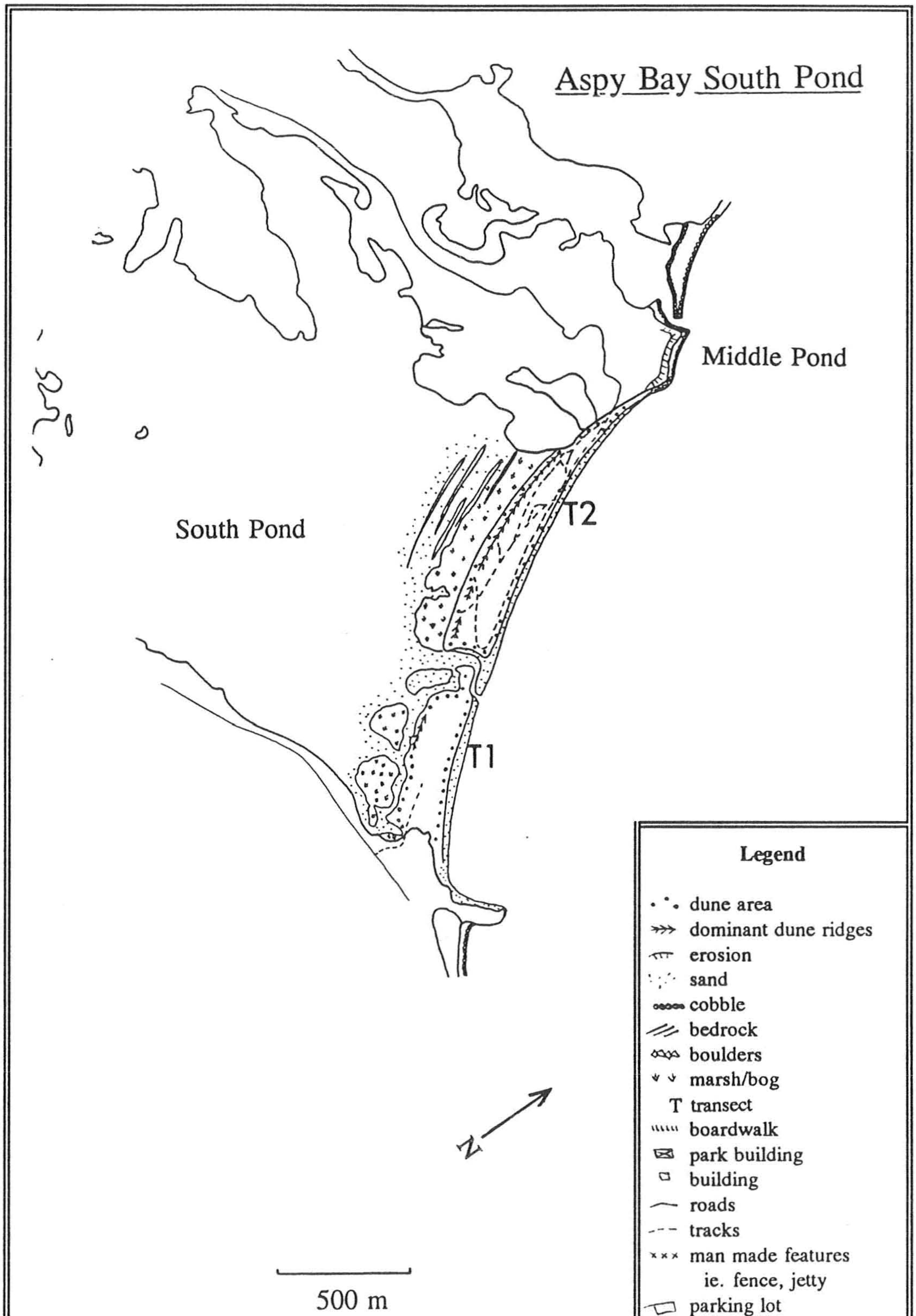
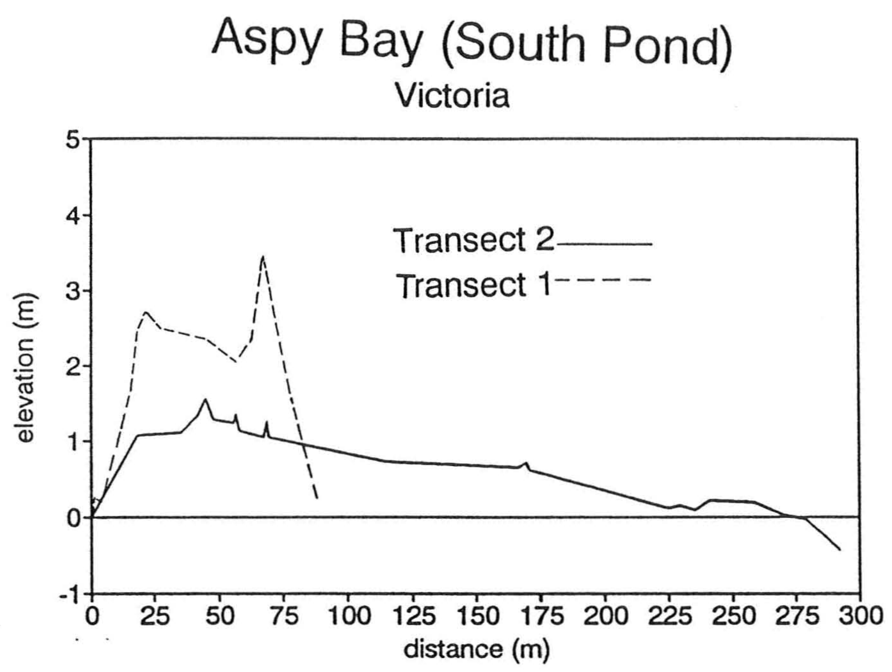


Figure 5.10. Aspy Bay South Pond dune system: map, profile and sediment.



Aspy Bay South Pond T1 = s, T2 = N

Sediment at transects 1 and 2				
location	T1 mean (O)	T2 mean (O)	T1 sorting (O)	T2 sorting (O)
foreshore	2.01	2.13	0.47	0.59
backshore	1.12	1.23	0.75	0.54
ramp	1.34	1.37	1.30	0.61
crest	1.75	1.47	0.59	0.64

Vehicle tracks were seen on all four parts of the barrier system (Fig. 5.11). The easiest vehicle access is at the south end of North Pond where the road to Dingwall Harbour continues onto the crest of the barrier, and aggregate appears to have been removed from the lee slope at this position. A very rough dirt road leads to well worn tracks on the dunes at the north end of the South Pond, but the condition of the road would prevent most vehicles from reaching the dunes. A fence across the back of the high dunes ridge suggests that this area may have once been used pasture. The south end of the South Pond is accessible only by a trail, and the most northern part of the system is accessible only by illegally driving across a provincial park (Fig. 5.12). Other than vehicle tracks, the Aspy Bay system appears to be in a natural state, with a balance maintained between aeolian deposition and overwash events, sacrificing overwashed areas for the stability of the whole system.

5.4 Northern Shore

The Northern Shore sand dune region stretches from the Nova Scotia - New Brunswick border to the northern tip of Cape Breton Island (Fig. 5.13). This area is predominantly microtidal, with a range which deceases from west to east (see Fig. 3.6). The prevailing winds are southwesterly, which results in an increase in fetch and, therefore, in wave height at the eastern end of Northumberland Strait. Much of the region, with the exception of western Cape

Figure 5.11. Aspy Bay. Track across low barrier at south end of North Pond.

Figure 5.12. Aspy Bay. Truck crossing dunes at Cabot Park, North Pond.

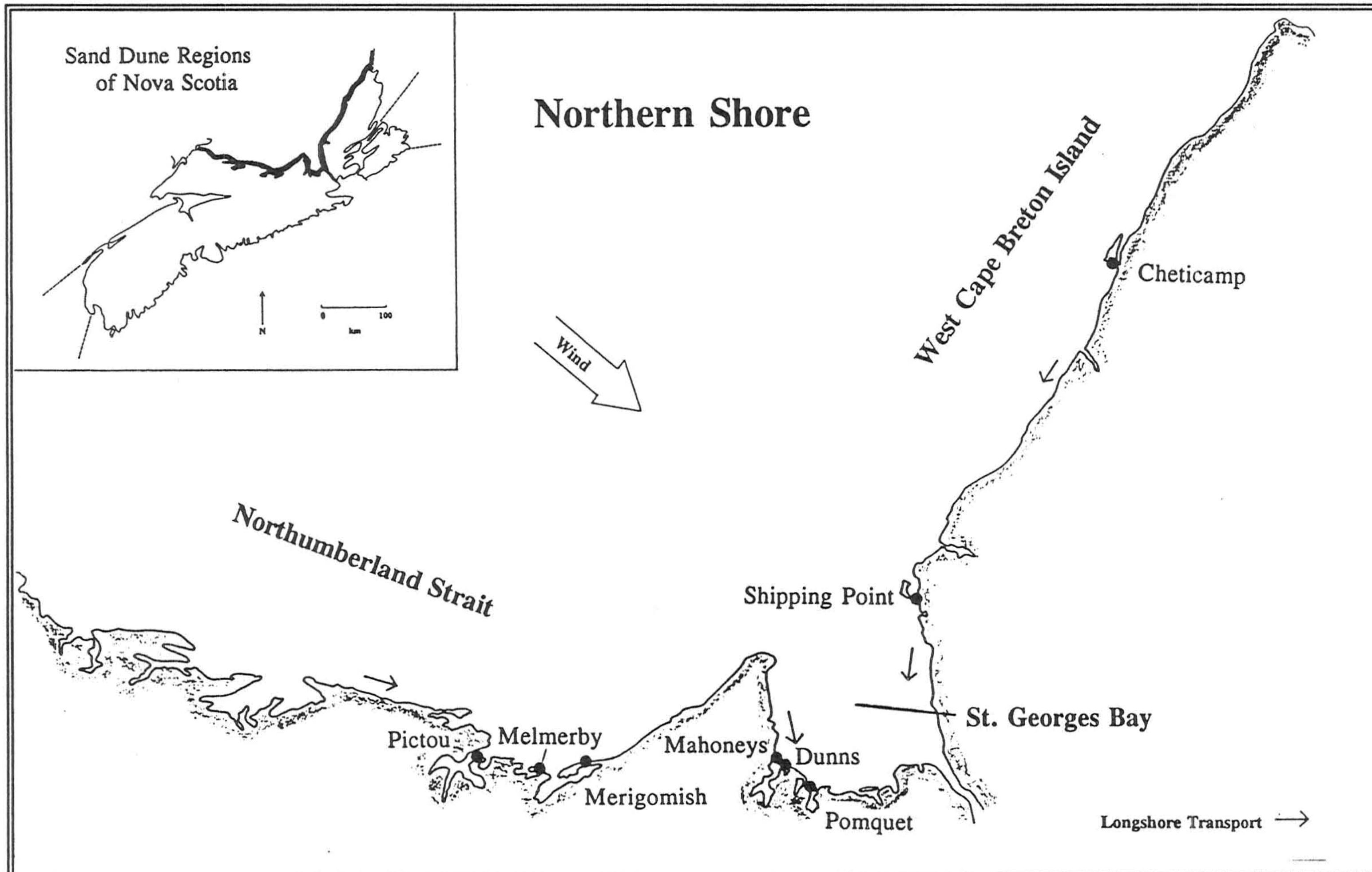


Figure 5.13. Sand dunes of the Northern Shore.

Breton Island, is protected from the strongest winds, which are from the northwest, by Prince Edward Island. Owens and Bowen (1977) classified this region as three separate units; Northumberland Strait, Antigonish - West Cape Breton Island, and St. Georges Bay (see Fig. 3.1). Northumberland Strait and St. Georges Bay have shores of sedimentary bedrock blanketed by thick till deposits, with several large embayments, while the coast of Antigonish - West Cape Breton Island is controlled by resistant rock outcrops covered in a thin till veneer (see Fig. 3.2).

5.4.1 Sediment

Sediment is most readily available on Northumberland Strait and in St. Georges Bay, where mean bluff erosion rates are 0.3 m/a (Taylor et al., 1985). Longshore transport is mainly to the east along the shore of Northumberland Strait, although it may vary within the numerous large bays. Within St. Georges Bay, sediment transport is to the south. The coast of West Cape Breton Island is different from those of the other two units in that it contains few large embayments and littoral sediment is scarce. Longshore transport is to the south along this coast (Owens and Bowen, 1977).

The sediment of the dunes of the North Shore is medium grained sand, often with coarser sand on the foreshore. It is the coarser foreshore sand which distinguishes the beach-dune systems of this region from that of Aspy Bay, which have fine grained sand in this position. Most of the beaches are primarily sand with some pebbles, although cobbles are found on a few, such as the northwestern side of Shipping Point. The beaches of Mahoneys, Dunns and Captains Pond are very pebbly, with some cobbles and some sand. The cobbles found along the back of Dunns barrier are very angular, indicating that they have not travelled far from their place of origin, most likely the islands to which the barrier is attached.

5.4.2 Sand Dunes

Although there are important variations between the coastline formations and the availability of sediment in these three areas, Northumberland Strait, St. Georges Bay, and Antigonish - West Cape Breton Island, there are similarities in the sand dune systems. They tend to be larger than those of other regions of the province, have multiple ridges, and are frequently bay mouth barriers attached to islands at some point along their length. Although they are similar to the dunes of the Western Shore in their height and numerous parallel ridges, those of the Northern Shore exist in a different environment, microtidal with ice protection during the winter months.

Northumberland Strait:

The major systems the Northumberland Strait section of the North Shore are Melmerby and Merigomish, both of which are bay mouth barriers. Melmerby, now a Provincial Park, is now only a single dune ridge with a height of 4 m, (Fig. 5.14) the remnant of a much higher and wider dune system (Bowen et al., 1975). High, wide multiple ridges are still intact at Merigomish, the longest system in the province, approximately 5 km (Fig. 5.15). However, the eastern half of the system is very narrow, consisting of a discontinuous dune ridge augmented by large boulders and a 1 km wooden retaining wall. This part of the Merigomish dune system is lower and narrower than the western portion, and would likely have failed by now if not for the reinforcing wall and boulders, and the stabilizing affect of the road which runs along the tombolo to Merigomish Island. The parallel ridges at the western end of the system reach over 5 m above mean high tide, and are well vegetated, although they are not forested. The highest ridge is the most seaward one, while the most landward ridges are low, and vulnerable to tidal flooding, as are those at Pomquet. The Merigomish system is separated from two smaller bay head barriers to the east by till bluffs.

The mid-bay spits of Pictou Harbour are an exception to the Northern Shore dune type. The low, gently sloping, single dune ridge of the southeastern spit is unlike any other dune in the province. However, the medium grained sand, with coarser sand on the foreshore, and the multiple ridges at the end of the spits give them some common characteristics with other dunes of this region (Fig. 5.16). The spit on the southeastern shore is retreating, as is evident from the erosion at the base of the lighthouse on the distal end and the new deposition

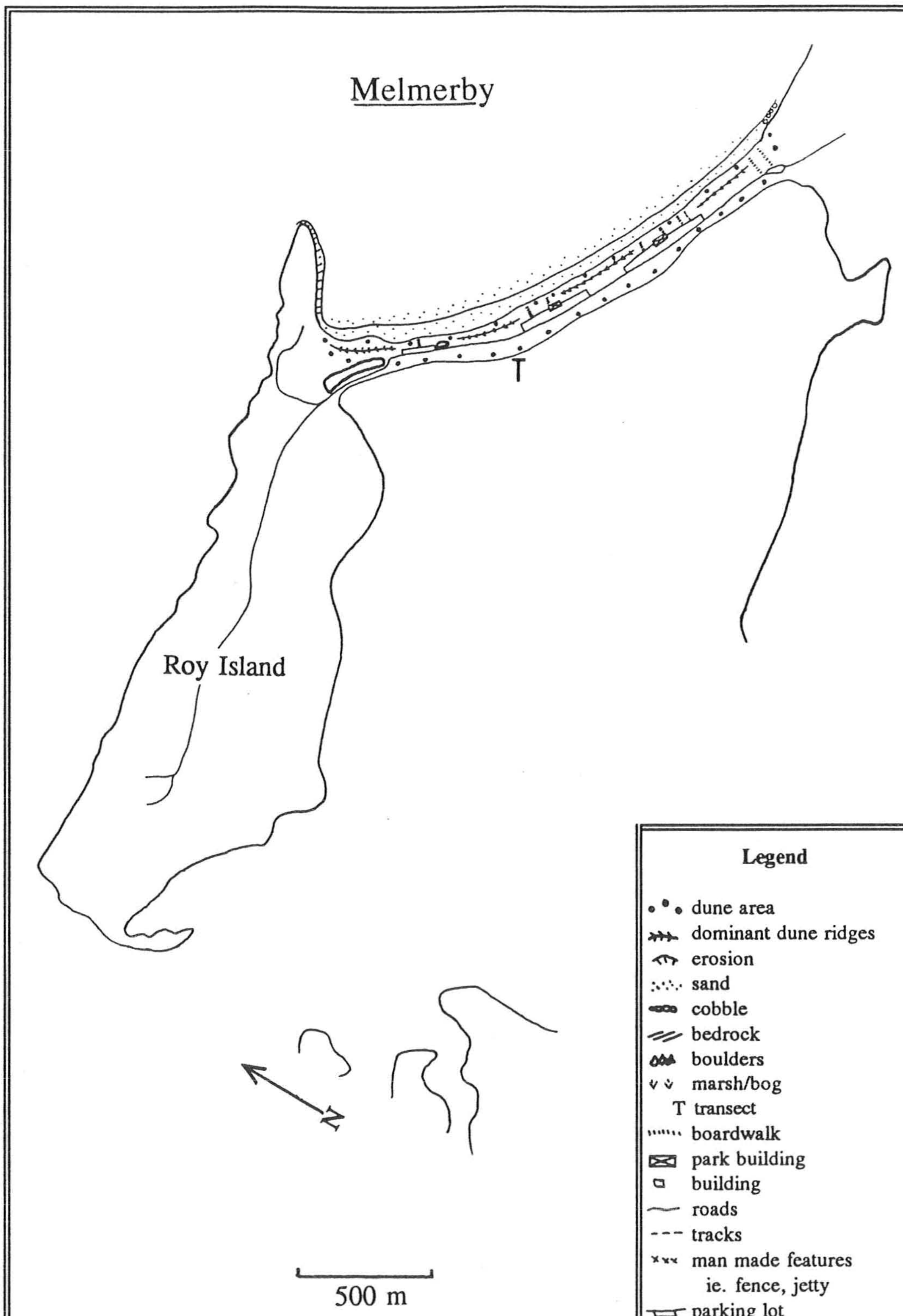
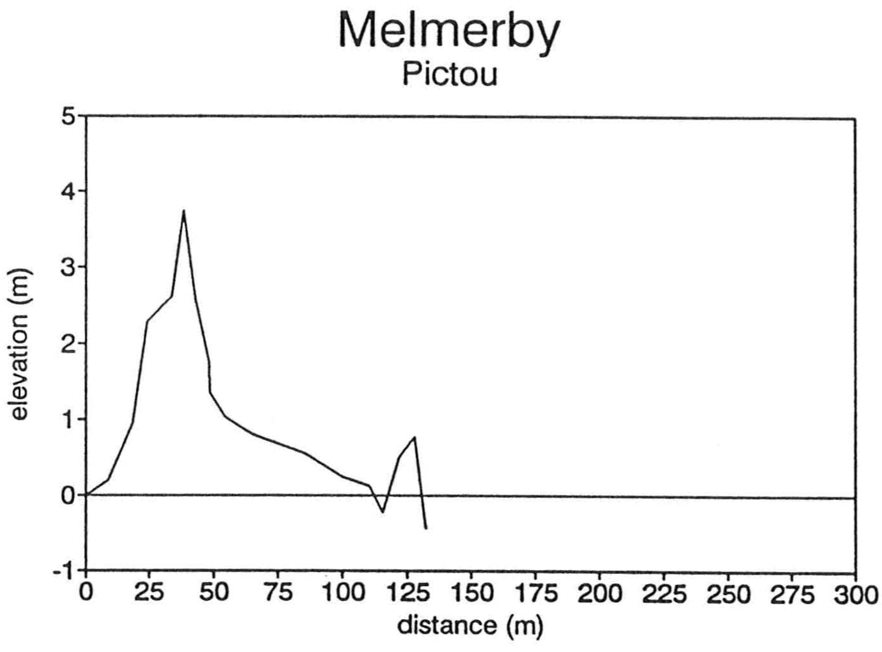


Figure 5.14. Melmerby dune system: map, profile and sediment sizes.



