COMMUNITY AND AERIAL PHOTOGRAPH ANALYSES OF SALT MARSH VEGETATION WITHIN THE SOUTHERN GULF OF ST. LAWRENCE

By

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A Thesis
Submitted to the School of Graduate Studies
in Partial Fulfilment of the Requirements
for the Degree
Master of Science

McMaster University
January, 1982

COMMUNITY AND AERIAL PHOTOGRAPH ANALYSES OF SALT MARSH VEGETATION

FRONTISPIECE: BRACKLEY MARSH, P.E.I. AT MID TIDE, AUGUST 1978.

MASTER OF SCIENCE (1982)
(Geography)

McMASTER UNIVERSITY
Hamilton, Ontario

TITLE: Community and aerial photograph analyses of salt marsh vegetation within the southern Gulf of St. Lawrence

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NUMBER OF PAGES: xvi, 237

ABSTRACT

A classification of salt marsh communities for barrier environments within the southern Gulf of St. Lawrence is presented. Communities are described in terms of their species composition, frequency and cover, phenology, and habitat requirements. An idealized marsh profile outlining typical marsh communities, species frequencies and tide relations is constructed from surveyed transect and vegetation data. Its applicability to other sites within the study area is evaluated through aerial photo interpretation.

The tide is identified as one of the controlling factors in community distribution or zonation across the marsh profile. Indicator communities, whose occurrence is indicative of specific tide levels are identified for mean sea level, mean high water and higher high water levels.

Photo communities are compared to floristic communities. An evaluation of aerial photo interpretation for marsh community identification and delineation is carried out. The optimal film type, scale and season combination for maximum community discrimination is determined.

Interpretation of marsh communities from aerial photographs is extended through space and time. Community-environment relationships and responses, identified from present data are shown to be consistent.

With the detailed background knowledge provided by the floristic analysis, the aerial photo interpretation of marsh communities was enhanced.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. P.J. Howarth for his supervision and encouragement throughout the course of this study. Professor S.B. McCann, who originally suggested this topic, is also thanked for his many suggestions. Appreciation is given to Dr. W.A. Glooschenko, National Water Research Institute, Environment Canada, for the insight provided by inumerable discussions regarding salt marsh ecology. The assistance of Mr. G.M. Wickware, Lands Directorate, Environment Canada, who both suggested and provided access to TWINSPAN, is also recognized. Tidal analysis and programming assistance was provided by Dr. W.P. Budgell, Bayfield Laboratory for Marine Science and Surveys, Department of Fisheries and Oceans.

The able assistance in the field by Ms. J.E. McNaught is recognized. The author also wishes to express her gratitude to Mrs. Mary Jurkovic for her skill and perserverance in the typing of this manuscript; and to B. Hosler for his assistance in the drafting of the figures.

Financial support for this study was provided by the Natural Sciences and Engineering Research Council of Canada.

And lastly, special thanks are given to Paul, who provided words of encouragement and tea, throughout the study period.

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CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT

The coastal zone in any environment is considered a fragile ecosystem, highly sensitive to external change. It serves as a buffer zone, protecting inland areas from destructive winds and water. Salt marshes fringe the coast of eastern North America providing many distinct habitats for marine fauna and are a vital component in nutrient recycling. It is ironic that this is the very system currently being subjected to intense pressure from two directions; urban and recreational land uses shorewards and water-borne pollutants, in particular oil, landwards.

Photographic remote sensing is well established as a rapid, accurate and comparatively simple basis for vegetation and landform mapping. It has been shown that the inherent characteristics of coastal and wetland systems are conducive to aerial analyses. In the past, such studies have focused on either the identification and delineation of broad plant groupings as defined by dominant cover species or the description of land form/shore variability through time. In both cases, accuracy is dependent upon interpreter ability and familiarity with the environment under investigation. Ground information is often lacking or of a cursory nature.