Melmerby

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	1.92	0.53
backshore	1.81	0.86
ramp	1.75	0.47
crest	1.72	0.50

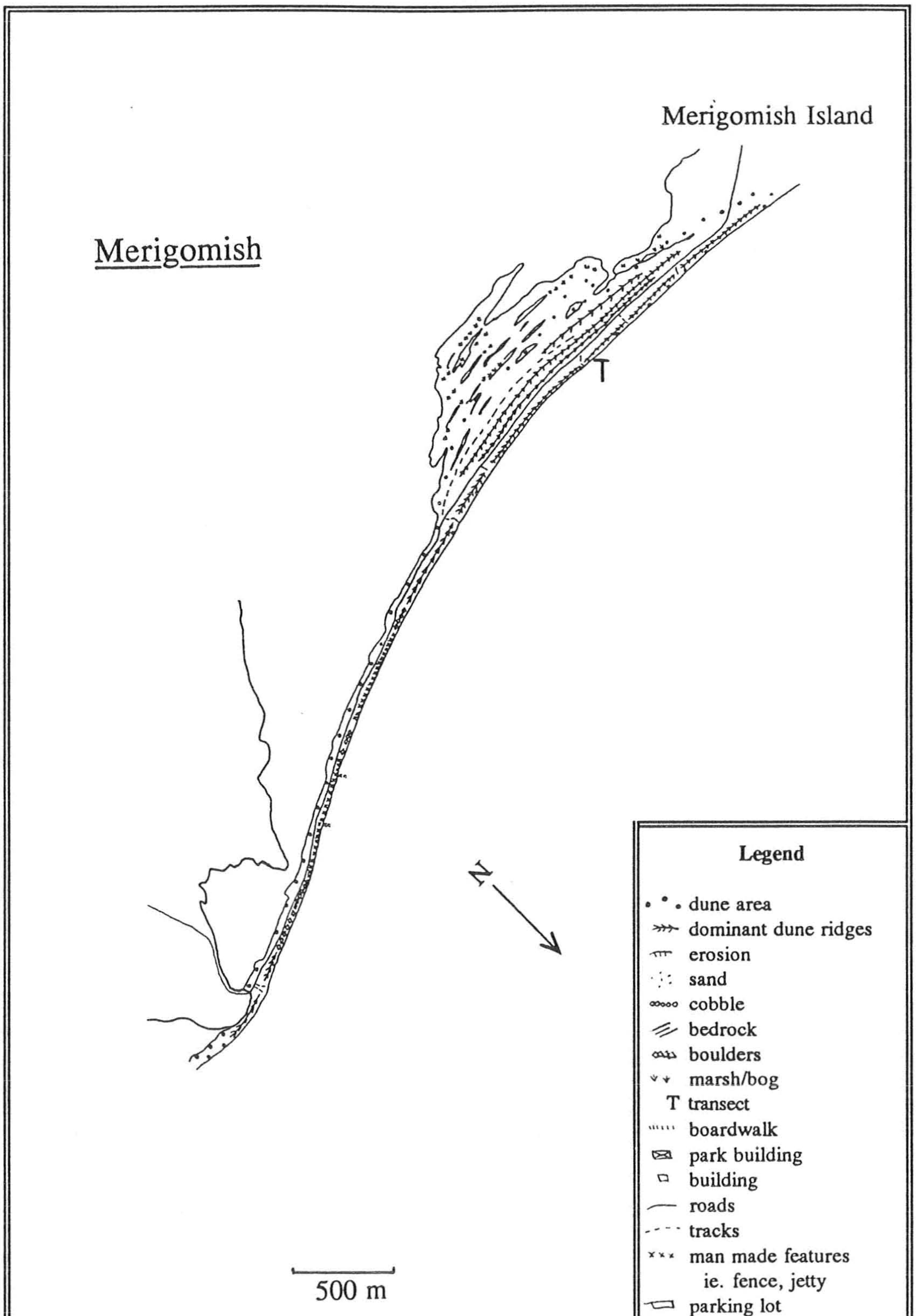
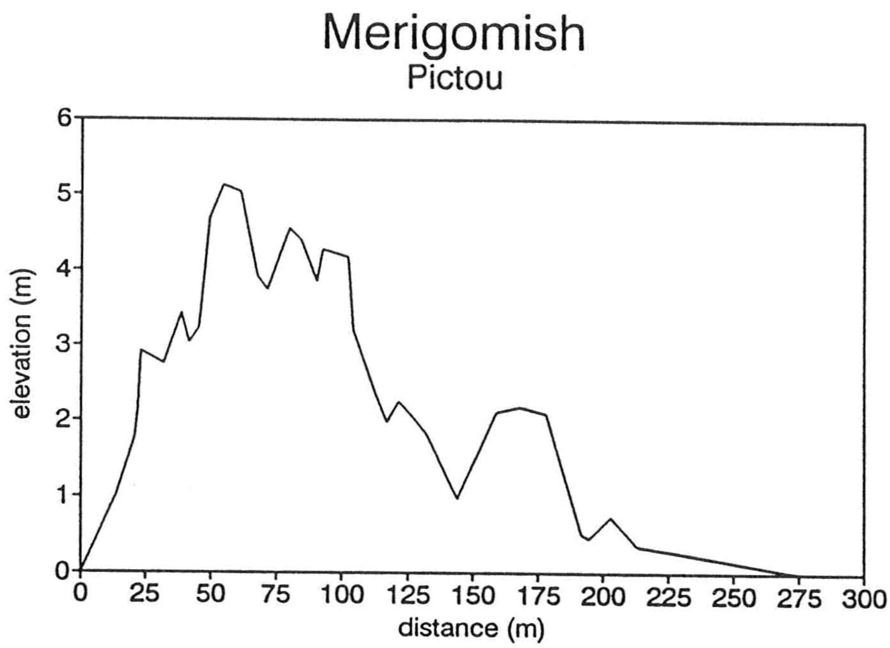


Figure 5.15. Merigomish dune system: map, profile and sediment sizes.



Merigomish

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	0.36	1.80
backshore	1.20	0.96
ramp	1.41	0.50
crest	1.58	0.56

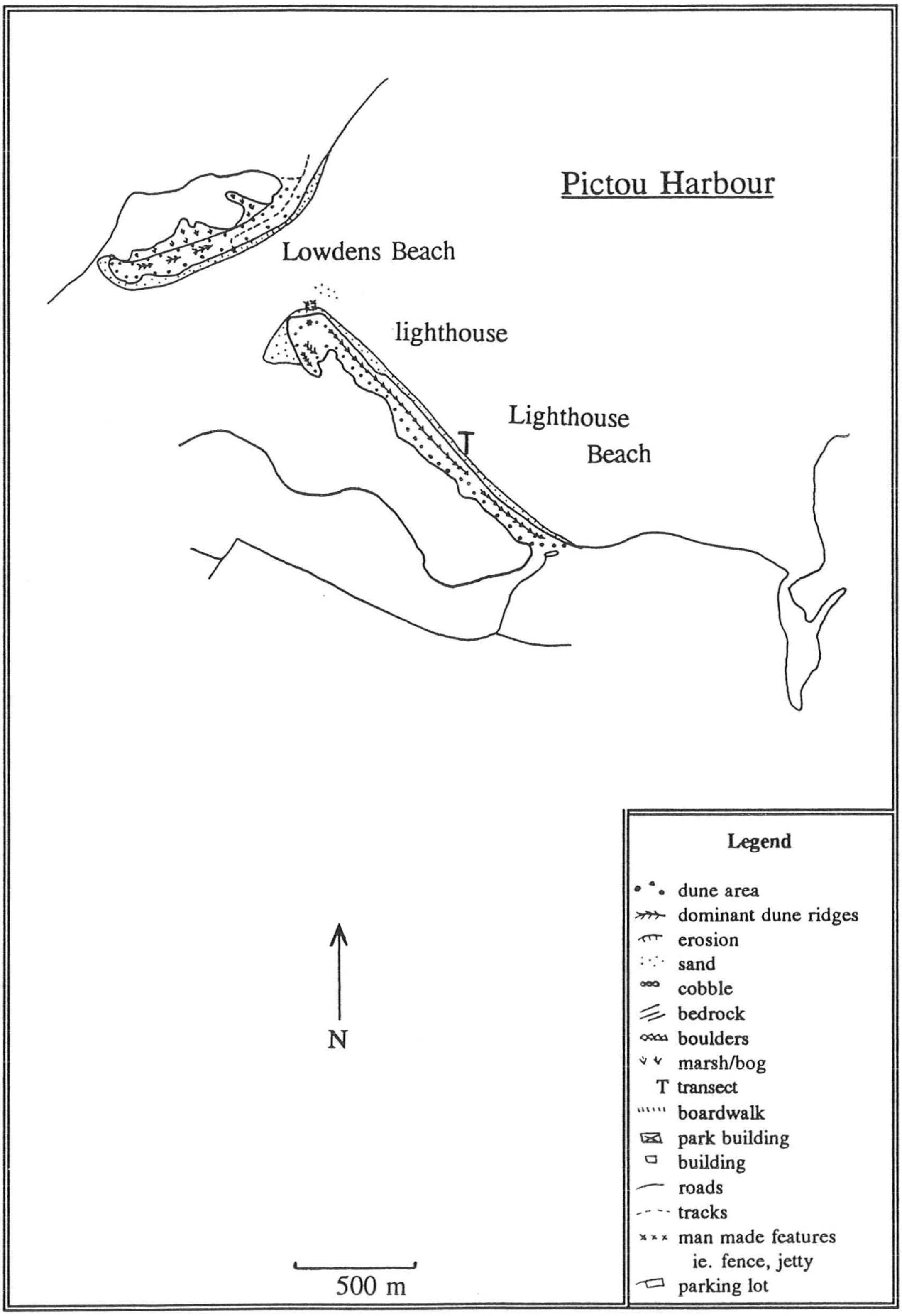
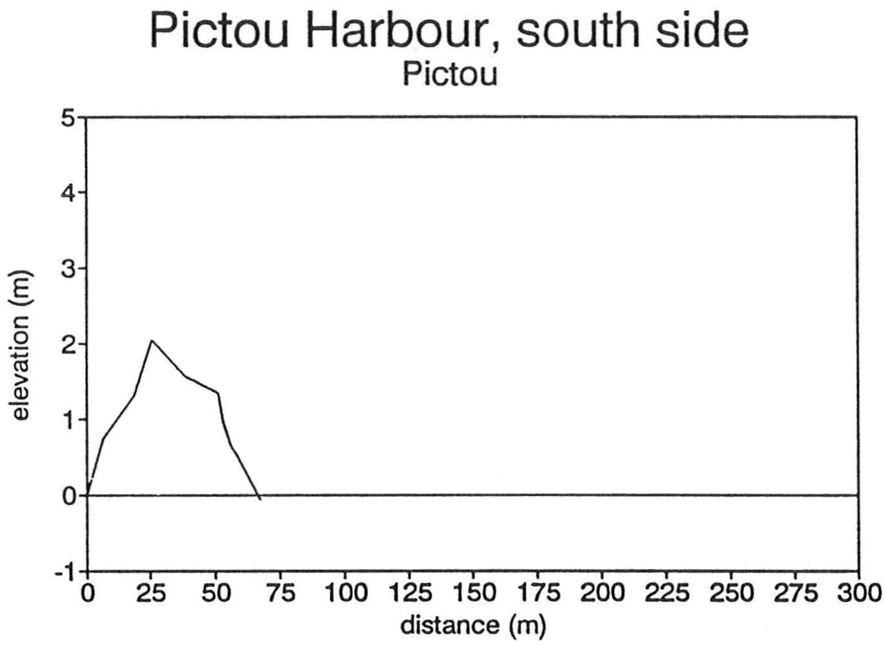


Figure 5.16. Pictou dune system: map, profile and sediment sizes.



pictou

Sediment at Transect		
location	mean (O)	sorting (O)
foreshore	0.15	1.72
backshore	1.82	0.67
ramp	1.97	0.48
crest	1.56	0.46

occurring behind the spit. According to a local resident the spit once had much higher dunes along it, with a road leading to the lighthouse.

St.Georges Bay:

The sand dunes of St. Georges Bay occur on the southwestern shore on bay mouth barriers across Antigonish Harbour, Captains Pond and Pomquet Harbour. Of these, only the barrier across Captains Pond is not connected to islands at some point. Two barriers exist across Antigonish Harbour, Mahoneys to the northwest and Dunns to the southeast (Fig. 5.17). Both these systems have several dune ridges lying parallel to the shoreline, are well vegetated, have both deposition and erosion along the ramp, and little evidence of active deposition on the dunes. The large amounts of poison ivy on both these systems acts as a deterrent, keeping people off the dunes, just as it does on Merigomish and Pomquet. Captains Pond, separated from Dunns by an eroding till bluff, is unlike the previous two beaches in that it has a high, single dune ridge backed by a wide marsh area.

Pomquet is the largest dune formation in Nova Scotia, with a length of over 3 km, a maximum width of 800 m, and with a typical foredune ridge height of 4.2 m above mean high tide (Fig. 5.18). Bowen et al. (1975) observed dunes of over 8 m in height at the western end of the beach. The system is essentially a huge bay mouth barrier, attached to the mainland at the northwest end and to an island at the back. It is very well vegetated, with the best developed dune forest in the province, and despite a great deal of disturbance in the past, old scars, such as burnt areas, are now revegetated (Fig. 5.19). Rising sea level has flooded the low lying ridges at the back of the barrier, creating salt marsh environments. The relatively similar height of the dune ridges suggests that this system is a recent formation, probably developing during the last one thousand years, which requires a progradation rate of 1 m/a (Bowen et al., 1975). The beach and dunes have been prograding over the last several years, producing a new foredune ridge in front of the main ridge and a wider beach at the eastern end. The dunes along the inlet, however, have decreased in height over the last fifteen years and exceptionally high tides have eroded both sides of the channel (Bancroft, pers. comm.). A few areas of erosion exist in the main dune ridge, but they are minor given the size of the system, and pose no threat to the overall integrity of the dunes.

West Cape Breton Island:

Sand dunes exist at several locations along West Cape Breton Island, but only those at Cheticamp and Shipping Point are greater than one kilometre in length. Cheticamp beach is a tombolo connecting Cheticamp Island to Cape Breton Island (Fig. 5.21). The highest dunes are found at the northwestern end, where they produce a 4 m high sand cliff at the back of the beach, with several

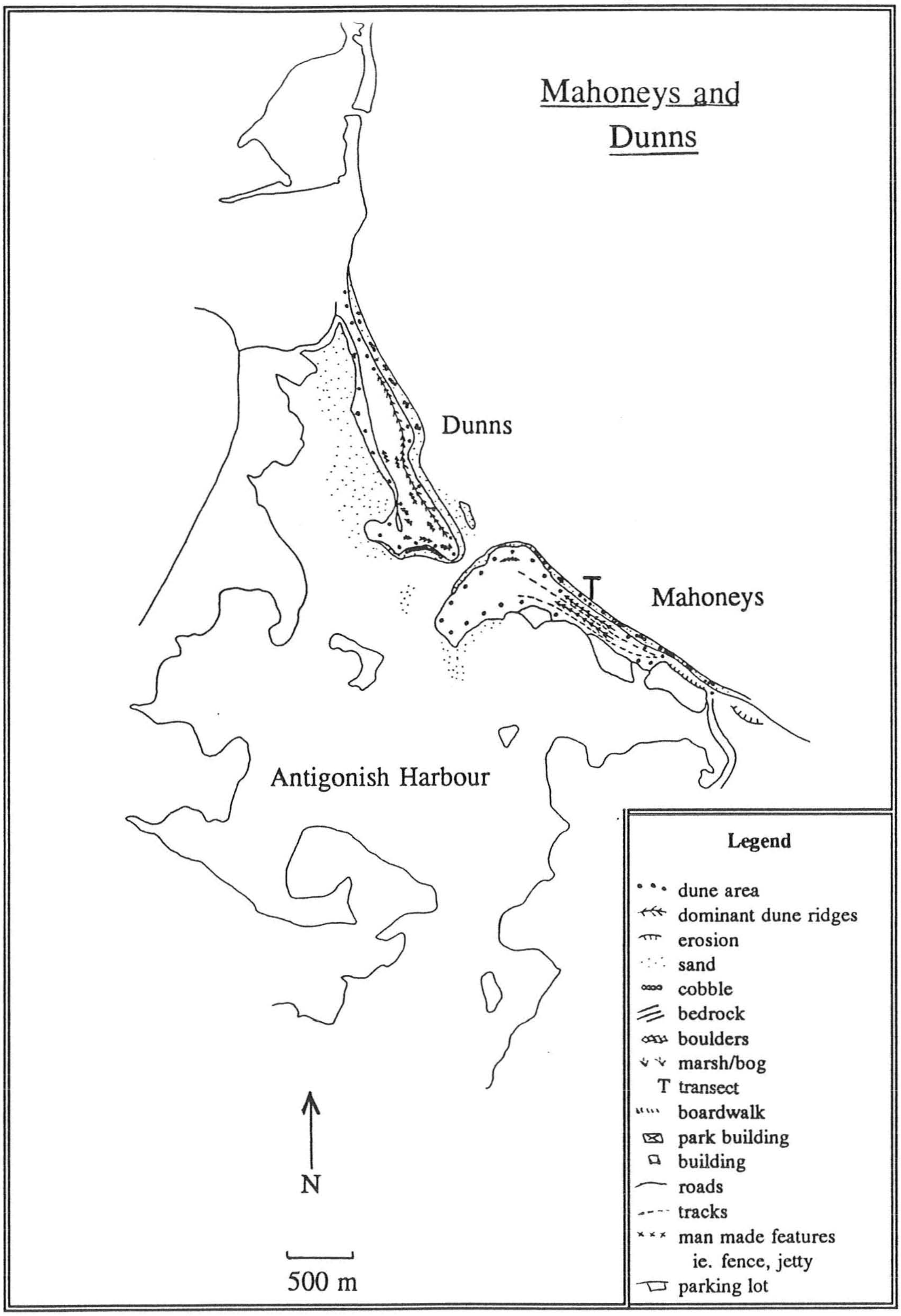
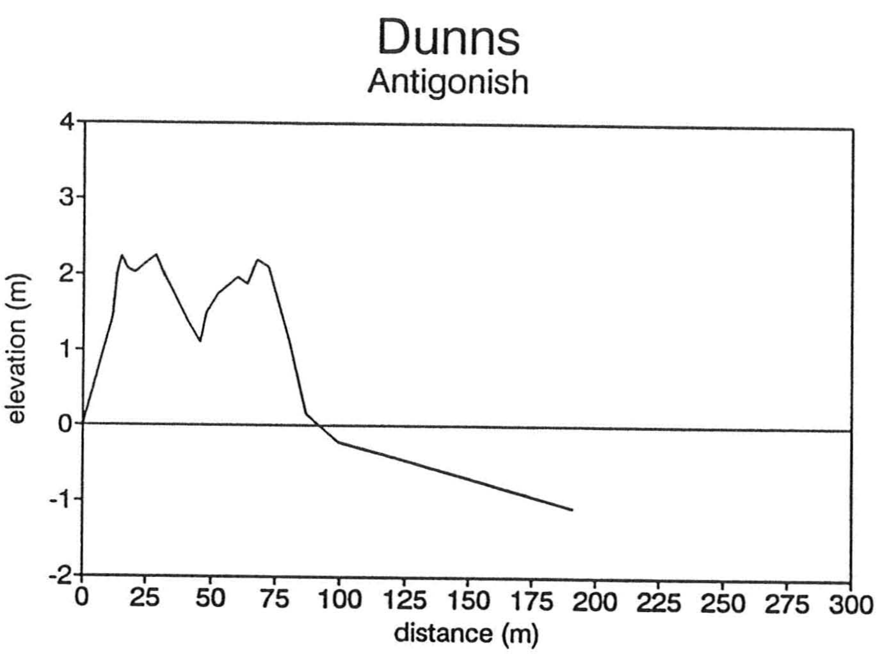


Figure 5.17. Antigonish Harbour dune systems: map, profile and sediment sizes.



Dunns

Sediment at transect		
location	mean (O)	sorting (O)
foreshore	-2.27	2.51
backshore	-0.02	2.21
ramp	-0.44	1.50
crest	1.67	0.49

Mahoney

Sediment at transect		
location	mean (O)	sorting (O)
foreshore		
backshore	0.54	1.52
ramp		
crest		

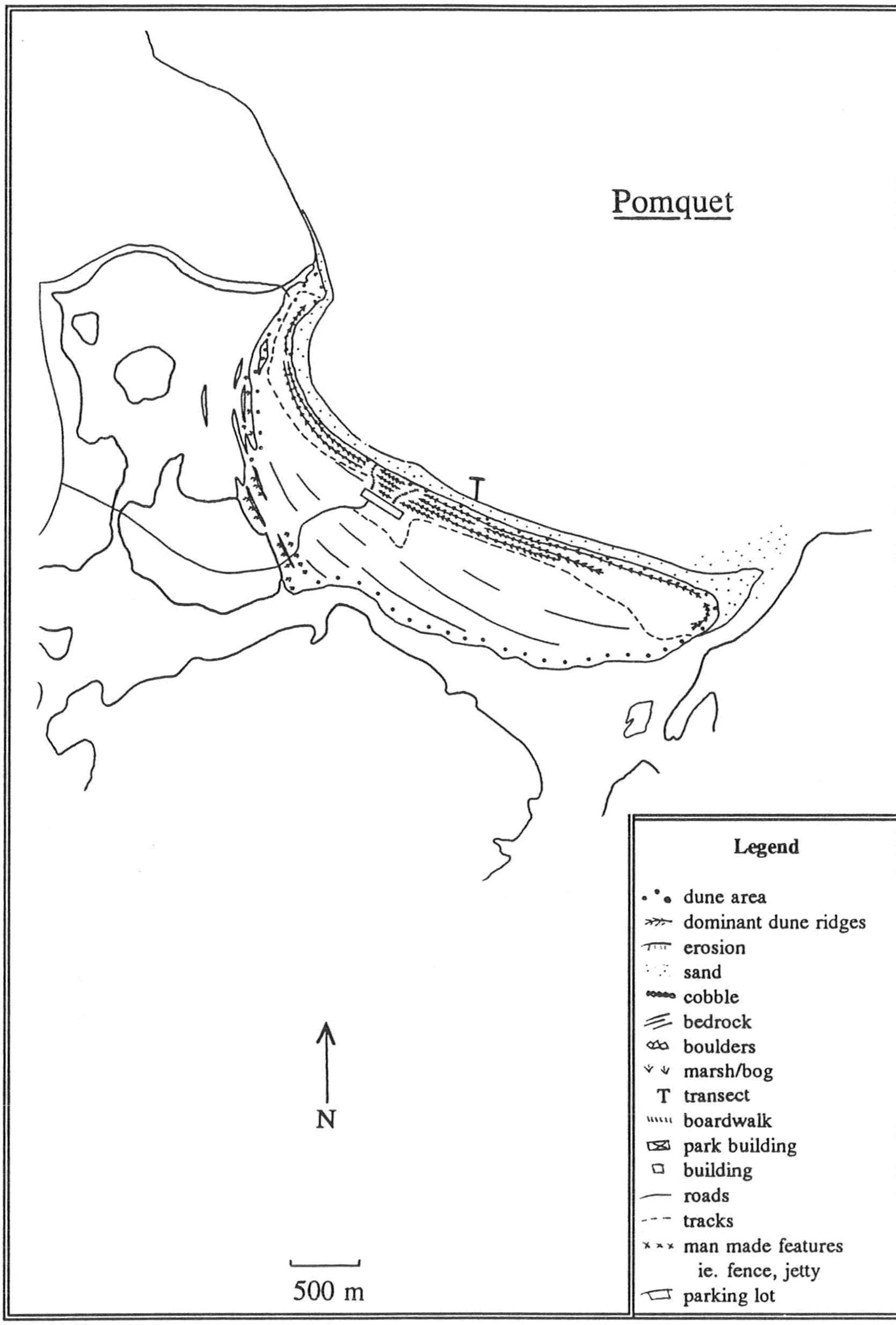
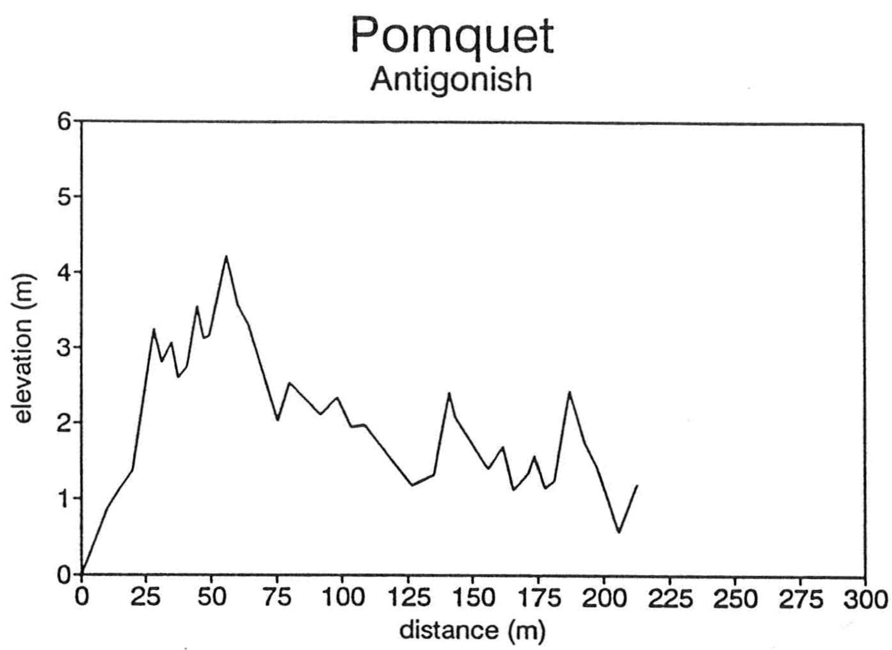


Figure 5.18. Pomquet dune system: map, profile and sediment sizes.



Pomquet

Sediment at transect		
location	mean (O)	sorting (0)
foreshore	1.95	0.80
backshore	1.43	0.54
ramp	1.68	0.49
crest	1.70	0.53

Figure 5.19. Pomquet. Well vegetated prograding system; forested at back.

Figure 5.20. West Mabou. Wide system of high ridges. Note person on ramp.

ridges inland, possibly overlying the island material. To the east the ridges become lower and narrower, with a maximum height of just over 2 m. Back of the foredune, the ridges are hidden by a spruce forest, or have been destroyed in order to build cottages. At the western end a campground exists on the landward dune ridges.

Shipping Point, the only true sand dune cuspate foreland formation in Nova Scotia, consists of a series of steep dune ridges enclosing an area of marsh and cranberry bogs (Fig. 5.22). It is protected by Hood Island located directly offshore, and may have benefitted by the destruction of the tombolo which connected the north end of Hood Island to the mainland. This tombolo was artificially cut between 1823 and 1839 to provide access to the harbour, and it is possible that sediment from the tombolo accumulated at Shipping Point. Attempts to rebuild the tombolo have failed to trap much sediment, demonstrating how scarce sediment is along this coast (Owens and Bowen, 1977).

The most interesting dune system on West Cape Breton Island is that at West Mabou, which is just less than 1 km in length and nearly as wide. It consists of a series of very large sand dunes, which are possibly climbing up the till behind (Fig. 5.20). Since it does not meet the 1 km length requirement, no further studies were made of this dune system.

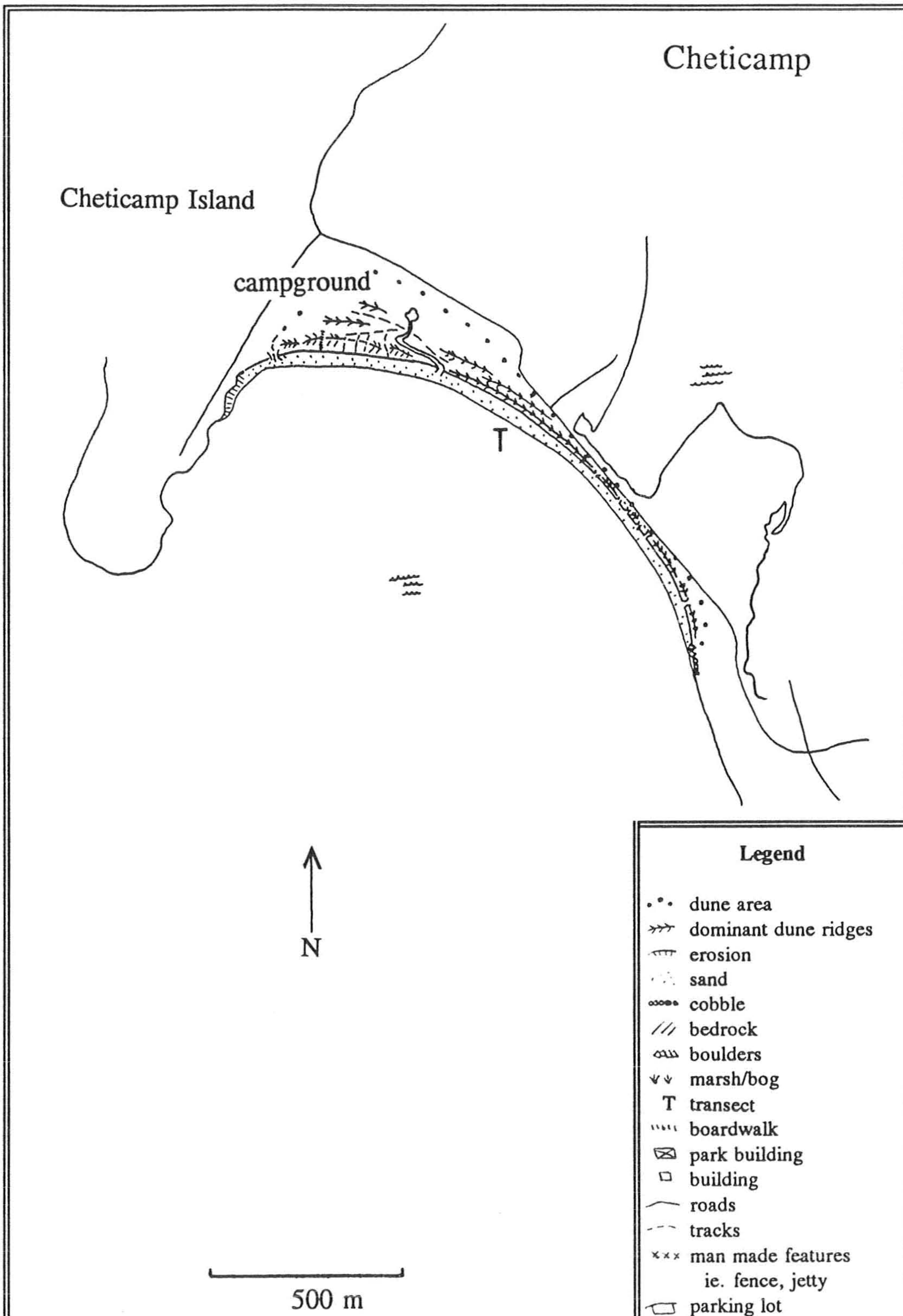
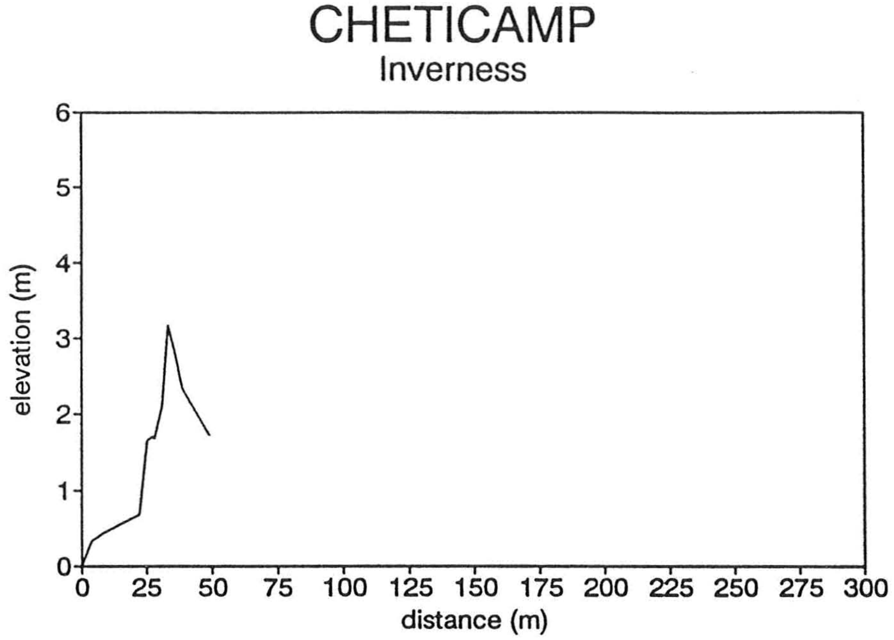


Figure 5.21. Cheticamp dune system: map, profile and sediment sizes.



Sediment at transect		
location	mean (O)	sorting (O)
foreshore	1.35	1.38
backshore	0.96	1.53
ramp	2.27	0.36
crest	2.35	0.35

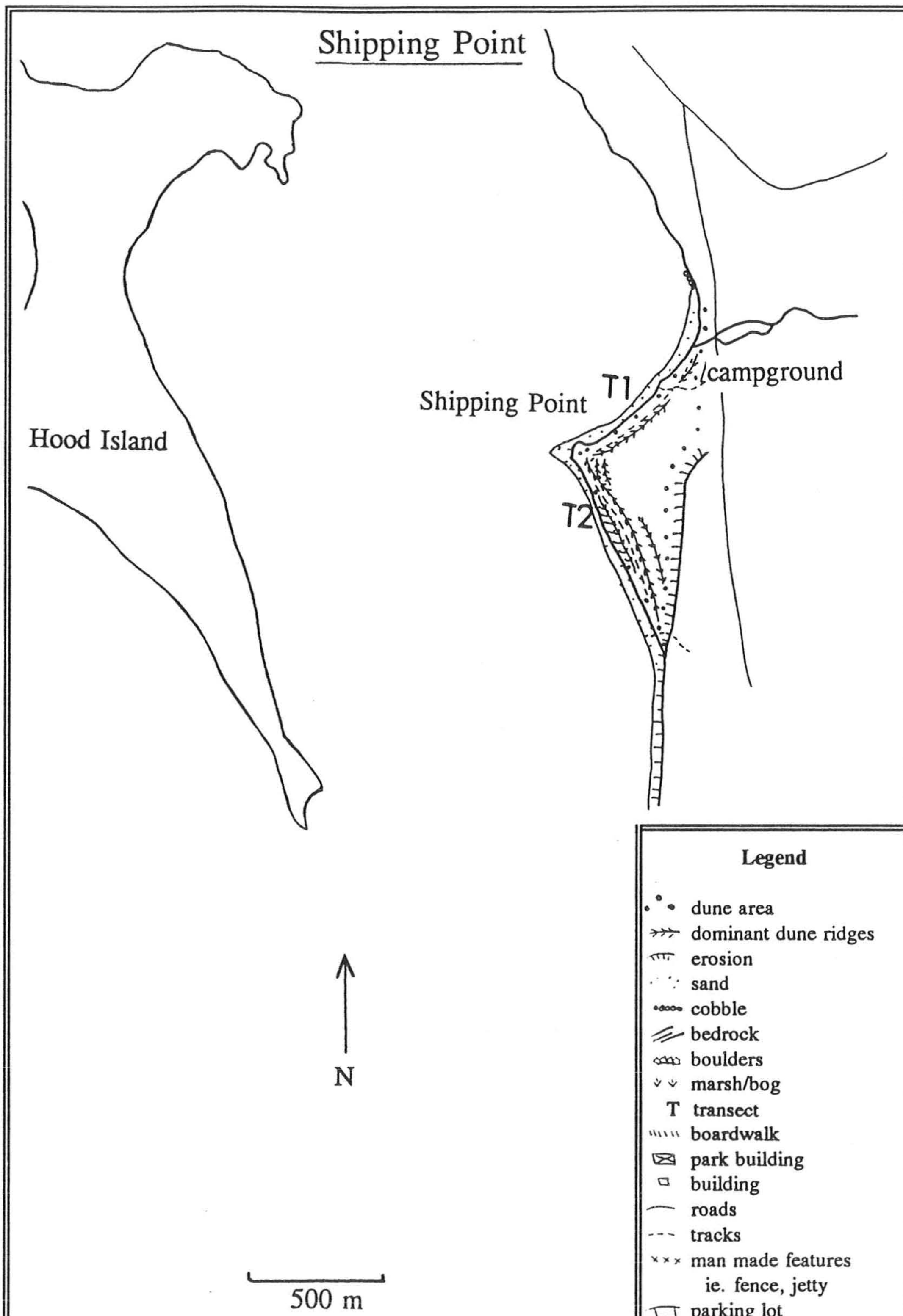
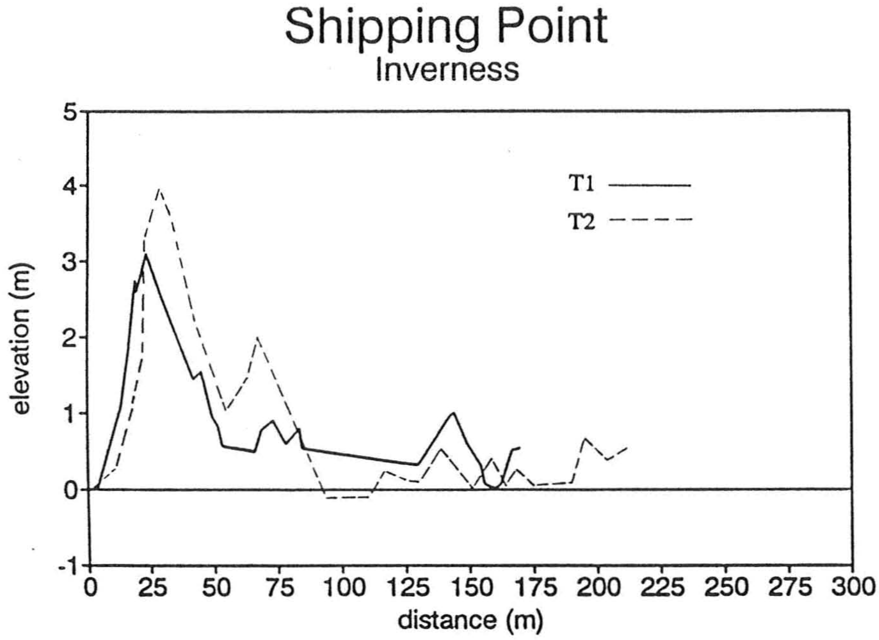


Figure 5.22. Shipping Point dune system: map, profile and sediment sizes.



Shipping Point

Sediment at transects 1 and 2				
location	T1 mean (O)	T2 mean (O)	T1 sorting (O)	T2 sorting (O)
foreshore	0.99	1.23	1.45	0.50
backshore	1.58	1.54	0.48	0.54
ramp	1.66	1.81	0.41	0.38
crest	1.70	1.84	0.40	0.41

5.4.3 Dune Condition

In general the sand dunes of the North Shore are in good condition, although the impact of human activity can clearly be seen on most of them. The southeastern spit in Pictou Harbour has a lighthouse and the remains of a wharf at the far end, hence the name Lighthouse beach, and, according to local residents, it once had an access road along the spit which has now been eroded away. Melmerby was described in 1975 as "a line of fragmented, truncated dunes with an unvegetated outer slope and frequent damage caused by vehicles or sand removal on the landward side" (Bowen et al., 1975). Now the tombolo, a provincial park, has a well vegetated, continuous dune ridge and appears to have stabilized, since there is no evidence of sand blowing in to the lagoon and forming a sand beach along the back of the barrier. The condition of Merigomish has already been described, with the eastern end badly fragmented and susceptible to further erosion. Merigomish is a popular beach, but has no designated parking areas, and consequently beach access trails have been cut across the dunes in at least six different places. Dunns, Mahoneys and Pomquet all have well worn vehicle tracks along them, and evidence of sand removal in the past. Pomquet also has been used as pasture and logged for red oak and white pine (Bowen et al., 1975). The most severe damage to these systems, as to many others, is done by vehicles being driven across the dunes. Vehicle access is now restricted on those systems which are provincial parks, such as Pomquet. A track also runs along the dunes at Shipping Point, however it is old and now has revegetated. The dunes at Cheticamp appear to be eroding at the western end, but prograding at the centre, and have been cut across by at least eight paths.

5.5 Conclusion

The sand dune systems of Nova Scotia may be divided into five regional groups, the Western Shore, the Atlantic Shore, East Cape Breton Island, Northeast Cape Breton Island, and the Northern Shore, according to their dune morphology, the type of barrier system on which they are located, and the beach and dune sediment. Sand dunes most frequently occur on bay mouth barriers, and are low in comparison to the dunes on the large barrier systems along the shores of the other Maritime provinces. The average typical height of the Nova Scotia dunes is 2.7 m, with a maximum typical height of 5.56 m at Bartletts. The dunes at Kouchibouguac, New Brunswick, reach heights of 9 m above the low water line (Bryant, 1972), while the foredune ridge along the northern shore of Prince Edward Island ranges from 2 to 8 m in height, with large old dune of over 15 m at Blooming Point (Atkinson, 1986; Byrne, 1986; Nutt, 1990). The foredune ridges along les Iles-de-la-Madeleine are also large in comparison to the dunes of Nova Scotia, reaching heights of 11 m (Giles, 1992). Unlike the extensive barriers mentioned in the other Maritime provinces, the length of the sand dune systems of Nova Scotia is restricted by numerous rocky headlands and limited sediment supply

In morphology the sand dunes of Nova Scotia are very similar to most of those of the rest of the Maritimes, with a steep seaward slope and a more gentle lee side. The foredune ridge is usually the most dominant and highest ridge, with exceptions such as Bartletts, Carters, Rissers, Pomquet, and Merigomish where lower ridges have formed seaward of the dominant ridge, indicating that progradation has occurred. The relative rise in sea level, which is influencing the morphology of the sand dune systems in all areas of the Maritimes, is forcing the dunes of Nova Scotia to retreat landward. In areas of adequate sediment supply the dunes are able to retain their form, and in a few cases such as Pomquet, are able to prograde. However, most of the sand dune systems of Nova Scotia are losing sediment to areas landward of the dunes as the transgression takes place, and consequently some, such as Martinique, Crescent and Merigomish, are in danger of breaking up. On many dune systems the natural process of erosion is being augmented by human activity, as will be discussed in chapter 7.

CHAPTER 6

VEGETATION OF THE SAND DUNES OF NOVA SCOTIA

6.1 Introduction

The relationship between vegetation and coastal sand dunes can be approached in two ways. Vegetation plays a vital role in the initiation and development of sand dunes, and sand dunes provide a unique environment in which a wide variety of plants exist. The first section of this chapter is a review of coastal dune vegetation literature, with comments on the dune vegetation of Nova Scotia where applicable. Next is a section on the vegetation of Nova Scotia, including a discussion of the sand dune vegetation in a regional setting. The sand dune vegetation is divided into seven groups, referred to as vegetation associations. These are discussed in section 6.3, and compared to other studies in 6.4.

6.1.1 Dune Development

There is a distinct difference between dune-initiating plants and dune building-plants (Woodhouse, 1982). The former tend to be small grasses or forbs which can exist in the inhospitable environment of the unstable beach. Although these plants are able to stabilize the sand surface, allowing other species to take root, their vertical growth rate is not sufficient to build dunes. The most important species of this type in Nova Scotia is Cakile edentula (sea rocket), which is found on both the Pacific and Atlantic coasts of North America, and on the shores of the Great Lakes. As would be expected of a plant whose habitat is the beach and foredune zone, Cakile edentula has a high salt tolerance. The fruits of this species have a corky outer coating, allowing them to be buoyant in water for long periods of time and to be dispersed over great distances in this manner (Maun et al, 1990). Plants such as Cakile are the true pioneer species, stabilizing the sand for secondary colonizers.

Dune-building plants are those which trap and stabilize blown sand (Carter, 1988), resulting in the development of shadow dunes, and eventually foredunes. The influence that different species have on the morphology of developing dunes can be seen in variations in area, shape and height of shadow dunes (Olson, 1958b; Carter, 1988). For example, dunes formed by Ammophila (marram grass) are capable of expanding over large areas due to horizontal vegetative propagation, while those created around Elymus mollis (American dune grass) are limited in their growth since Elymus does not reproduce vegetatively and dune-building conditions are poor for seedlings. Ammophila breviligulata can expand by means of rhizomes into adjacent bare areas at a rate of 3-4 m/year, and has a great capacity for vertical growth, withstanding burial of up to 1 m annually (Woodhouse, 1982; Maun, 1985).

Once sand dunes have developed, vegetation plays a very important role in stabilizing the sand (Jungerius and van der Meulen, 1988). There are three ways in which plants increase dune stability: 1) roots effectively bind the sand together; 2) organic matter in the sand increases the water retention and the cohesion of the sand; and 3) by increasing the surface roughness, vegetation decreases the velocity of the wind at the surface, reducing the potential for erosion. Thus, the less vegetated yellow dunes, the seaward dunes which are receiving sand deposition, are more vulnerable to wind and water erosion than the more vegetated grey dunes, the landward dunes on which soil development has occurred. Disturbance of the protective vegetation cover, for example by trampling, grazing or burrowing, may result in stable dunes becoming eroded and mobile.