To obviate these difficulties, a detailed ground survey will be completed prior to aerial photo analysis in this investigation. An objective community classification will be carried out using the collected floristic data in a two-way indicator species analysis. Communities derived from the botanical survey will be related to communities delineated on the aerial photographs. This procedure will help to reduce the dependence of the air photo interpretation upon the experience and ability of the analyst. By incorporating ground survey data in this manner, an attempt will be made to extend the aerial photo interpretation of salt marsh communities through time and space.

These procedures will be applied in the analysis of marsh communities in three study areas within the southern Gulf of St. Lawrence. Specifically, these are Buctouche, N.B., Brackley/Rustico Island, P.E.I. and South Richibucto Beach, N.B. A comprehensive literature review has revealed a paucity of detailed information regarding marsh community composition and distribution throughout eastern Canada. Based on the botanical analyses, a marsh profile typical of all three study areas will be derived to summarize major communities and relate frequency of occurrence of component species to tidal heights.

Using available photography for the study areas, interpretation of marsh communities will be carried out and various combinations of film type, scale and season will be evaluated for the purpose of community identification. Aerial photo interpretation will then be extended to areas not specifically included in the ground survey. Based on a sequence of aerial photographs from 1935 until 1978 and the community analysis from 1978, the development of one of the sites, Brackley Marsh, P.E.I., will be documented. Frequently, temporal studies are required for environmental impact assessment. As will be demonstrated here, the reliability of results may be enhanced by the inclusion of community analyses from floristic data.

1.2 REGIONAL SETTING

Four major zones of barrier island/spit development fringe the sheltered, shallow waters of the southern Gulf of St. Lawrence. These are les Iles de la Madeleine, Miscou Island- Point Escuminac, Kouchibouguac and north Prince Edward Island (McCann 1979). The latter two areas and a third, Buctouche, N.B., have been studied in detail by the author (Figure 1.1). However, the ideas and concepts developed in this work may be applicable to all barrier/spit systems within the southern Gulf of St. Lawrence. Although variations within and between individual barrier systems may be locally significant, many characteristics can be related to regional factors. Each of these factors will be discussed in turn and a comparative review will be made of the three study sites.

1.2.1 The Barrier Environment

In the past, the genesis of barriers and barrier islands has generated much discussion and a number of hypotheses. Among the first was that proposed by Johnson (1919). Barriers were perceived as features characteristic of emerging coasts. The formative process was described as the upward building of offshore bars. While it is now well-known that barriers are by no means restricted to emergent coastlines, this hypothesis is often cited as a possible mode of formation, especially in the Russian literature (Leontyev 1965).

Beaumont (1845) suggested barriers were formed as the result of landward movement of material from the offshore. Independently, Ganong (1908) arrived at similar conclusions for barriers within the southern