6.1.2 The Dune Environment

Coastal sand dunes provide an ecological setting that is like no other. Factors that contribute to the uniqueness of this environment include water availability, salt spray, soil salinity and nutrients, light and temperature, sand movement, and exposure. Barbour et al. (1985) provided a review of the adaptations of beach and foredune plants to these environmental conditions.

Water:

Three sources of fresh water (less than 700 ppm of salt) are available to dune plants: 1) atmospheric precipitation, including fog drip; 2) water table within the root zone of tap-rooted species; and 3) internal dew, the condensation of water vapour in the soil as a result of the differences in diurnal and nocturnal soil temperatures (Ranwell, 1972; Barbour et al., 1985). The most readily available fresh water is found in the dune slacks, which represent the ground level of the dune system and are close to the water table.

Salt Spray:

Salt spray is another environmental factor with which coastal dune plants must contend. The usual response to salt spray is leaf hypertrophy (enlargement of cells), resulting in succulent leaves. However, none of the dune grasses exhibit hypertrophy, and consequently may be damaged by intense salt spray. The thick cuticle on many dune plants may be an adaptation to minimize the effect of intense salt spray (Barbour et al., 1985).

The intensity of salt spray in different areas of the dunes is related to the distance from the tideline, height above ground, wind velocity, and local microtopography. In general the intensity of salt spray decreases inland, and variations in salt spray concentration result in species zonation, typically with the most tolerant nearest the tideline (Barbour et al., 1985).

Soil Salinity and Nutrients:

Dune soils in temperate regions typically have salinity concentrations less than 1%, except following storm surges. In general, these concentrations are no greater than ordinary cultivated soils, and consequently, there does not appear to a correlation between soil salinity and species zonation (Barbour et al., 1985).

The majority of the nutrients in the soil of dunes nearest to the shore come from sea spray and fog, rather than from substrate weathering. Sodium, magnesium, calcium and chlorine are supplied in quantities in excess of plant requirements. However, concentrations of potassium, nitrogen and phosphorus are often deficient. Grey dunes have more soil development, due to greater stability and larger quantities of organic material. Rapid leaching through the dune sand prevents dune soils from acquiring high levels of salinity and nutrients (Ranwell, 1972; Barbour et al., 1985; Willis, 1989). The soil conditions in the dune slacks are different to those of the dunes. Levels of soluble iron and manganese may be high due to the waterlogged conditions. Calcium levels may also be high (Willis, 1989).

Light and Temperature:

Light intensity, influenced by season, canopy and the rate of burial, can be very high on coastal sand dunes. The leaves of many dune species seem to be anatomically adapted to deal with such intensities. For example, plants other than grasses may have thick cuticles, high stomatal indices and special mesophyll construction. Sword shaped leaves, such as those of Ammophila, are efficient users of direct and diffuse sunlight. Light intensity also influences germination, enhancing it in some species and inhibiting it in others (Barbour et al., 1985).

Dune environments are areas of large temperature fluctuations. As previously mentioned, differences in diurnal and nocturnal temperatures influence the development of internal dew. Temperature also affects germination. Some species, such as Ammophila breviligulata, require alternating temperatures to enhance germination (Barbour et al., 1985).

Sand Movement:

Sand movement on dunes is inevitable. In order to survive, species must be able to grow rapidly enough to keep ahead of the rate of sand deposition. This is particularly true on the yellow dunes, where deposition is the greatest. Some species require sand burial to maintain vigour. Ammophila breviligulata, for example, exhibits a decrease in flowering, shoot weight, plant height, and plant number per unit area with a decline in sand deposition (Eldred and Maun, 1982). Ammophila may exist in a depauperate state for decades before being rejuvenated by renewed sand deposition (Carter, 1988). As well as the ability to grow rapidly enough to continue to project above the sand, seed size is an example of adaptation to sand deposition. Beach and foredune species tend to have larger seeds than landward species, suggesting that large seeds may be required to withstand deep burial (Barbour et al., 1985).

Exposure:

Plants living on coastal sand dunes must withstand a high degree of exposure. Due to their proximity to open bodies of water, dune environments are unprotected from onshore winds. These may vary from gentle sea breezes to hurricane force gales. In most cases the environmental factors discussed above are the result of, or intensified by, the exposed nature of coastal sand dunes. Exposure to the elements is by no means uniform across dune systems. The foredunes and the dunes directly behind them are the most vulnerable, while the slacks and the inland dunes are more protected. Local topography also plays a role in determining the exposure of an area. For example, the tops of ridges experience higher wind velocities than the valleys, and north facing slopes are more shaded than those with a southern aspect. Species zonation is greatly influenced by these variations in exposure (Carter, 1988; Ranwell, 1972: Willis et al., 1959).

Dune Succession:

Dune ecosystems are comprised of a variety of gradients, created by the different environmental factors (Carter, 1988). This results in a succession of vegetation zones, ranging from the sparsely vegetated, mobile seaward dunes, to stable landward dunes covered in dune meadow and shrub-heath species, eventually giving way to forest. Within these zones are moist, sheltered dune slacks, although these tend to be rare in the Nova Scotian dunes. It must be remembered that dune species succession does not necessarily follow a set path, it may proceed in a variety of ways, even reversing if disturbed, or halting at what appears to be a transitional stage (Carter, 1988).

6.2 Vegetation of Nova Scotia

6.2.1 Regional Setting

Nova Scotia is in the Acadian forest region, dominated by coniferous trees, particularly spruce and balsam fir (Rowe, 1972). Generally the hardwoods are more conspicuous in the northern half of the province, and spruce, fir and red maple are dominant in the southern and eastern areas (Roland and Smith, 1969). An imaginary line can be drawn across the province, approximately from Digby Neck to Canso, separating these two vegetation habitats. This division, due to differences in geology, soil type, climate and geomorphology, applies primarily to plant species of the interior of the province. There is little variation in the species which occupy the coastal zone of Nova Scotia, including those of sand dunes, because of the continuity of the coastal environment (Roland and Smith, 1969). The climate limits the growing season, with the southwestern part of the province having more frost free days, and lower July temperatures than other areas. The shortest growing season is found in the most northern part of the province, Cape Breton Island (Roland and Smith, 1969).

Roland and Smith (1969) provide a review of the flora of Nova Scotia and a description of the species found in the province. Vegetation has been named according to their book, with the exception of Honkenya peploides, which they refer to as Arenaria peploides. The following is a summary of their review.

Greater variation in sand dune vegetation occurs between areas to the north and south of Nova Scotia, than within the province itself. Nova Scotia is a transitional area, often the most northern extent of southern dune vegetation, and the southern limit of species which inhabit more northern regions. Solidago sempervirens (seaside golden rod), for example, is a southern dune plant, the northern range of which includes Nova Scotia and the southern portions of Newfoundland. Other species, such as Elymus mollis, Juncus balticus, Juncus Gerardi, Honkenya peploides, Potentilla Anserina, Lathyrus japonicus and Mertensia maritima, are essentially northern plants which have a southern range extending through Nova Scotia to Cape Cod or Virginia. A small number of dune species have a very restricted range, only found along the eastern coast of North America from the Gulf of St. Lawrence southward, and, in some cases, along the coast of Europe. These include Ammophila breviligulata, Ligusticum scothicum, Carex silicea, Rumex pallidus and Cakile edentula, which has a slightly larger range from southern Labrador and Iceland to South Carolina. Many of these dune species have migrated inland, possibly along old shorelines, and now inhabit the Great Lakes region. Introduced species, such as Hieracium (hawkweed) and Artemisia Stelleriana (beach wormwood or dusty miller) are still rapidly spreading. Artemisia Stelleriana, a northern species native to Japan and Kamchatka, is a garden-escape with a coastal range from Quebec to Virginia (Roland and Smith, 1969; Thannheiser, 1984). It plays an important role as a sand stabilizer along the foredune ramp of many beaches. Hieracium is found primarily in the lee of the foredune ridge, where it is a common ground cover.

6.2.2 Vegetation of the Sand Dunes

Vegetation on each dune system was sampled by using 1 m by 1 m quadrats along a transect across a representative area of the dune system, as was described in section 1.2. The number of quadrats analysed depended on the width of the dunes and the complexity of vegetation cover, but typically ranged from five to twelve at each site.

One hundred and twenty-one plants were identified, many of which were found in most regions of the province (Table 6.1). Ammophila breviligulata was the most common species, found on all the dunes studied. Other frequently observed species were Cakile edentula, Lathyrus japonicus and Artemisia Stelleriana on the foredunes, with Myrica pensylvanica and Rosa sp. common on the lee slopes. Where forest occurred on the dunes, they were dominated by Picea, particularly Picea glauca. A few species, such as Smilacina stellata (false starry solomon's seal), Equisetum hyemale (scouring rush), and Rhus radicans (poison ivy), had a limited range, although they were often conspicuous on the dunes on which they were found. Other species which were found in nearly all areas were absent from specific dune systems. Myrica pensylvanica (bayberry), the most common dune shrub species, was not observed on any of the dunes of Aspy Bay. The other common shrub species, Rosa, of which there are several varieties, was also infrequently seen at Aspy Bay. In fact both Myrica pensylvanica and Rosa are less common on the low lying dune systems of the high energy coast of Northeastern, Eastern and Southeastern Cape Breton Island, than they are in any other area of the province.

The number of species found on each dune system varies dramatically from three on the south end of the North Pond of Aspy Bay, to thirty nine on Pomquet (see Table 6.2). Fewer species were generally found on low lying, narrow dune systems subject to washover events, while the greatest number of species tend to occur on those sand dune systems with the greatest number of ridges. This is not surprising, since the presence of multiple ridges creates a wider variety of habitats, from exposed environments near the beach to sheltered dune slacks. Pomquet is the extreme example in this case, with over twelve ridges and thirty-nine species. Those systems which have progressed to a forest level of succession also tend to have more species diversity. There are many factors influencing the number of species that exist on a dune system, such as exposure, climate, age and height of the system, and proximity to potential sources of new species. The varying importance of different factors and the interaction between them, make it very difficult to compare systems.

PLANTS FOUND ON NOVA SCOTIAN SAND DUNES

PLANT TAXA		WESTERN SHORE	CAPE SABLE IS. TO HALIFAX	HALIFAX TO CANSO	S.E. CAPE BRETON IS.	E. CAPE BRETON IS.	N.E. CAPE BRETON IS.	NORTHERN SHORE
Abies balsamea*	fir, balsam							-
Acer sp.	maple						-	
Achillea lanulosa	yarrow	*	*	*		-	-	*
Alnus crispa	downy alder		+	-	-		-	+
Amelanchier laevis*	serviceberry/shadbush/bilberry							-
Ammophila breviligulata	marram grass	*	*	*	*	*	*	*
Anaphalis margaritacea	pearly everlasting							*
Arctostaphylos Uva-ursi	bearberry						-	-
Arenaria lateriflora	grove sandwort	*	*	+	-		-	+
Aronia prunifolia*	chokeberry							-
Artemisia Stelleriana	beach wormwood	*		+	*	+	*	*
Aster sp.	aster			-				-
Atriplex patula	orach		*					+
Betula papyrifera*	birch, white/paper/canoe							*
Betula populifolia*	birch, wire/grey							*
Brassica hirta	white mustard		-					
Bryophytes	moss		*	-	-	-		*
Cakile edentula	sea rocket	*	*	*	-	-	-	*
Campanula rotundifolia	harebell						+	
Carduus crispus	curled/welted thistle		+	-	-			
Carex pallescens	pale sedge							-
Carex silicea	seabeach sedge		*	-		*		
Centaurea nigra	knapweed						-	
Chrysanthemum Leucanthemum	ox-eye-daisy	*	*	*			-	
Cladonia sp.	lichens	*	*		*		-	*
Comptonia peregrina	sweet-fern		-					
Convolvulus sepium	bindweed/morning glory		+	-				+
Corema Conradii*	broom-crowberry							-
Cornus canadensis*	bunchberry							-
Crataegus chrysocarpa*	hawthorn, American							-
Crepis capillaris	hawk's-beard							-
Cypripedium acaule*	ladies slipper, common							-
Drosera rotundifolia	round-leaved sundew				-			
Elymus mollis	American dune grass		*	-	-	-	+	-
Empetrum atropurpureum	purple crowberry		-					
Empetrum nigrum	black crowberry		-		-		-	
Epilobium angustifolium*	fireweed/large willow-herb							-
Equisetum arvense	field horsetail							-
Equisetum hyemale*	rush, scouring							-
Erigeron annuus	daisy-fleabane							*
Fragaria virginiana	wild strawberry		*	*	-	-	-	*
Galeopsis Tetrahit	nettle, hemp		-					
Galium asprellum	bedstraw, rough		-					
Galium palustre	common/marsh bedstraw							-
Gaultheria procumbens*	teaberry/wintergreen							-
Gnaphalium uliginosum	low cudweed	*	-	-				+
Gramineae	grass family	*	*	*	*	*	*	*
Hieracium canadense	Canada hawkweed							-
Hieracium floribundum	hawkweed, pale/ king-devil	*	*	-	-			
Hieracium Pilosella	mouse-eared hawkweed		*	-	-	+	-	*
Honkenya peploides	seabeach sandwort		-		-			
Hudsonia tomentosa	woolly/false/beach heather							-
Hypericum perforatum	common St.John's wort		-					
Iris versicolor	iris/blue flag	*	*	-	*		-	-
Juncus balticus	rush		=	+	+	-	-	+
Juncus canadensis	rush, Canada	*						
Juncus Gerardi	rush		+					
Juniperus communis	juniper, common		+	+				-
Juniperus horizontalis	juniper, creeping		-	-				
Kalmia angustifolia	sheep laurel, lambkill				-			
Lathyrus japonicus	beach pea	*	*	*	*	-	*	*
Ledum groenlandicum	Labrador-tea		-					
Ligusticum scothicum	scotch lovage			-	-			
Lysimachia terrestris	loosestrife, swamp candle							-
Maianthemum canadense*	lily-of-the-valley, wild							-
Melampyrum lineare*	cow-wheat							-

Mertensia maritima	lungwort, sea		+		-			
Myrica Gale	sweet gale		-		-		-	*
Myrica pensylvanica	bayberry	*	*	*	-	+		*
Oenothera biennis	evening-primrose		*	-	-	-	-	*
Onoclea sensibilis	sensitive fern							*
Picea glauca	white spruce		*	*	*		-	*
Picea mariana	black spruce							
Pinus Strobus*	pine, white							-
Populus tremuloides	trembling aspen							+
Potentilla Anserina	silverweed	*	-		-	-	-	-
Potentilla norvegica	rough cinquefoil		-		-			
Potentilla palustris	marsh cinquefoil		-					-
Potentilla tridentata	three-toothed cinquefoil			-				
Prunus virginiana	choke-cherry						-	
Quercus borealis*	oak, red							-
Ranunculus avis	buttercup					-		
Rhinanthus Crista-galli	yellow-rattle						-	
Rhus radicans	poison ivy							*
Ribes hirtellum	gooseberry		-	-			-	-
Rosa carolina	wild rose							
Rosa nitida	swamp rose	*	*	*	-		-	*
Rosa rugosa	wild rose							
Rosa virginiana	common wild rose							
Rubus sp.	brambles		-					
Rubus strigosus	wild raspberry		-		+			-
Rumex Acetosella	sheep-sorrel	*	*	+	-			+
Rumex pallidus*	dock, seabeach/white							-
Salix humilis	willow			-				-
Sambucus pubens	red-berried elder						-	
Scutellaria galericulata	skullcap	*					-	
Sedum acre	mossy stonecrop		-					
Senecio Jacobaea	tansy ragwort/stinking-willie							-
Sisyrinchium montanum	blue-eyed grass						-	
Smilacina stellata	starry false solomon's seal		+	*				+
Solanum Dulcamara	nightshade/bittersweet							-
Solidago juncea	early golden rod							-
Solidago puberula	downy/rough golden rod		-					+
Solidago sempervirens	seaside golden rod	*	*	*	-		-	+
Sonchus arvensis	sowthistle, milkweed		+	-	*			
Spartina pectinata	broad leaf cord-grass							-
Spiraea latifolia	meadowsweet/hardhack		+					
Spiraea tomentosa	steeple-bush							-
Spiranthes lacera*	ladies'-tresses, slender							-
Stellaria graminea	stitchwort	+	*	-				
Taraxacum officinale	dandelion	*	-	*	+		-	
Thalictrum polygamum	meadow rue			-				
Trientalis borealis*	star-flower							-
Trifolium pratense	red clover		+	*		-	-	-
Trifolium procumbens*	clover, low hop-							-
Trifolium repens	creeping white clover						+	
Vaccinium angustifolium	low bush blueberry			+	-		-	-
Vaccinium macrocarpon	cranberry		-		-			-
Vicia angustifolia	wild vetch		-					
Vicia Cracca	cow/tufted vetch	*	+	*			-	*
Viola pallens	violet, small white		-					

Table 6.1. Plant species identified on sand dunes in Nova Scotia, with their occurrence in different regions of the province. Species denoted by "* " were found only on Pomquet.

*** = very common, + = common, - = rare.**

Another influence on species diversity seems to be the history of human disturbance. Dune systems which were badly disrupted in the past by human activity, such as aggregate removal, and which have been allowed to recover often display a wide variety of plant species. Summerville, which was the site of a railway line and later used as an unofficial trailer park during the summer months, has a couple of species not commonly found on Nova Scotian dunes, such as brambles and Sedum acre (mossy stonecrop), a garden escape. Pomquet, with its great diversity of plants, also falls into this category of misuse and later recovery. On the other hand, those dunes which are being actively disturbed often have a very limited number of plant species. Only five species were observed on the dunes at Glace Bay, which has a history of disturbance as a transportation route and building site and is still misused by vehicle traffic. On the dunes at Dominion, in the neighbouring bay, which have a similar history of disturbance, but are being allowed to recover under the protection of the provincial park system, eleven species were noted.

6.3 Vegetation Associations

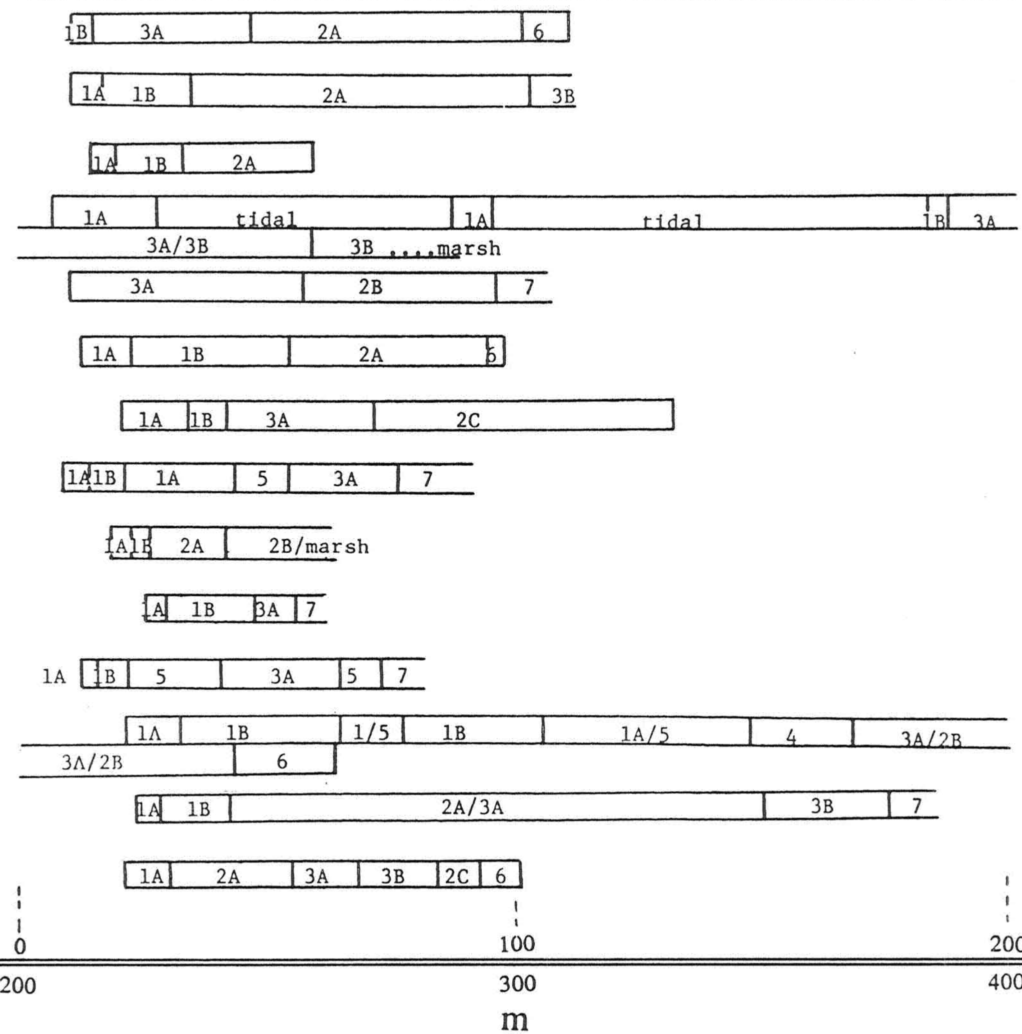
A vegetation association may be defined as an essentially homogeneous ecological unit characterized by two or more dominant species. Seven vegetation associations, based on species composition and density, were identified on the sand dunes of Nova Scotia: 1) foredune; 2) dune meadow; 3) shrub-heath; 4) dune slacks; 5) deflation-lichen; 6) marsh-lagoon edges; and 7) forest. Table 6.2 depicts the vegetation associations found on each dune system, giving the distance of each association from the high water line. Associations 2 through 5 occur in the lee of the foredune and may be present in any order, although most often the dune meadow association follows the foredune vegetation, with shrub-heath next, and ending with either the marsh-lagoon edge association or forest. The dune slack and deflation-lichen associations may occur at any point in the lee of the foredune. Not all associations appear on every dune system.