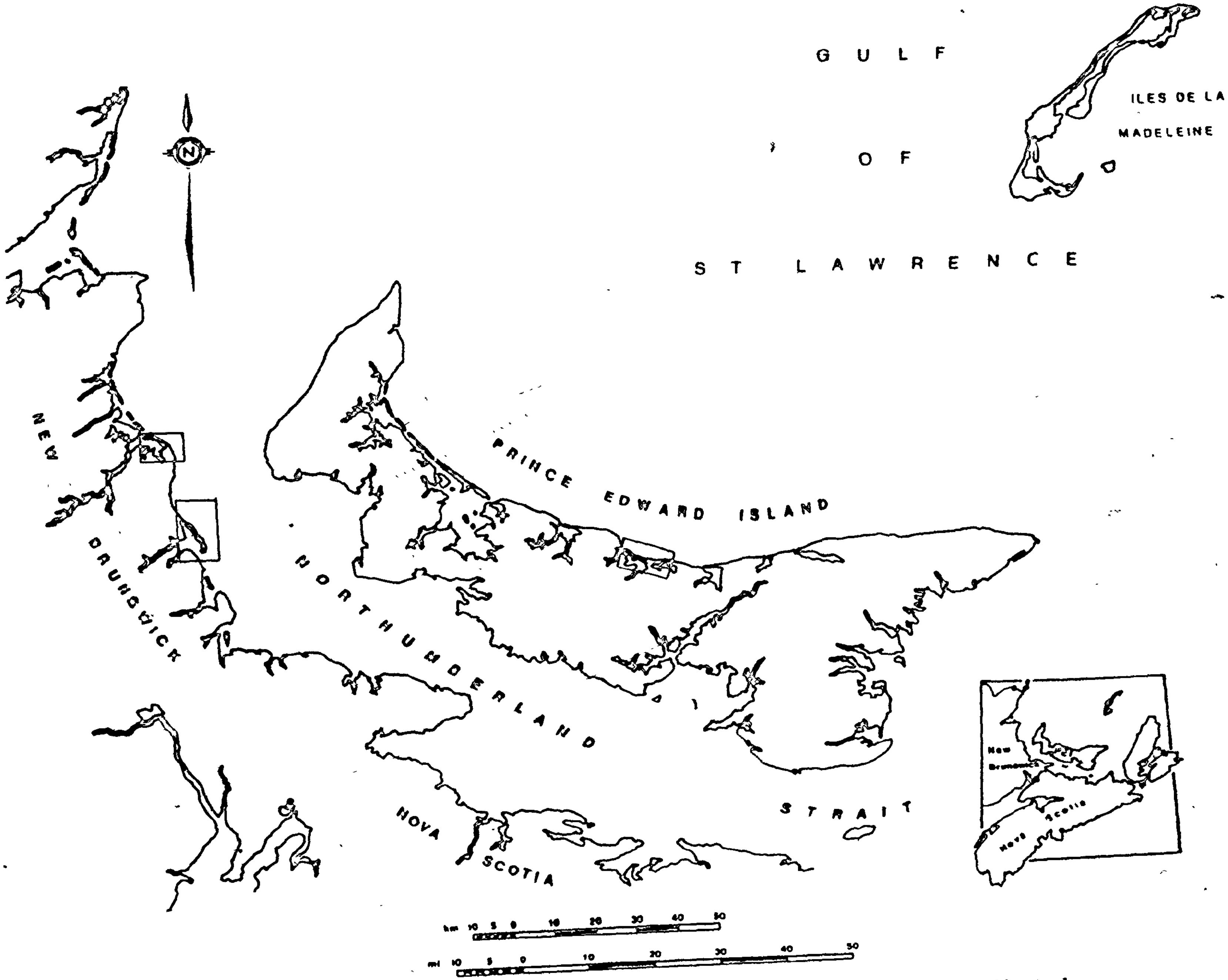

Figure 1.1: The southern Gulf of St. Lawrence. The three study areas are indicated.

Gulf of St. Lawrence.

Expanding upon this, Hoyt (1967) provided a full description of the genesis of barriers. Originating as beaches and spits at lower Holocene sea levels, the resultant ridge becomes a barrier island as sea level rises. A lagoon forms in the lee of the barrier, the depth of which reflects the amount of submergence. The depth and width of the lagoon is also affected by infilling and subsequent marsh development. According to this hypothesis, the rate of submergence is critical. If it is too rapid, then the barrier (and associated marshes) will be drowned; if too slow, then the lagoon infills completely. As sea level continues to use the beaches and dunes on the exposed ocean (or gulf) shore are eroded landwards.

It is apparent that the barrier environment is a dynamic system and vulnerable to alteration as surrounding conditions change.

1.2.2 Geology

Predominantly sedimentary rocks of the Maritime Plain underlie much of the southern Gulf of St. Lawrence (Bostock 1970). Dipping gently to the northeast, the bedrock forms a syncline, bounded to the north by the Laurentian Channel. It is thought that during a period of low water, the pre-glacial drainage system produced a cuesta topography across the Magdalen Shelf. Prince Edward Island is a resistant remnant of this cuesta (Johnson 1925). Present day drainage along the coasts of northern and eastern New Brunswick and northern P.E.I. can also be related to pre-glacial submarine patterns. During periods of using sea level, P.E.I. became separated from the mainland and major estuaries were drowned creating a number of large shallow embayments (Kranck 1972).