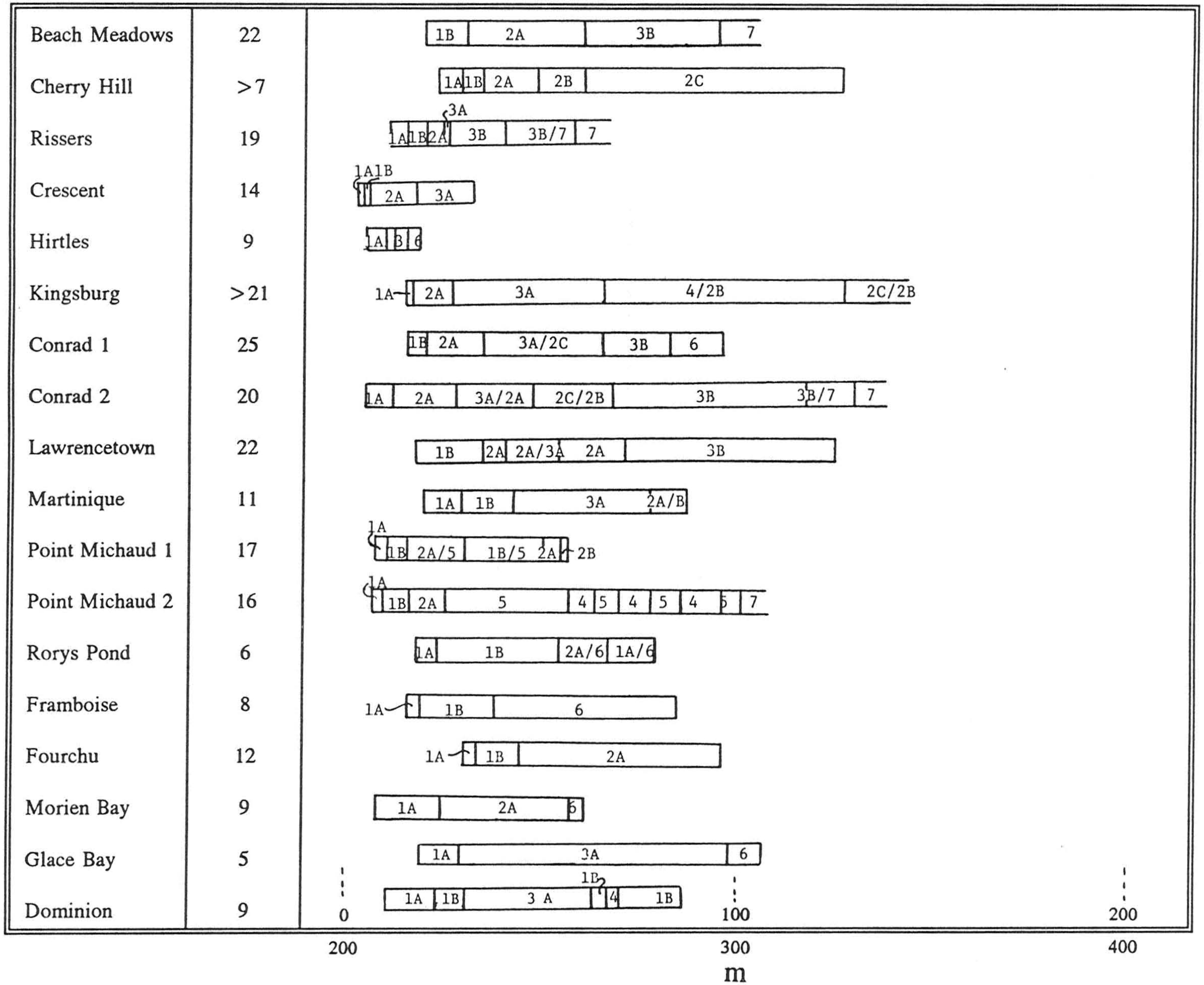
6.3.1 Foredune Vegetation Association

The foredune vegetation may extend from the high tide litter zone to the lee slope of the foredune ridge. The association is characterized by the following dune initiating and dune building plants: Ammophila breviligulata, Elymus mollis, Cakile edentula, Artemisia Stelleriana, Atriplex patula, Lathyrus japonicus, Mertensia maritima, and Brassica hirta. Sparse, new growth, providing less than fifty percent ground cover is labelled 1A in table 6.2, and is found on embryo dunes, ramps and occasionally in the lee of the foredune ridge. Although Ammophila and Cakile are the most common species of the ramp and dune ridge, on some systems an Elymus-Cakile association is dominant on embryo dunes.

An older, more stable foredune vegetation association, providing more than fifty percent cover, labelled 1B in table 6.2, is found on the crest of the dune and

LOCATION	# OF SPECIES	DISTRIBUTION OF PLANT ASSOCIATIONS
Bartletts	21	
Absalom Point	18	
Clam Point	5	
Sand Hills 1	15	
Sand Hills 2	>8	
Baccaro	11	
Red Head	15	
Roseway	6	
Black Point	7	
Louis Head	5	
Sandy Bay	11	
St. Catherines	15	
Carters	12	
Summerville	19	




Beach Meadows 22 1B 2A 3B 7
Cherry Hill >7 1A 1B 2A 2B 2C
Rissers 19 1A 1B 2A 3A 3B 3B/7 7
Crescent 14 1A 1B 2A 3A
Hirtles 9 1A 3 6
Kingsburg >21 1A 2A 3A 4/2B 2C/2B
Conrad 1 25 1B 2A 3A/2C 3B 6
Conrad 2 20 1A 2A 3A/2A 2C/2B 3B 3B/7 7
Lawrencetown 22 1B 2A 2A/3A 2A 3B
Martinique 11 1A 1B 3A 2A/B
Point Michaud 1 17 1A 1B 2A/5 1B/5 2A 2B
Point Michaud 2 16 1A 1B 2A 5 4 5 4 5 4 5 7
Rorys Pond 6 1A 1B 2A/6 1A/6
Framboise 8 1A 1B 6
Fourchu 12 1A 1B 2A
Morien Bay 9 1A 2A 6
Glace Bay 5 1A 3A 6
Dominion 9 1A 1B 3 A 1B 4 1B
0
100
200
200
300
400
m

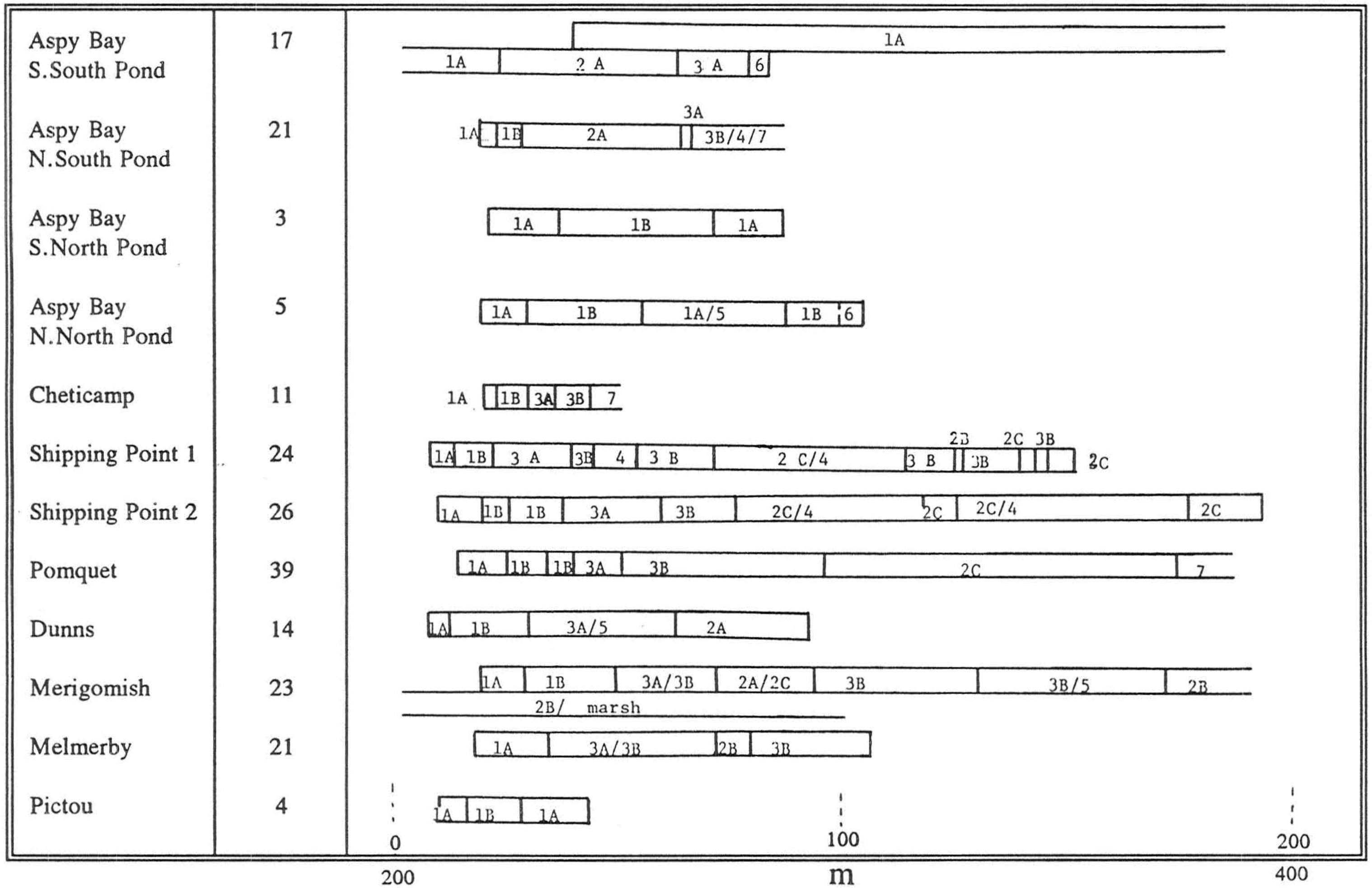


Table 6.2. The distribution of plant associations across each dune system is shown as the distance of association boundaries from the high water line (0 m). The associations are represented by the numbers assigned in section 6.3.

1A = sparse foredune, 1B = dense foredune, 2A = dune meadow dominated by Ammophila, 2B = dune meadow, 2C = dune meadow with some shrub-heath, 3A = shrub-heath dominated by Ammophila, 3B = shrub-heath, 4 = dune slack, 5 = deflation-lichen, 6 = marsh-lagoon edge, 7 = forest on the lee slope. As in the 1A association, Ammophila breviligulata is the dominant species, however Cakile edentula, Atriplex patula and Mertensia maritima are less common. Lathyrus japonicus (beach pea) is more frequent in the 1B association, except on the dunes facing the Northumberland Strait where it is also common on the ramp and beach. Equisetum hyemale is found only on Pomquet, where it forms a dominant part of the 1B association. Another common species of this vegetation zone on Pomquet is Rhus radicans, which is also found on Merigomish, and Dunns beach. Smilacina stellata is a dominant species in the lee of the dune ridge along with Ammophila breviligulata on Conrads and Lawrencetown.

Three forms of foredune were observed in Nova Scotia: 1) a vegetated ramp with no embryo dune; 2) a vegetated ramp with embryo dune formation; and 3) a dune ridge truncated by wave action. Figure 6.1 depicts the three forms of foredune, their vegetation cover, and provides their locations. Each of these forms is not exclusive of the others and they frequently exist along the same beach, as is seen at Carters beach (Fig. 6.2).

6.3.2 Dune Meadow Association

The dune meadow has three subassociation. The first, dominated by Ammophila breviligulata, is referred to as 2A, and is characterized by having at least two herbaceous plants that are not found in the foredune association. Dune meadow dominated by herbaceous plants and grasses is labelled 2B, and that in

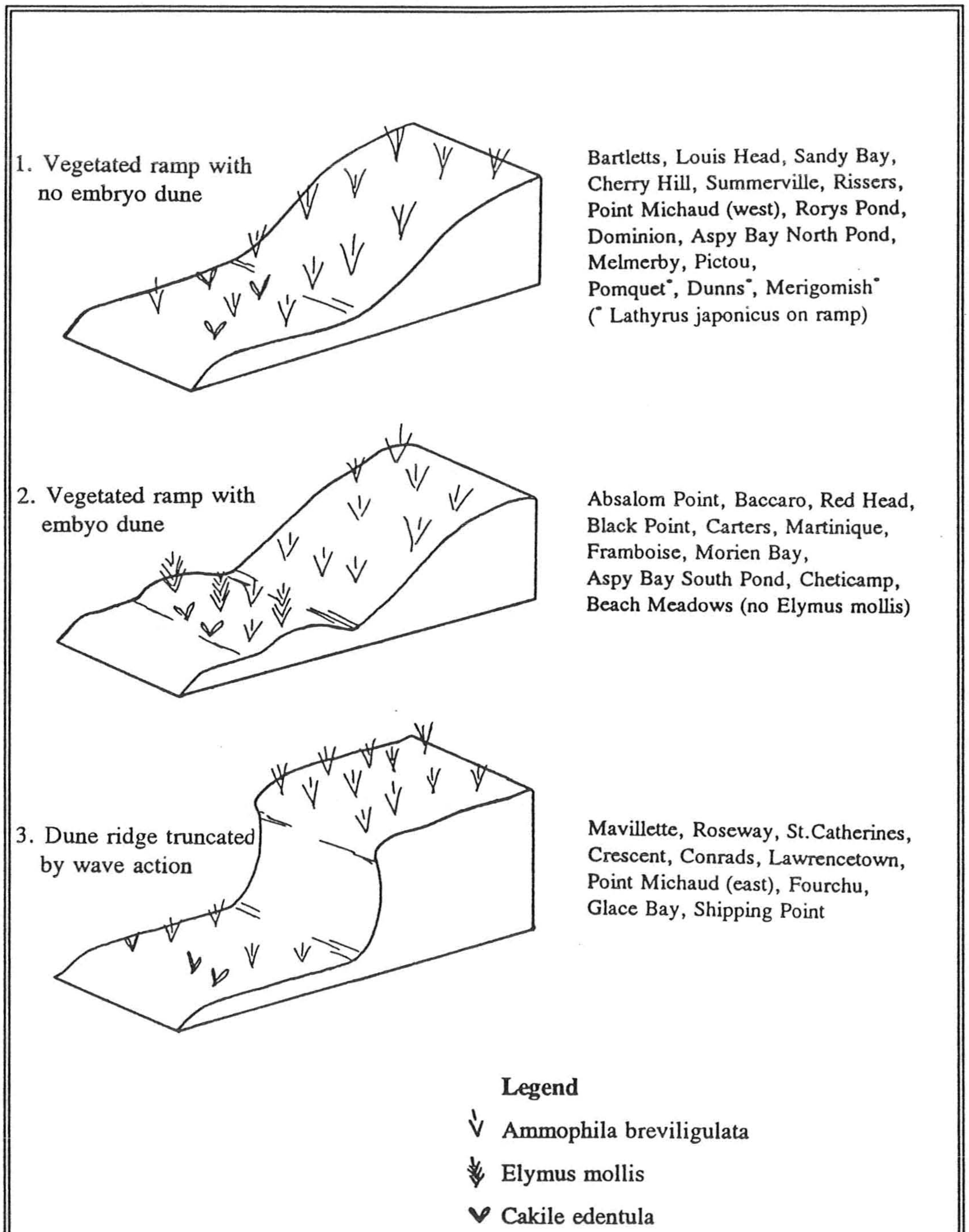


Figure 6.1. Three typical forms of foredune exist in Nova Scotia, as shown above, with the characteristic vegetation and the sites at which they are found. Most dune systems have more than one form, but are listed according to that which is most common.

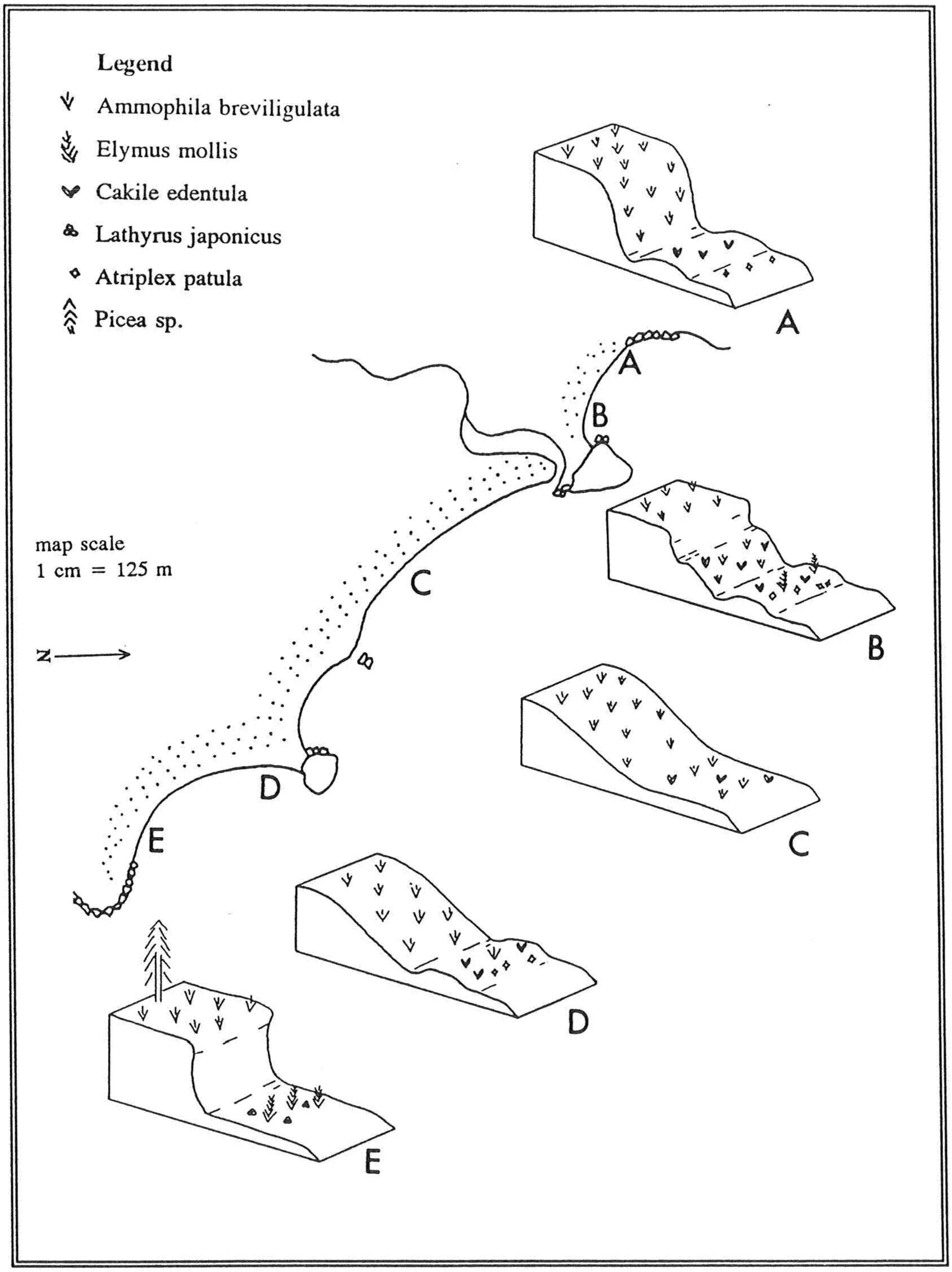


Figure 6.2. Variations in foredune morphology and the associated vegetation at five locations along Carters Beach.

which a few shrubs exist is called 2C. Dune meadow most often occurs immediately behind the foredune vegetation association, seaward of shrub-heath associations. This is particularly true along the Atlantic shore, where this pattern was observed on every beach from Carters beach to Rorys Pond. The opposite arrangement is prevalent on those beaches along the North Shore, where the dune meadow association was located landward of shrub-heath vegetation on five of the seven beaches (one beach has neither association).

6.3.3 Shrub-Heath Association

This association is characterized by Myrica pensylvanica and the many varieties of Rosa. Two subassociations exist, 3A in which Ammophila breviligulata is the most frequent plant, and 3B which is dominated by either Myrica pensylvanica or Rosa and includes numerous herbaceous plants. At Shipping Point Spirea tomentosa is an important component of 3B. Unlike the vegetation pattern seen on the more southern dunes of Cape Cod, in Nova Scotia Rosa is rarely the dune shrub in the most seaward position. It generally occurs landward of, or with, Myrica pensylvanica. The shrub-heath association is rarely seen on north eastern, eastern or south eastern Cape Breton Island, and when it does occur it is only a 3A association. The only true heath vegetation, Hudsonia tomentosa was seen on Merigomish. The shrub species are much more varied on Pomquet, and include many which were found in no other location.

6.3.4 Dune Slack Association

Dune slacks and the associated vegetation are rare in Nova Scotia, found only on Shipping Point, the eastern side of Point Michaud, Kingsburg, St. Catherine's and Dominion. All of these are wide systems, over 100 m in width, with multiple ridges, the exception being Dominion, where the hollow forming the dune slack was likely created by human activity. The characteristic vegetation is Juncus balticus and Vaccinium macrocarpon, although other species such as Juncus Gerardi, Empetrum nigrum, and mosses and grasses occur. Vaccinium angustifolium, Alnus, Myrica Gale and Kalmia angustifolia were often associated with the dune slacks located close to the landward extent of the dunes.

6.3.5 Deflation-Lichen Association

Dry areas, often experiencing deflation, are found in the lee of the foredune on several beaches. The vegetation cover, excluding lichens, is less than forty percent, and plant such as Ammophila lack vigour. The characteristic plant species are Cladonia sp.(lichens), Hieracium Pilosella and senescent Ammophila breviligulata. The deflation-lichen association may occur along with the foredune vegetation 1A or the shrub-heath vegetation 3A. South of Halifax the deflation-lichen association often exists on exposed cobbles of the underlying substrate.