In New Brunswick, medium- and coarse-grained feldspathic sandstone of the Pictou Group, Pennsylvanian age, outcrop occasionally along the coast (Gussow 1953). Locally, this is interbedded with red siltstone and minor coal seams, with red and green clays at the contacts (Kranck 1967). Prince Edward Island is composed of similar sandstone and siltstone with minor shale and conglomerate beds, also of Perma-Carboniferous age.

In areas of barrier development, the near horizontal bedrock gives a low coast with relief usually less than 10 m (Owens 1974). Where exposed to wave action, the massive but poorly indurated sandstone weathers easily, aided by occasional vertical jointing, perpendicular to the coast. High rates of erosion are common; up to 3 m/year in New Brunswick (Owens 1974) and 0.6 to 1.5 m/year on the north shore of P.E.I. (D.R.E.E.1969). The material produced by the erosion is a secondary source of sediment for barrier development, often creating cobble beaches locally (Crowl & Frankel 1970).

In most places the bedrock is covered by a mantle of locally derived sandy till and glacio-fluvial deposits from the Wisconsin glaciation (Prest 1970). Depth varies locally, but deposits are usually less than 1 m in thickness. Reworked by longshore currents, these materials from both offshore and land areas, are the primary source of barrier sediment (Crowl & Frankel 1970).

1.2.3 Sea Level Change

Since the Pleistocene glaciation, sea levels within the southern Gulf of St. Lawrence has undergone several periods of transgression and regression. These have been summarized into four stages by Loring and Nota (1973), although there is presently much debate over the timing of events and relative elevations. Hence, further discussion regarding early sea level change is beyond the scope of this study.

Grant (1970) has detailed the changes in the past 5,000 years. For the last 4,000 years, eustatic sea level rise has been estimated at 6 cm/century, a rate greater than Isostatic uplift. Thus, gradual submergence is currently taking place. However, evidence indicates a rate of submergence 3 to 5 times the eustatic rate for several Maritime locations. The tide records for Charlottetown, P.E.I., indicate a current rate of 26 cm/century, while the Bay of Fundy and the Gulf and Atlantic coasts have exhibited submergence rates of 30 and 50 cm/century, respectively. Maximum recent rates of submergence near Shippegan, N.B. have been estimated at 30 to 40 cm/century, with a zero isobase south of Buctouche, N.B. (Thomas et al. 1973). The high and variable rates of submergence have been attributed to regional tectonism, including crustal deflection and geosynclinal down warping (Grant 1970).

Although there is great variability in the present rate of sea level rise, it is apparent that most (if not all) of the southern Gulf coastline is submerging. This is an important consideration when discussing barrier/marsh development.

1.2.4 Climate

In this environment, the wind regime plays an important role in the development of barrier and marsh systems. Combined effects of the wind and barometric pressure can create local sea level changes greater than those caused by the tides (Owens 1974).

The region, which is situated between the Polar High and Temperate Low Pressure zones is dominated by the Westerlies. Seasonal differences are important, as the winter months are characterized by more frequent and sever storm activity. However, extra-tropical storms, which may include hurricane-force winds, are usually confined to the months of July through October (Owens 1974).

Two meteorological stations, Moncton and Charlottetown, were selected for detailed analysis as representative of the New Brunswick and Prince Edward Island study sites. Wind direction data summarized for 1955-1972 are shown in Figures 1.2 and 1.3. Although it has been shown that wind records from coastal areas can be very different from inland records, few problems are encountered if data are averaged over the long term (Greenwood & Davidson-Arnott 1977). Moncton data averaged over the period, 1955 to 1972, indicate a summer climate dominated by winds from the southwest quadrant. A secondary peak from the northeast is noted during the winter months. A similar pattern is recorded for the Charlottetown station except that the secondary peak is from the north.