6.3.6 Marsh-Lagoon Edge Association

This association occurs only at the very back of dune systems, adjacent to the salt marsh or the tidal flats. There is usually an increase in grasses and occasionally Ammophila, a decrease in herbaceous plants, and a slight overlap with marsh species may occur. Iris versicolor is often a characteristic species. Other plants commonly found in this area include Juncus balticus, Convolvulus sepium, Solidago sempervirens, Oenothera biennis, Lathyrus japonicus, and young Picea.

6.3.7 Forest Association

The forest association, found only on eleven dune systems, also occurs only at the back of the dunes, most frequently on those systems which are fully attached to the mainland. The characteristic species is Picea, primarily the salt tolerant Picea glauca (Fowells, 1965). All meadow, shrub and tree species observed on the sand dunes of Nova Scotia also belong to this vegetation association. A wider variety of trees and bushes exist on Pomquet, such as Aronia prunifolia, Crataegus chrysocarpa, Pinus Strobus, and Quercus borealis, as may be expected given the forest regions discussed in the section on regional vegetation (6.2.1). The existence of a forest zone does not appear to have any strong relationship to the width of the dune system, the number of ridges, or the exposure of the beach to the open ocean. However, a combination of all of these factors together, as well as the age of the system, and its height above sea level must play a role in determining whether or not a forest can exist on a specific dune system.

6.4 Summary of the Dune Vegetation of Nova Scotia

The most common order of vegetation succession is from the foredune vegetation association to the dune meadow, followed by the shrub-heath vegetation, and ending with either forest or marsh-lagoon edge (Fig. 6.3). The deflation-lichen association may occur at any point within the shrub-heath or the dune meadow. The same applies for the dune slack association, however it only occurs in low lying areas and tends to be found at a more landward position than the deflation-lichen association. Dune plant succession is not necessarily in this order since it varies greatly depending on the conditions on each dune system. On some narrow barriers the whole system is vulnerable to sand blasting, salt spray, and overwash, and it is possible to get only foredune vegetation.

The vegetation associations may be placed into more general vegetation groups according to the location of their habitat (see Fig. 6.4B). The first plants occurring on the backshore, part of the foredune association, are the initial colonizers. The vegetation of the foredune, or primary dune, is typically that of the foredune association, although it may include part of the dune meadow and the shrub-heath communities. The landward portion of the dune system, the secondary dunes, are vegetated by the dune meadow, shrub-heath, deflation-

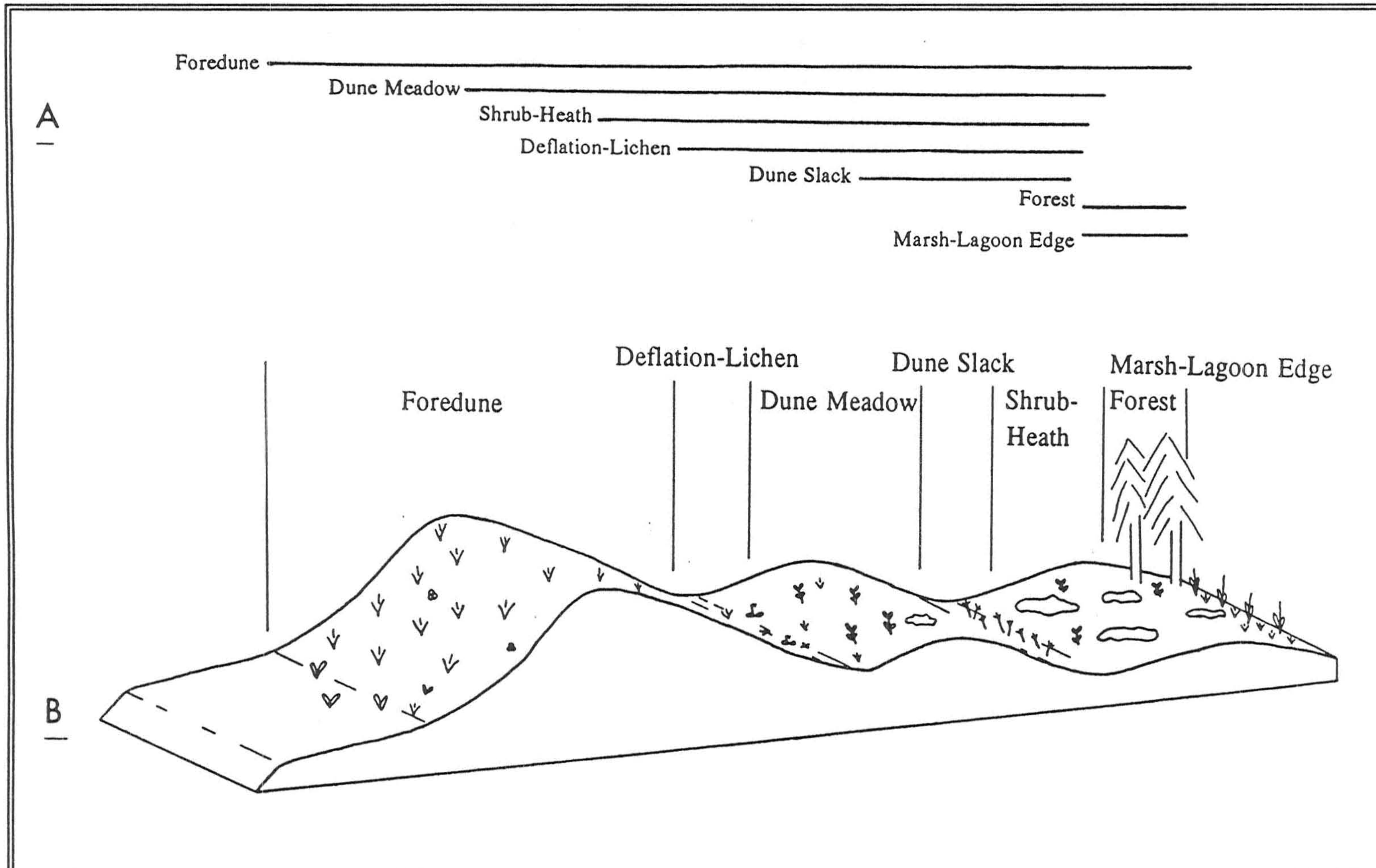


Figure 6.3. Typical vegetation succession (A), and vegetation distribution (B) across sand dune systems in Nova Scotia.

lichen, dune slack, forest and marsh-lagoon edge communities.

6.5 Comparison With Other Studies

Thannheiser (1984) provides the only comprehensive study of the coastal vegetation in eastern Canada. His concept of the dunes of this region includes four zones: 1) embryo dunes; 2) fore or primary dunes; 3) white or secondary dunes; and 4) grey or tertiary dunes (Fig. 6.4A). The embryo dunes, located along the foreshore, are dominated by Honkenya peploides or Mertensia maritima, while the fore or primary dunes, found immediately landward of the embryo dunes are inhabited by Elymus mollis. Maun also found Elymus mollis along the shores of Nova Scotia, Prince Edward Island and New Brunswick (personal communication). The high, mobile main dune ridge of white or secondary dunes is primarily vegetated by Ammophila breviligulata. The stabilized grey or tertiary dunes are dominated by senescent Ammophila, grading into shrub-heath vegetation. According to Thannheiser, a Lathyrus japonicus-Ammophila breviligulata association replaces the Elymus mollis on the foredune in the warmer areas of eastern Canada, such as Prince Edward Island and Les Iles de la Madeleine. In colder regions, such as eastern Labrador and eastern Newfoundland, only the Honkenya-Elymus association exists. In New Brunswick and Nova Scotia both associations are found, with Elymus in the seaward position, as described above. Later in his paper, Thannheiser contradicts himself

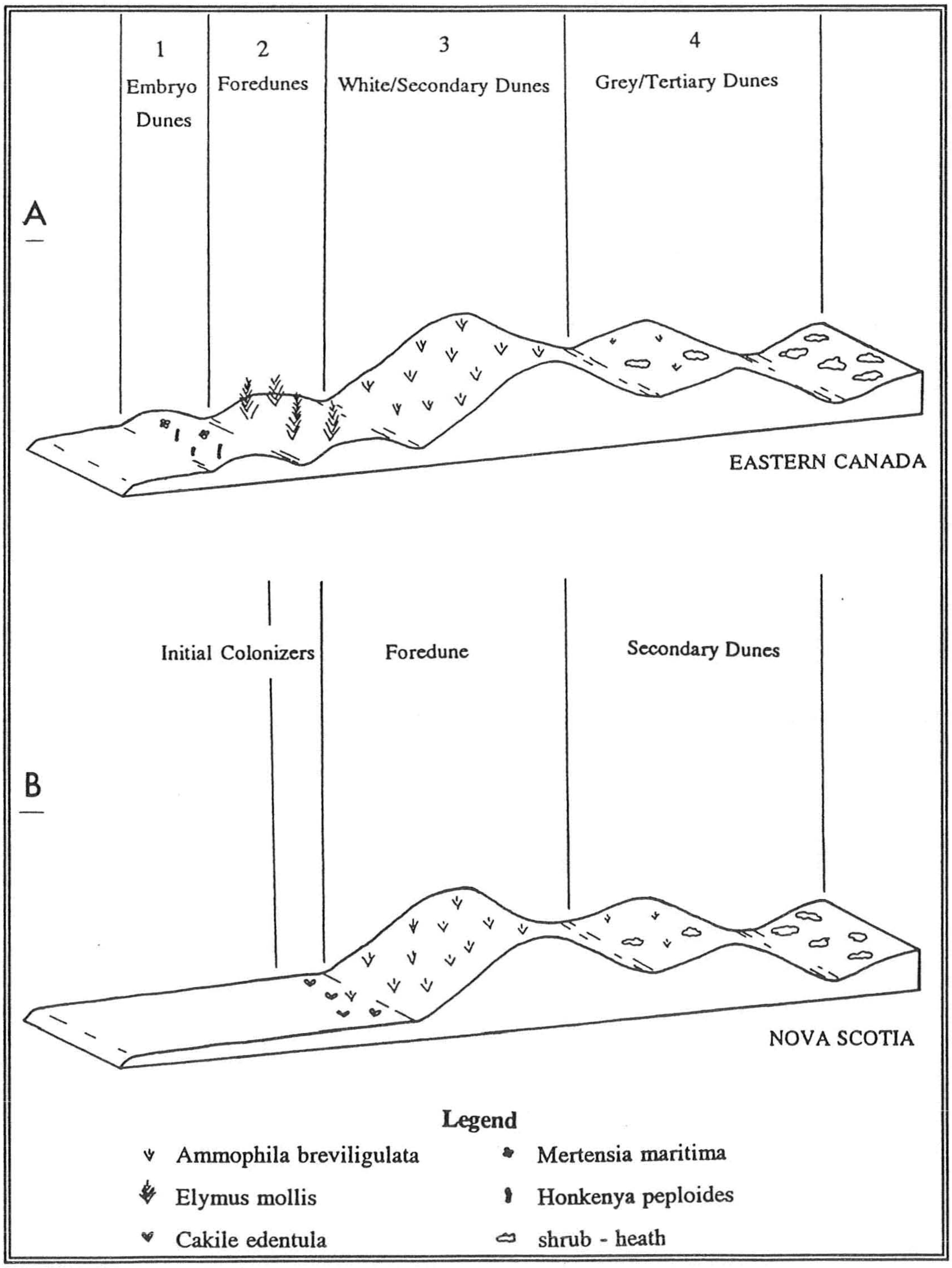


Figure 6.4. (A) A general model of sand dune morphology and vegetation redrawn from description by Thannheiser (1984), and (B) model of dune morphology and vegetation of Nova Scotia taken from figure 6.3.

by saying that Lathyrus-Ammophila is the typical association of the southern part of eastern Canada. Unfortunately, Thannheiser does not provide the exact locations of his field sites, so it is not possible to compare his model directly to the vegetation found on specific beach-dune systems during the summer of 1991. In general Thannheiser's zone 4 corresponds with the shrub-heath and dune meadow associations, however Thannheiser's zones 1, 2 and 3 do not agree with the foredune vegetation observed in Nova Scotia (Fig.6.4).

The major discrepancy between our observations and Thannheiser's model is the dominance of a Honkenya-Elymus association on the seaward side of the main dune ridge. Elymus mollis was only seen on thirteen beaches, seven of which were not in the areas visited by Thannheiser. Where Elymus was observed, it did occupy the zone described by Thannheiser, however it never created a continuous band along the beach, as is demonstrated by the example of Carter's beach. Honkenya peploides was observed on three beaches, of these two occurred on a gravel substrate, and it was never seen in association with Elymus. Honkenya was observed as a dune-initiating plant only at Sand Hills, which is also not in the region of the province visited by Thannheiser. Mertensia maritima was also only seen on three beaches, each time on sand-covered cobbles. The plant species most commonly observed in the foreshore zone and on the ramp were Cakile edentula, Atriplex patula, Artemisia Stelleriana, and Lathyrus japonicus, with Cakile being the most prevalent. In most instances Ammophila breviligulata was also seen in this area of the beach.

A possible explanation of the discrepancy between this research and Thannheiser's model, is the occurrence of hurricane Hugo in September, 1989, which affected many of the beaches and dunes facing the Atlantic Ocean, according to local residents. If the resulting waves had removed much of the ramp area and the associated vegetation, it is possible that Elymus mollis had not had time to recolonize in great quantities by summer, 1991, but had re-established itself further by summer, 1992, when the province was visited by Maun. However, those sites where Elymus mollis was observed were not more sheltered than those were it was absent.

The species observed on the beach-dune systems of Nova Scotia correspond to other studies of vegetation at specific locations within the province, such as Pomquet (Lynds, 1986) and St. Catherine's River (Farrier et al., 1991).

Table 6.3 provides a summary of the vegetation found on the sand dunes of the eastern coast of the United States of America, and of the maritime provinces. The initial colonizing vegetation of the sand dunes in Nova Scotia is similar to that of Prince Edward Island and les Iles-de-la-Madeleine, with Ammophila breviligulata, Cakile edentula, and Lathyrus japonicus being the common species. The initial colonizers of Sable Island differ in that Honkenya peploides, which is uncommon on Nova Scotia dunes, is a dominant species. Elymus mollis was not recorded as a major initial dune colonizer in any of these studies. The major change in the grassland vegetation occurs between the dunes north of New Jersey and those of North Carolina to Florida; the latter are dominated by Uniola paniculata rather than Ammophila breviligulata. The shrub-heath and forest vegetation most common in Nova Scotia do not correspond closely to those of les Iles-de-la-Madeleine, Prince Edward Island or the Maine to New Jersey region, but have some similar plant species. The shrub-heath and forest vegetation of Pomquet, however, are very similar to those of Prince Edward Island, having a greater number of deciduous species. In general, the shrub-heath vegetation of Nova Scotia is most like those of Sable Island, with the exception of Calluna vulgaris and Empetrum nigrum. The forest of Nova Scotia dunes is dominated by Picea sp., unlike the forests described in the other regions, which have a greater number of deciduous species. Picea is not dominant on the dunes south of Nova Scotia, but is on those to the north, suggesting that Nova Scotia may be a transitional area. The distribution of Quercus also suggests this as it is found to the south, but not to the north of Nova Scotia, and is found on Pomquet.

6.6 Conclusion

The vegetation of the sand dunes in Nova Scotia may be categorized into seven homogeneous associations, foredune, shrub-heath, dune meadow, deflation-lichen, dune slacks, marsh-lagoon edge, and forest, all of which do not necessarily appear on each dune system.

With the exception of forest vegetation, the vegetation found on the dunes

REGION	INITIAL COLONIZERS	GRASSLANDS	SHRUB - HEATH	DUNE SLACKS	FOREST	REFER-ENCES
NOVA SCOTIA	Ammophila breviligulata Cakile edentula Artemisia Stelleriana Lathyrus japonicus Elymus mollis	Ammophila breviligulata Hieracium sp. Cladonia sp. Oenthera biennis Lathyrus japonicus Artemisia Stelleriana Myrica pensylvanica Rosa sp. Solidago sempervirens Graminae sp. Achillea lanulosa Rumex acetosella	Myrica pensylvanica Rosa sp. Juniperus communis Graminae sp. Achillea lanulosa Spirea tomentosa	Juncus balticus Iris versicolor Potentilla sp.	Picea sp. Alnus crispa	
PRINCE EDWARD ISLAND	Ammophila breviligulata Honkenya peploides Cakile edentula Lathyrus japonicus	Ammophila breviligulata Lathyrus japonicus Solidago sempervirens Oenothera biennis Aster novi-belgii	Myrica pensylvanica Rhubus strigosus Rosa carolina Rosa rugosa Amelanchier Aronia melanocarpa	Myrica Gale Salix sp. Onoclea sensibilis Spirea latifolia Equisetum fluviatile Phalaris arundinacea Iris versicolor Scipus sp. Hypericum virginicum Lycopus uniflorus Vicia cracca Convolvulus arvensis Potentilla palustris Lysimachia terrestris	Picea glauca Prunus pensylvanica Acer rubrum Alnus rugosa Betula populifolia Sorbus americana Spirea latifolia Solidago rugosa Solidago graminifolia Aster novi-belgii	Lane, 1990
LES ILES DE LA MADELEINE	Ammophila breviligulata Cakile edentula Honkenya peploides Lathyrus maritima	Ammophila breviligulata Festuca rubra Poa pratensis Myrica pensylvanica Empetrum nigrum Cornus canadensis Vagnera stellata Potentilla tridentata Achillea lanulosa	Empetrum nigrum Arctostaphylus urva-ursi Juniperus communis Juniperus horizontalis Myrica pensylvanica Hudsonia tomentosa	Vaccinium macrocarpon Juncus balticus Lysmachia terrestris Lycopus uniflora Tortella tortuosa Sphagnum sp. Scapania sp. Amblysteglum serpens		Giles, 1990

SABLE ISLAND	Honkenya peploides Cakile edentula Ammophila breviligulata Solidago sempervirens	Ammophila breviligulata Lathyrus maritima Solidago sempervirens Achillea lanulosa Festuca rubra Frageria vesca Rosa virginiana Anaphalis margaritacea Myrica pensylvanica Rumex acetosella	Empetrum nigrum Juniperus communis Myrica pensylvanica Rosa virginiana Vaccinium angustifolium Calluna vulgaris	Vaccinium macrocarpon Juncus balticus Myrica pensylvanica Aster novi-belgii Viola lanceolata Calopogon pulchillus		Freedman et al, 1981 Byrne, 1991
MAINE TO NEW JERSEY		Ammophila breviligulata Solidago sempervirens Artemisia Stelleriana Rhus radicans Lathyrus japonicus	Arctostaphylus urva-ursi Hudsonia Corema Lechea Myrica pensylvanica Rosa	Typha Phragmites Rhododendron Vaccinium Alnus Viburnum Acer Rubrum	Prunus maritima Prunus sp. Amelanchier Rosa Quercus velutina Quercus alba Pinus rigida Fagus grandifolia Acer rubrum Sassafras albidum Juniperus	Godfrey, 1976
NORTH CAROLINA TO FLORIDA		Uniola paniculata Spartina patens Panicum amarulum Eragrostis Muhlen bergia Physalis Hydroctyle	Morus rubra Myrica cerifera Ilex vomitoria Calicara + numerous vines		Quercus virginiana Quercus phellos Quercus lauriflora Ilex opaca Persea barbonia Osmanthus Pinus taeda Juniperus virginiana	Godfrey, 1976

Table 6.3. Dune vegetation of regions of the eastern coast of North America using the vegetation groups defined by Godfrey (1979).

of Nova Scotia places it in a larger regional vegetation area which includes the other maritime provinces and the eastern coast of the United States of America as far south as New Jersey. The distribution of forest vegetation suggests that Nova Scotia is a transitional area between the forests containing Quercus to the south, and those with Picea to the north.

Over one hundred plant species were identified, however it is likely that some species were missed given that field work extended from early June to late July, essentially covering two seasons. Late flowering plants may have been missed on the dunes visited during June, those south of Halifax, while early flowering plants may not have been seen on the dunes of the North Shore, which were studied in late July, those of the northern shore. It is also possible that an annual embryo dune ridge may develop around the backshore and ramp vegetation on many of the beaches by the end of the summer, but was not observed due to the timing of the field work.

CHAPTER 7

HUMAN USE OF THE DUNES OF NOVA SCOTIA

7.1 Introduction

In many areas the importance of managing coastal sand dunes is just being recognized (ie. Clark, 1977; Meulen et al., 1989; and Chapman, 1989). Much of the growing interest in protecting dune systems from over use and exploitation results from the rapid increase in recreation in these areas and the associated degradation of the dune environment. The overall carrying capacity of coastal sand dunes is low, approximately 100 persons per hectare (Carter, 1988). There has also been an increasing awareness in the significance of the coastal dune environment as an ecological area. It provides an important habitat for many plants and animals, and nesting sites for a variety of birds (Willis et al., 1959; Ranwell, 1972; Willis, 1989).

The sand dunes of Nova Scotia have a long history of use. Since European settlement, beginning in the seventeenth century, sand dunes have been used for agriculture and as pasture, and as a readily available source of well sorted sand.

These uses continued well into the twentieth century, with the most destructive, aggregate removal, occurring at commercial levels on several systems until the 1970s (ie. Conrads, Point Michaud, Framboise, Dominion, and Pomquet; Bowen et al., 1975). Since then recreational uses have become the most damaging influence on the sand dunes. This chapter will discuss the general impact of human activity, the resulting problem areas, and the policies of the Provincial and Federal Governments concerning sand dunes.

7.2 The Present Condition of the Sand Dunes

The impact of human activity on each system has been described in chapters 4 and 5, where applicable. Most of the damage on the sand dunes in Nova Scotia is the result of activities such as aggregate removal and recreational pastimes, in particular, driving vehicles and camping for extended periods on the dunes. Aggregate removal has been stopped on a commercial scale, but, many systems continue to be disturbed as the result of a variety of activities.

The impact of six activities which have, or are, causing degradation of Nova Scotian sand dunes will be discussed in this section.

7.2.1 Mining

The removal of sand from dunes for commercial purposes was stopped in the 1970s, but some very small removal still occurs for local use on some of the more remote dunes. The effect of past mining is still visible on dune systems such as Conrads, Lawrencetown, and Rainbow Haven. The resulting large hollows are now vegetated, and due to the size of these systems, the whole dune area is not threatened by this past activity, as were systems like Silver Sands (see section 5.3.2). Bowen et al. (1975) provide a more detailed account of the practice of commercially mining beaches and dunes, such as Point Michaud, Framboise, Dominion, Pomquet and Melmerby, for their sediment. The amount of sediment removed is estimated to have been between 750,000 and 1,000,000 tons over the last hundred years from Dominion, and 100,000 to 1,500,000 tons from Melmerby. On most beach and dune systems the actual amount of sediment removed is not known, since there was often a variety of groups involved. Sand was mined for several different purposes, the most common being for industrial use, such as by Dominion Coal Company, construction, sanding roads, and personal use.

7.2.2 Camping

Camping no longer occurs at random on most of dune systems, and there is now a well-developed system of provincial and private campgrounds. Until the end of the 1980s it was popular to drive campers up onto the dunes at Summerville, where they caused a lot of damage to the vegetation and resulted in extensive erosion (R. Williams, pers. comm.). The provincial campground at Rissers is adjacent to sand dunes, as will be the new one at Sandy Bay, Thomas H. Raddall Provincial Park, which is to open in the spring of 1993. Camping is also allowed on a small scale by permit in the Kejimkujik Seaside Adjunct, but will be phased out as the Sandy Bay site is opened (R. Farrier, pers. comm.). During the fieldwork in June and July of 1991, the only place where trailers and tents were observed in a unsupervised area adjacent to sand dunes was at Louis Head, and although there were other problems associated with the camping, such as waste disposal, there was no direct threat to the dunes. One tent was observed in the middle of the high dunes at Crescent, in a location which could be harmful if used often, resulting in yet another area of erosion.

7.2.3 Vehicles

The most damaging activity on the majority of the dunes in Nova Scotia is the driving of vehicles, mainly off-highway vehicles, across the dunes (ie. Fig. 5.6, 5.11, and 5.12). All but three of the dune systems visited had obvious vehicle tracks across them, and it seems unlikely that these three would have escaped given their proximity to communities. It is more likely that erosion and subsequent revegetation has hidden any tracks. Vehicle tracks were causing erosion at eighteen of the sites, particularly when they crossed the foredune ridge, or continued over large old dunes, to which new sediment supply is very limited.

Most of the vehicles responsible are those referred to as off-highway vehicles by the statutes of Nova Scotia, which includes three- and four-wheeled all-terrain vehicles, motorcycles, minibikes, dune buggies and four wheel-drive vehicles. Regular cars and trucks were also observed on the dunes of Cape Sable Island, Glace Bay, Aspy Bay, and Point Michaud, and on the beach at Crescent, where they are allowed legally.

In 1987 the Province passed the Off-Highway Vehicles Act, which makes the operation of an off-highway vehicle on beaches and sand dunes illegal without the permission of the owner or occupier (Fig. 7.1). However, this does not apply to the use of such vehicles for the purpose of lawful fishing, harvesting Irish moss or sea plants, or clam digging. Given the number of dunes still held by private owners, the activities which make the operation of these vehicles legal, and the isolated location of many of the sand dunes, the enforcement of this law is very difficult. Fortunately, there has been a decline in the use of off-highway vehicles for joy riding over the last few years, according to local residents in several areas of the province. This decrease is the result of increased enforcement of limited access at Provincial Parks, and public awareness of the environmental destruction caused by such activity. However, vehicles are still a problem on many beaches, particularly those of Cape Sable Island.

Figure 7.1. Signs prohibiting vehicles on dunes and piping plover nesting area.

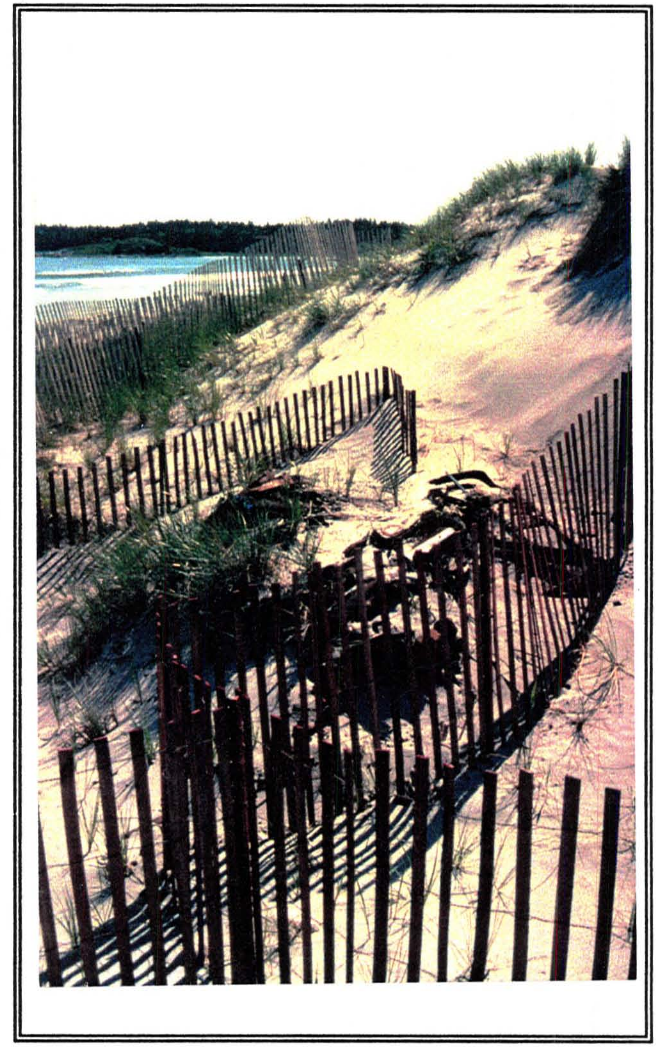


Figure 7.2. Rusted metal and sand fencing in dunes at Lockeport, Shelburne County.

7.2.4 Fire

Evidence of recent fire was only noted at Morien Bay, where a large area of dune vegetation had been burnt, and at Glace Bay, where a small patch of vegetation had been burnt. Bowen et al. (1975) noted fire as a problem on the dunes of Nova Scotia, since it destroys the vegetation layer, and may result in erosion of the dunes. However, with the exception of Morien Bay, fire was not assessed as being a serious problem during the fieldwork in June and July of 1991.

7.2.5 Pedestrians

The natural aesthetics of the coastal dune landscape has resulted in recreation becoming a major use over the last few decades, and the most common human activities on the dunes today are recreational pursuits, such as walking, observing nature and accessing the adjacent beach. Unfortunately even these activities can be harmful to dune vegetation, and subsequently cause erosion (ie. Fig. 4.7). Destruction of vegetation tends to occur along paths and roads, which are often created to provide access to the beach. On dunes covered with Ammophila breviligulata, one or two passages of a vehicle or a dozen by foot over the same path within a week will destroy the majority of the vegetation (Clark, 1977). The sand surface will then become susceptible to wind and water erosion, possibly leading to blowouts where paths cut across lowered sections of dune ridges. On the more popular beaches owned by the province, and operated as Provincial Parks, boardwalks have been installed to provide stable access across the dunes and to prevent excess erosion. Damage caused by walking is generally worst on those dunes close to large communities, such as Lawrencetown and Conrads near Halifax and Dartmouth, Dominion and Glace Bay near Sydney and Glace Bay, and Melmerby, Merigomish and Pomquet near Antigonish.

7.2.6 Garbage

Although, not a direct threat to the integrity of the sand dunes, garbage on the dunes and beaches does lower their aesthetic value. Garbage was only observed to be a problem on the beaches of Cape Sable Island, Cheticamp and Glace Bay. Garbage, particularly rusting metal, often parts of old cars, was observed in the dunes of Cape Sable Island and Crescent Beach at Lockeport, Shelburne County (Fig. 7.2). This creates a serious hazard to any one walking or playing on the dunes. In general, the amount of garbage on the dunes and beaches of Nova Scotia has dramatically decreased since the observations made by Bowen et al. (1975), who identified garbage as a serious problem on Point Michaud, Sand Hills and Mavillette. Garbage, including old car bodies, was removed from Conrads in the 1960s and 1970s (Taylor et al.,1985). Pollution was identified as a problem on ten beaches associated with dunes greater than 1 km in length in Rutherford (1986), and this was felt to be an under estimation of the problem.

7.3 Problem Sand Dunes

The sand dunes of Nova Scotia, the integrity of which are currently, are likely to become, or have been threatened, can be divided into four groups: 1) those currently severely disturbed by human activity; 2) those threatened by natural processes; 3) those which are potential problems if pressure increases; and 4) those which have been severely damaged in the past and are now recovering (Fig. 7.3). These groups are not necessarily exclusive of each other; the sand dune systems have been placed in the group which is currently the most appropriate. Several factors were considered in order to establish these groups, including the impact of vehicle traffic, the degree of active erosion, the recreational use and the availability of new sediment. The results are summarized in table 7.1, along with the ownership of each dune system as of 1986 (Rutherford, 1986). In order to classify the dune systems, the various factors were each considered, allowing for the varying importance of different factors on each system.

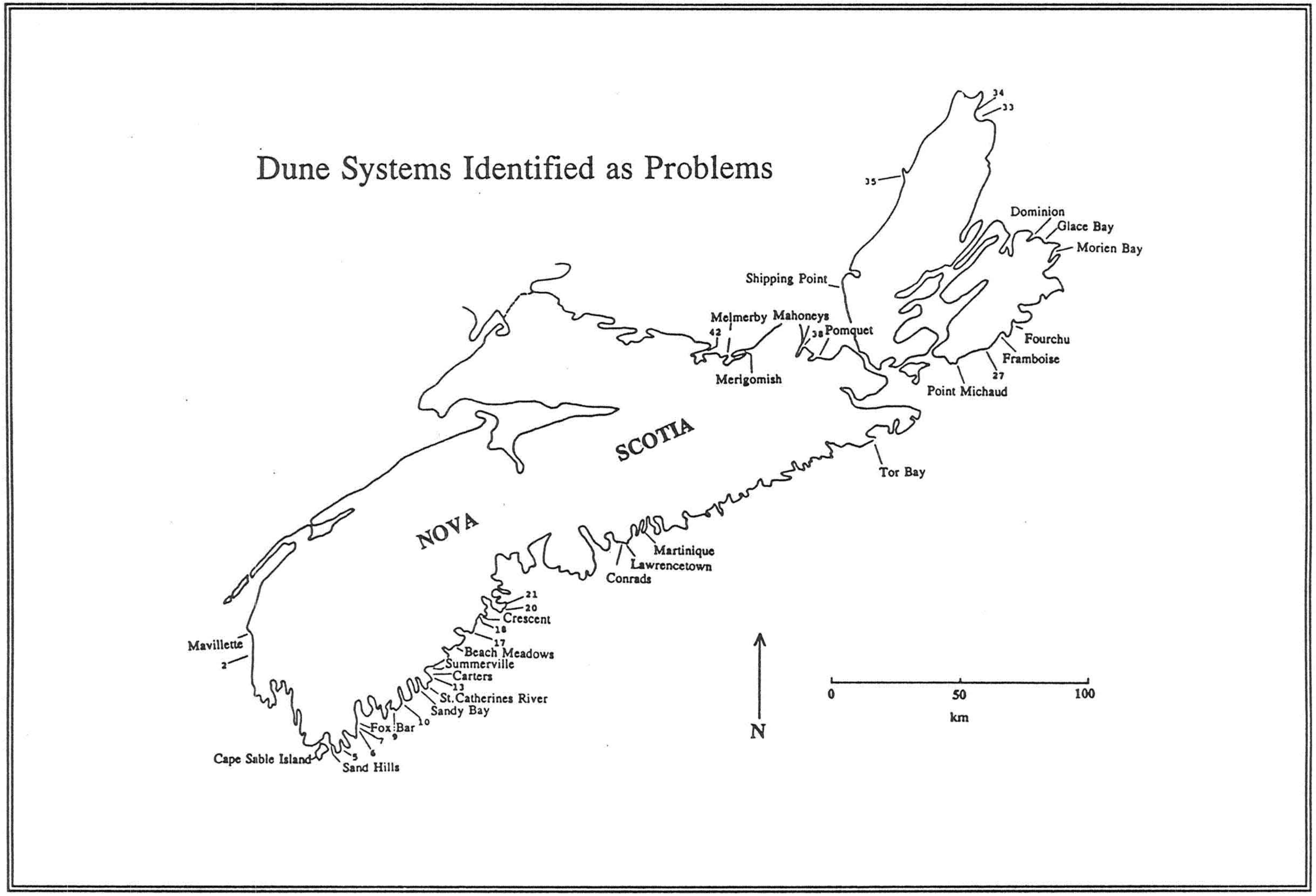


Figure 7.3. Sand dunes which are currently, or are likely to become, or have been degraded (see Table 7.1).

SUMMARY OF THE CONDITION OF THE SAND DUNES							
LOCATION	Ranking	Vehicle Tracks	Erosion	Aggregate Removal	Recreational Use	Sediment Availability	STATUS as of 1986 * = recent change
Mavillette	1	P	5	Y	H	M	provincial park
Bartletts	O	P	4	Y	M	M	provincial
Cape Sable Island	1	P	5	Y	L	L	private,provincial
Sand Hills	2	N	4	N	H	L	provincial park
Baccaro	O	N	3	N	L	S	private,provincial
Red Head	O	N	3	N	L	S	private
Roseway	O	P	3	N	M	S	private
Fox Bar	2	N	4	N	L	S	private
Black Point	O	N	1	N	L	S	?
Louis Head	O	N	4	N	M	L	private,provincial
Sandy Bay	3	N	4	N	L	L	*provincial park
St.Catherines	3		2	N	L	L	*federal park
South West Port Mouton	1	P	5	N	L	L	private
Carters	1	P	4	N	M	L	private
Summerville	4	N	4	N	H	L	provincial park
Beach Meadows	2		4	N	H	L	municipal park
Cherry Hill	0	P	2	N	M	S	provincial
Rissers	0		0	N	H	M	provincial park
Crescent	1,2	N	5	N	H	L	provincial
Hirtles	0	N	2	N	H	H	private
Kingsburg	0	P	3	N	L	M	private
Conrads	2,4	N	4	Y	M	H	provincial

Lawrencetown	4	N	3	Y	H	H	provincial park, private
Martinique	2	N	5	Y	H	L	provincial park
Tor Bay	3	N	2	N	L	S	provincial park
Point Michaud	1	P	3	Y	M	H	provincial park, private
Rorys Pond	0	P	3	N	L	H	provincial, private, municipal
Framboise	4	P	3	Y	L	H	provincial, private
Fourchu	4		2	Y	L	H	provincial, private
Morien Bay	1	P	3	N	M	M	provincial, private
Glace Bay	1	P	5	N	H	M	federal, provincial, private
Dominion	4	P	4	Y	H	M	provincial park
Aspy Bay	0	P	2	Y	L	L	private, provincial park
Cheticamp	0	P	4	N	M	L	federal, provincial
Shipping Point	3	N	3	N	M	S	private
Pomquet	4	N	0	Y	H	H	provincial park, private
Dunns	0	P	3	Y	L	M	private
Mahoneys	1	P	3	Y	M	M	provincial, private
Merigomish	2	N	4	Y	M	M	provincial, private
Melmerby	4	N	3	Y	H	M	provincial park, private
Pictou	0		2	N	L	L	federal, private

Table 7.1. Summary of the condition of Nova Scotia dunes. Key is on following page.

KEY TO TABLE 7.1

Ranking:

0 - dune systems which are not currently a problem, or in any other group
1 - those currently severely disturbed by human activity
2 - those threatened by natural processes
3 - those which are potential problems if pressure increases
4 - those which have been severely damaged in the past and are recovering

Evidence of Vehicle Tracks:

N - tracks present but not harming dunes
P - tracks damaging dunes
blank if no tracks observed

Erosion:

0 - dunes well vegetated, prograding ridges
1 - dunes well vegetated, new embryo dunes
2 - dunes have no serious erosion, but vegetation thin, therefore vulnerable
3 - seasonal erosion along ramp, generally well vegetated
4 - active erosion in isolated areas
5 - active erosion threatening dunes

Visible Evidence of Aggregate Removal:

Y - yes, in most cases the scars are old
N - no

Recreational Use: (based on our observations and the park facilities provided)

H - heavy, popular recreation area
M - moderate, local recreation area
L - light, used by a few local residents

Availability of New Sediment: (based on observations of local coastline and the condition of the beach and the dune ramp)

H - high, readily available from eroding bluffs
M - moderate, available from cliffs of unresistant bedrock or till with low sand content
L - limited supply,
S - scarce, very little new sediment available

Status as of 1986:

Based on Rutherford (1986), and observations of change in status made in the field during June and July, 1991.

7.3.1 Currently Disturbed by Human Activity

The majority of the systems which are currently severely disturbed by human activity are being primarily damaged by vehicle traffic. The one exception is Mavillette, where pedestrian disturbance is the greatest problem, and is exacerbating the damage created by vehicle traffic. The high old dunes at Carters Beach are being destroyed by vehicles driving over them and by foot traffic, as is happening at South West Port Mouton, which is also being seriously eroded by wave action. The dunes at Glace Bay are thinly vegetated, most likely due to the unstable nature of the sand dunes, which are a popular area for walking and riding off-highway vehicles. This system can be likened to the description of Dominion in 1974 as a remnant of a much larger dune system with frequent blowouts and washovers (Bowen et al., 1975). The recovery of the Dominion dunes under the care of the Provincial Parks, suggests that the same can be done for Glace Bay. On the other systems of this group vehicle traffic, and foot traffic, as mentioned before is the biggest problem, destroying the vegetation cover and initiating erosion. The dunes on Crescent Beach are being threatened by both human activity and natural processes. Human activity has, and is, damaging the dunes, while rising sea level is forcing the barrier to retreat, although it is being held by the paved road along the back of the dunes and the wooden retaining wall along their seaward side. Merigomish is in exactly the same position. These two dune systems belong in both the group of systems severely disturbed by human activity, and in those disturbed by natural processes.

7.3.2 Threatened by Natural Processes

Sand dunes threatened by natural processes, such as wind and wave erosion, are those of Sand Hills, Fox Bar, Beach Meadows, Conrads, Martinique, and, as previously mentioned, Crescent and Merigomish. Martinique is threatening to fail, as is might be expected of a transgressing system, due to the pressure of increased wave erosion. At present the area most likely to fail is not being damaged by human activity, but has in the past been strengthened by sand fencing. A shift in currents has resulted in the erosion of dunes at Sand Hills Provincial Park, but has also initiated the growth of a new spit with dunes. Water erosion is also occurring on the eastern side of Conrads and on both sides of the spit at Beach Meadows. Wind erosion is most serious in the high dunes on Fox Bar. This erosion looks like that initiated by vehicle or foot traffic, but no tracks were seen on the dunes.

7.3.3 Potential Problems

Sand dunes which could easily become eroded exist in those areas of the province where new sediment is not readily available. Although any dunes in these areas could be included, those which are most likely to be a problem are at Sandy Bay, St. Catherines, Tor Bay, and Shipping Point. Sandy Bay is the site of a new Provincial Park, with a large campground, and will consequently attract a large number of people to what was an isolated beach. The high dunes at the northeastern end of the bay will be an automatic target for climbing and walking. Already these dunes have large erosion scars in them and have been used as party sites, and increased access will cause much greater erosion. A similar situation could occur at St. Catherines River Beach if access into the National Park is greatly improved, encouraging more visitors. Easy access to Tor Bay and Shipping Point is already available, but the areas are not heavily used and the beaches are the primary recreational targets. However, if visitor numbers were to greatly increase on these small beaches, resulting in more people making use of the dunes, the steep, sparsely vegetated foredune ridges could quickly become vulnerable to blowouts. The same could occur at Taylor Head Provincial Park, where dunes back the southern end of the beach designated as a picnic area.

7.3.4 Past Problems

Several beaches in Nova Scotia have been very badly damaged in the past by mining activities and excessive vehicle use. Most of these have recovered to some degree, becoming revegetated and, in some cases, rebuilding continuous dune ridges. Summerville, Lawrencetown, Dominion, Pomquet, and Melmerby have recovered with the help of the Parks and Recreation Division of the Department of Lands and Forests. The "help" has primarily consisted of limiting vehicle access, keeping foot traffic out of the dunes by means of boardwalks, and increasing sand deposition by the use of sand fencing. Beach and dune systems such as Framboise, Fourchu, and Conrads have been left to recover by themselves, although vehicle access has been restricted at Conrads.

7.4 Management of the Nova Scotia Sand Dunes

The sand dunes in Nova Scotia are owned by a number of different institutions, the Provincial Government, the Federal Government, Municipalities, and private citizens. This variety of owners, often more than one to a single dune system, makes coordinating dune management difficult, a particularly crucial problem, since the nature of dune and beach environments require that they be dealt with as a whole, not as separate entities. Through the creation of the Beaches Act in 1988, the Province of Nova Scotia has approached this problem. The policies of the Province, and those of the National Park will be considered.

7.4.1 Provincial Policy

Prior to 1960 there was no legislation to protect or manage sand dunes, and consequently many dunes were badly misused, as has been discussed. The Beaches Protection Act was created in 1960, giving the province the authority to declare a beach protected even if it was privately owned. When necessary this could be extended to include adjacent land. The Act allowed for the removal of sand and gravel from Crown land, but required a permit, and compensation was to be available to those who suffered loses as a result of not being permitted to remove aggregate, if they may have done so prior to the Act. In general, this Act did not affect privately owned sand dunes which were not specifically identified as protected, and did not prevent the wide spread non-commercial removal of aggregate (Bowen et al., 1975).

The Beaches Protection Act was repealed in 1975, and replaced by the Beaches Preservation and Protection Act, which was in turn succeeded by the Beaches Act in 1988 (Nova Scotia, 1989). This latest legislation specifically includes sand dunes in its purpose to "provide protection of beaches and associated dune systems as significant and sensitive environmental and recreational resources" and to "control recreational and other uses of beaches that may cause undesirable impacts on beach and associated dune systems". The Beaches Act, unlike its predecessors, makes provision for the province to make arrangements with land owners to manage and preserve land adjacent to a beach in order that it may compliment the beach, and to acquire such land in order to provide access to the beach and to provide facilities. Although this may be interpreted to benefit dune protection and preservation, it would be much stronger if the actual term "dune" was included. The same applies to the clause which makes it illegal to "wilfully destroy property and other natural resources found on or adjacent to a beach".

The Department of Lands and Forests park policy of 1988 states the intention to protect beaches and sand dunes outside current park boundaries by:

-identifying and designating beaches which require protection and regulating activities in order to control destructive practices and management problems,

-evaluating beach protection and management requirements and implementing appropriate strategies to control and protect beaches and beach dune systems,

-and providing facilities and services and incorporating beaches into provincial parks where feasible (Nova Scotia, 1988).

At present sixteen sand dune and beach systems are incorporated into provincial parks, all of which have the basic facilities of car parks, washrooms, and garbage cans. Of these sixteen, twelve have dune systems greater than 1 km in length (see Table 7.1). The seventeenth provincial park, at Sandy Bay, is due to open this spring. With the exception of Point Michaud Park and Cabots Landing Park, at Aspy Bay, all these parks have some form of dune protection, usually in the form of boardwalks, which provide beach access and help prevent people from wandering across the dunes.

Other common forms of dune protection utilized in provincial parks, and at some other dune sites, include parking lots, sand fencing, and piping plover protection. By identifying specific parking areas and providing beach access from these areas, visitors are prevented from parking anywhere along the dunes and crossing to the beach at random, a practice which results in numerous trails across the dunes, possibly resulting in multiple areas of erosion. Sand fencing fills two roles. Its primary purpose is to increase sand deposition, however it also affectively prevents people from crossing fenced areas (ie. Fig. 5.7 and 7.2). The sand fencing on the high dunes at Summerville, for example, is collecting little sand, but is reducing further erosion by stopping people from walking on these sensitive areas. Isolating areas of the beach and dune for the piping plover, an endangered species in the Maritimes, by roping them off and by posting signs prohibiting entry, also protects the dunes in the area (Fig. 7.1). Plovers usually nest between late April and early August, allowing dune protection during most of the busiest recreational season (Farrier et al., 1991). Poison ivy, common on Pomquet, Merigomish and Mahoneys, is also affective in keeping people off the sand dunes, however its introduction would not be recommended for this purpose. Through use of these techniques, badly damaged dune systems such as Lawrencetown, Dominion, and Melmerby have regained their integrity. It should be noted, however, that all these systems are in areas of adequate sediment supply, and that the same methods may not be so successful in areas with little new sediment input.

7.4.2 National Parks

One national park exists in Nova Scotia with sand dune systems greater than 1 km in length, Kejimkujik Seaside Adjunct. The Seaside Adjunct, which includes the St.Catherines River system and the Little Port Joli system, has only recently become a national park, acquired in 1985 and designated in 1988. At present it is undeveloped, having only two access trails, the shortest distance to the shoreline being 3 km. At present no vehicle access exists to the park boundary, however the management plan calls for such access within the next few years (R. Farrier, pers. comm.). At present the location of the vehicle access has not been decided, but according Ray Farrier, the senior park warden, they would like to focus some of the pressure on the Little Port Joli side, to ease the use of the St.Catherines River system and reduce the disturbance of the piping plovers in this area. Protection of the piping plover nesting area on the dunes is the only dune protection currently occurring, and is more than adequate given the isolated location of the dunes and the season of plover nesting, late April to early August, the busiest recreation period.

The Seaside Adjunct is still operating under interim management guidelines until an approved management plan is finalized. The management objectives call for the preservation of representative geomorphological areas such as beaches, dunes and tidal flats, and for the monitoring of changes which occur in surficial coastal features, including beach development and erosion (Farrier et al., 1991).

It is interesting, and valuable, to compare the Seaside Adjunct to the other two maritime national parks with extensive dune systems, Kouchibouguac in New Brunswick and the Prince Edward Island National Park. Kouchibouguac, established in 1969, has pedestrian access to the barrier islands and dunes at Kellys Beach and, as of 1991, plans to open a second access at Callenders Beach. Both these locations are easily accessible by boardwalks, but other dune areas are generally inaccessible (Harry Beach, pers. comm.). The national park on Prince Edward Island is very different, with extremely easy accessibility due to the fact that a major road runs the length of the park through, or adjacent to, the dunes. With thousands of visitors every day, it is virtually impossible to control the hundreds of potential dune access points, and the 1985 Conservation Plan identified the concern that there was conflict between the high pressure of recreational use and the ecosystem, the result being increased numbers of trails across the dunes, killing vegetation and initiating erosion (Olshefsley, 1988). These two national parks have taken different approaches to visitor dune access, with easy but controlled access at Kouchibouguac, and open, essentially uncontrolled access at P.E.I., although the uncontrolled nature of the access is being changed at P.E.I. (P. McCabe, pers. comm.). In contrast, Kejimkujik has very limited access. The use of the three parks also varies greatly, with 300,000 (in 1987) and 170,000 (in 1990) visitors at P.E.I. and Kouchibouguac respectively (Gribbin, 1990; Kouchibouguac, 1991), while the estimated number of visitors to Kejimkujik on a sunny weekend in 1991 was 50 per day (G. Kenney, pers.

com.). The size of the national park dune systems is also very different, with extensive dunes at the New Brunswick and Prince Edward Island parks (see chapter 2), and small dunes at Kejimkujik, limited in length and size by rocky headlands. The vulnerability of the Kejimkujik dunes, discussed earlier in this chapter, suggests that they could not tolerate the quantity of use experienced by the dunes of the other two national parks, and that while the policies and experiences of Kouchibouguac and Prince Edward Island National Parks provide useful information, the dunes at Kejimkujik must be managed in a different manner. Fortunately, other coastal beaches exist in the Seaside Adjunct and beach recreation can be focused on these.

7.5 Conclusion

The condition of sand dunes in Nova Scotia has improved greatly since Bowen et al. (1975) did their study. Problems caused by inappropriate use on those dune systems which are now provincial parks have been addressed by Parks and Recreation, and have generally resulted in the dunes regaining stability. There also has been a change in the provincial acts which deal with the coastal area, increasing the power of the province to protect beaches and dunes, although enforcement is still very difficult in the more isolated locations. Most importantly there seems to be a changing attitude in the people who use the dunes. Most of the general public talked with on the dunes expressed concern in the changes in the dunes, were fairly knowledgable about the causes of these changes, and were supportive of initiatives by the province to protect the dunes.

Many dunes, however, are still very vulnerable to any increase in pressure due to human activity, because of the fragility of the dunes and the lack of available sediment. These areas should be carefully watched, and any destructive activities prevented, in most cases the use of off-highway vehicles. It is very difficult, if not impossible to monitor the use of these vehicles on every beach, and access should not be completely closed since many dunes are used to gain access to hunting, fishing and clam digging areas. When access roads are along the back of the dunes, adjacent to the marsh or lagoon, they usually do not harm the dune system, since most damage is caused when vehicles cross the fordune ridge.

Those systems identified as being severely disturbed by human activity need immediate attention. In most cases the problems are due to uncontrolled access. The management of coastal sand dunes requires, as does the management of any land-based resource, the planning and control of human activity within the physical and ecological constraints of the area (Chapman, 1989). In order to successfully manage a dune system, it is vital to consider the whole system, incorporating all the different stages of dune development. It is also necessary to provide room and flexibility for the natural processes to take place. All to often planners and managers forget that coastal sand dunes are dynamic, not stable or static systems (Wanders, 1989; Carter, 1988). This is particularly true in Nova Scotia were the dunes are generally retreating under the influence of rising relative sea level, and because of this it is necessary to minimize capital expenditure on infrastructure in areas likely to undergo rapid transgression.

Some conditions which should be fulfilled if a whole dune system is to be successfully managed: 1) the largest area possible is required to allow room for natural processes and to limit disturbance from outside; 2) expertise that covers the complete range of systems to be managed, from geomorphological to ecological, is required; 3) hydrology, geomorphology, soil science and other related sciences be incorporated into management research, as well as biology; and 4) all those responsible for dune management, including planners and politicians, must recognize all the aspects of the dune environment and be aware that it is a dynamic, not static, system (Wanders, 1989). The complexities of the physical processes involved, and their close relationship with dune ecology, make it essential that coastal sand dunes are studied and managed as a complete system.

CHAPTER 8

CONCLUSION

8.1 Summary

The goal of this thesis was to complete a comprehensive study of the sand dunes of Nova Scotia. In order to fulfil this aim, all the dune systems greater than 1 km in length were identified, the morphology and vegetation on each system was studied, and the condition of the dunes with regards to human activity and natural processes was described. The principle conclusions are listed below:

1) Sand dunes greater than 1 km in length were found at forty-five sites. Based on the morphology and sediment of the dunes and the associated beaches, they were categorized into five groups; the Western Shore, the Atlantic Shore, East Cape Sable Island, Northeast Cape Sable Island, and the Northern Shore (table 8.1). Cross sections representative of these five groups are depicted in figure 8.1. The morphological classification of the dune systems is also a regional grouping, which is not surprising since environmental conditions, such as sediment availability, wind regime, and coastal topography, vary around the province, and are the factors which determine the characteristics of the dune

systems.

2) The majority of the dune systems are located on barriers, which are transgressing due to rising relative sea level. Sand dunes associated with beaches only occur on the Atlantic Shore.

3) The sand dunes of Nova Scotia are restricted in size by sediment availability, and in length by numerous headlands. Many are sediment deficient, and the dunes consist of a thin sand cap or a single foredune ridge. Nova Scotian dunes are smaller than those of the other Maritime provinces, although they are similar to them in morphology, with a steep ramp and a gentle lee slope.

4) Seven vegetation associations were identified; foredune, dune meadow, shrub-heath, deflation-lichen, dune slack, forest, and marsh-lagoon edge. The dominant plants are pioneer species of the foredune association, with the other associations occurring in the lee of the foredune on more developed systems (see vegetation on the cross sections in figure 8.1).

5) The dune vegetation of Nova Scotia places it in a region which is inhabited by both southern and northern dune species. The province is in a transitional area between the dune vegetation of the eastern United States and that of the rest of eastern Canada.

6) Human activity has caused degradation on many dune systems in the past, and continues to do so. The major problem on most of the sand dunes today is uncontrolled vehicle access.

7) The sand dune systems which are the most degraded at present are

Mavillette, Carters, South West Port Mouton, Crescent, Martinique, and Glace Bay.

8.2 Future Research

More research is required on the dynamics of coastal retreat due to rising sea level in areas of limited sediment supply. Studies have been made on coarse clastic barriers in such an environment (ie. Wang and Piper, 1982; Boyd et al., 1983; Carter et al., 1990; Forbes et al., 1990; and Forbes et al, 1991), but not of barriers, either sand or cobble, capped with sand dunes.

In order to approach the above problem, more information about the availability of sediment along the coast of Nova Scotia is needed. Very little is known about the sediments which exist immediately offshore, in the zone which is still influenced by wave energy, and the dynamics of this area. Such knowledge is very important in the management of the dune systems, particularly in areas of limited onshore sources of sediment, which includes most of the Atlantic Shore and Cape Breton Island. Information about sediment availability would enable planners to focus human activity on those areas where the sediment supply is sufficient to allow dunes to withstand increased erosion rates resulting from such pressure.

SUMMARY OF SAND DUNE REGIONS				
REGION	# of DUNE SYSTEMS	AVERAGE TYPICAL HEIGHT (m)	SAND SIZE	DISTINGUISHING FEATURES
Western Shore	2	> 5 m	fine	multiple ridges on bay head barriers
Atlantic Shore	27	2.6 m	fine (coarse on southeastern Cape Breton Island)	most on bay head barriers, only place where found behind beaches
East Cape Breton Island	3	2.2 m	fine	multiple ridges on mid-bay barriers
Northeast Cape Breton Island	2	2.3 m	medium, with fine at foreshore	pairs of bay mouth barriers, subject to overwash
Northern Shore	8	3.2 m	medium	bay mouth barriers attached to islands, only cuspate foreland in province

Table 8.1. Summary of the five regional sand dune groups of Nova Scotia, providing the number of locations with dune systems greater than 1 km in length, the average of typical dune heights at each site, the characteristic sand size, and the features which distinguish each region.

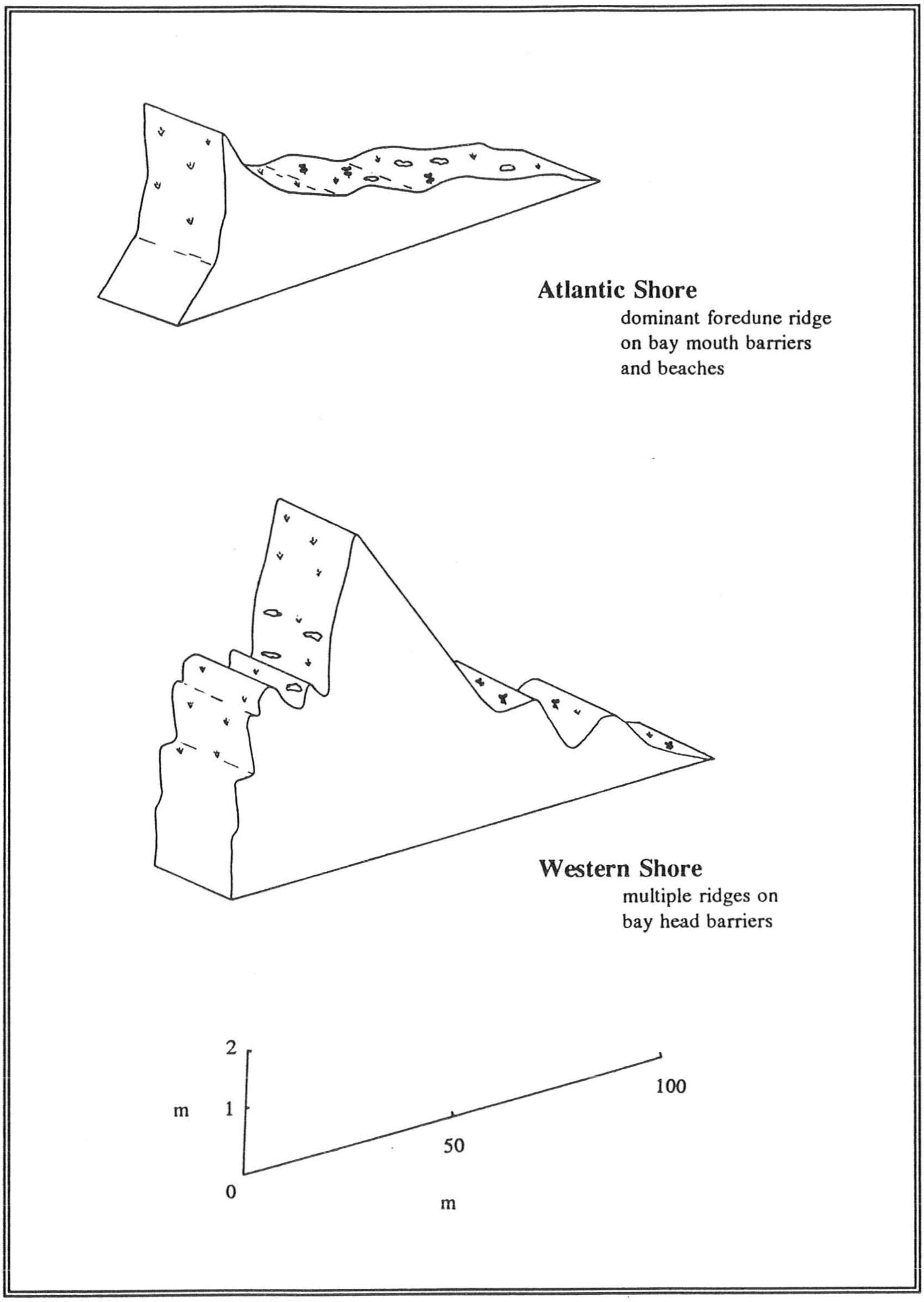
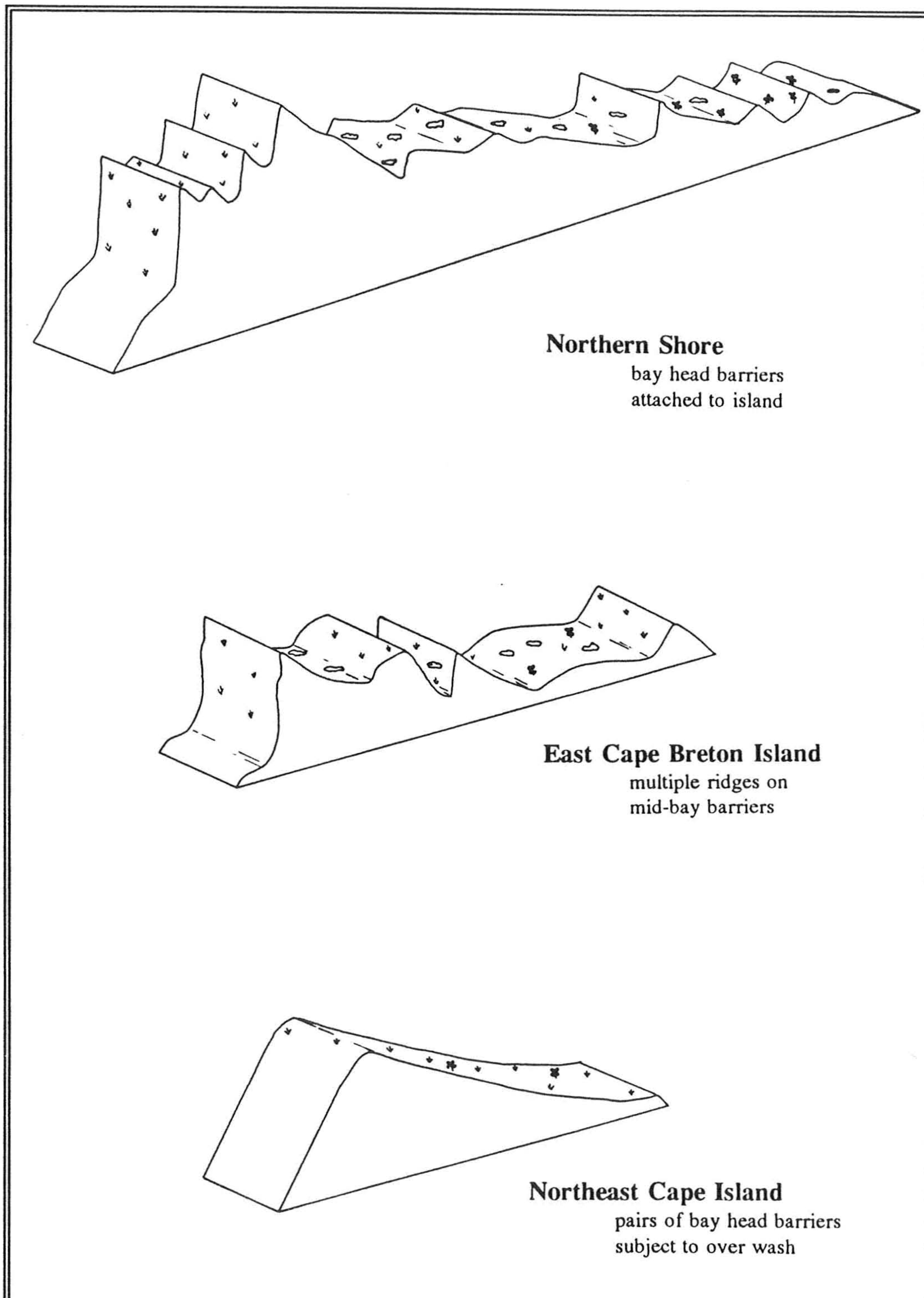


Figure 8.1. Cross sections representative of dune systems of the five morphological regions.



Typical vegetation association distribution of each region is also depicted.

Legend

Foredune

Dune Meadow

Shrub-Heath

The occurrence of large old sand dunes in certain areas of the province, where there is currently very little sediment available, could lead to interesting studies on the ages of these dunes and the sources of their sediment. Many of these dunes occur in areas which are sheltered from prevailing winds, or are situated back from the modern shore line. The most interesting of these are the dune systems at Carters and South West Port Mouton, and at West Mabou.

Legislation exists to protect the sand dunes of Nova Scotia from damage resulting from human activity. Studies are required to monitor whether the policies and laws are actually being enforced, and whether they are successfully achieving the goals they were designed to meet.

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PERSONNEL COMMUNICATIONS

The following individuals provided insight into the processes, conditions and management of the sand dunes in Nova Scotia, New Brunswick and Prince Edward Island during the fieldwork in June and July 1991, and May, 1992:

Bancroft, B., Department of Fisheries, Nova Scotia
Beach, H., Head Ecologist, Kouchibouguac National Park
Farrier, R., Senior Park Warden, Kejimkujik Seaside Adjunct National Park
Kenney, G., Park Warden, Kejimkujik Seaside Adjunct National Park
McCabe, P., Park Warden, Resource Section, P. E. I. National Park
Taylor, R., Atlantic Geoscience Centre, Geological Survey of Canada
Williams, R., Parks and Recreation, Department of Lands and Forests, Queens County, Nova Scotia

C. Trider, D. Forbes, J. Shaw, D. Frobel, and Department of Lands and Forest and provincial park personnel, in each county with sand dunes greater than 1 km in length, were also very informative.