An investigation of wind speeds reveals that maximum speeds do not necessarily coincide with dominant direction. This is an important consideration when identifying the effect of wave attack on the barrier systems. Wave generation is limited by the occurrence of offshore winds, the variability of wind direction and presence of sea ice, in addition to fetch (Bryant & McCann 1972). While storm associated wave attack has been shown to alter beach profiles, prevailing winds could influence lagoon shores, even though the limited fetch across the lagoon inhibits wave

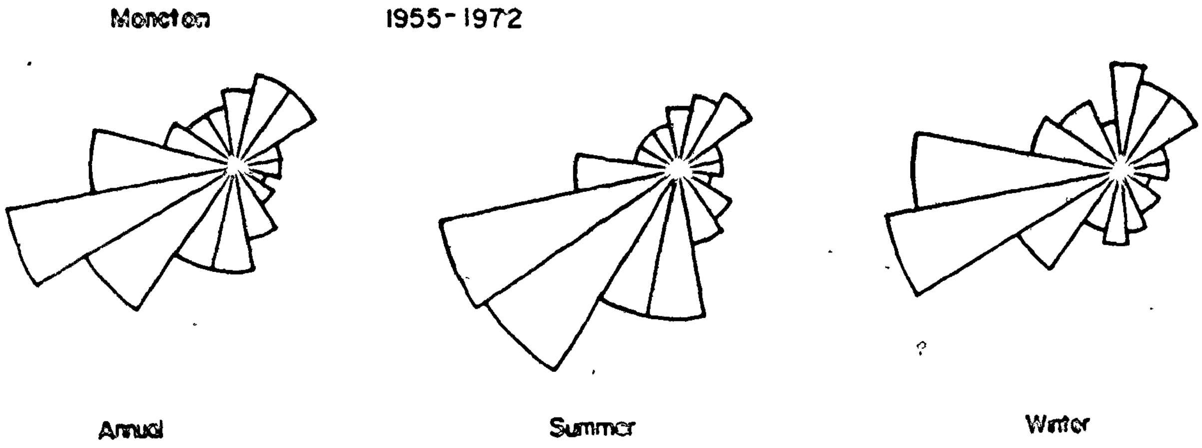

Figure 1.2: Wind summaries for Moncton, N.B. averaged from 1955 to 1972 (Source: Environment Canada 1975).

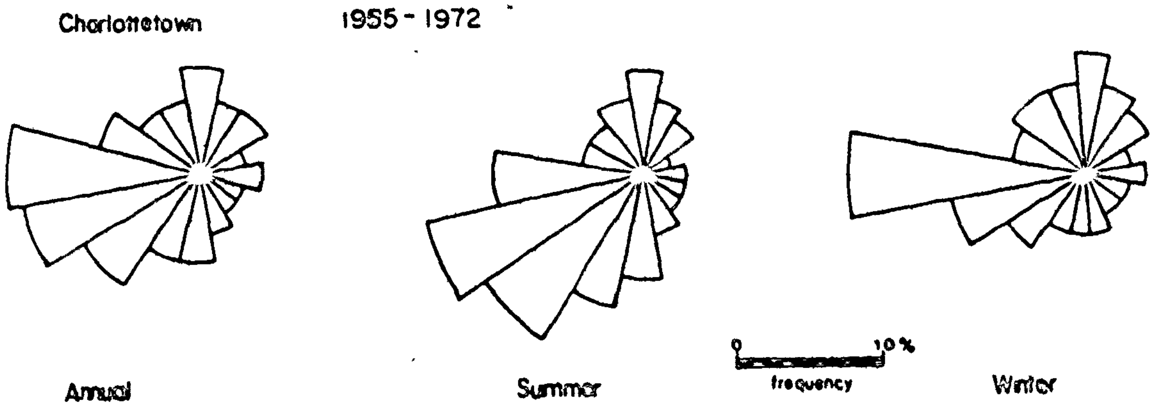

Figure 1.3: Wind summaries for Charlottetown, P.E.I. averaged from 1955 to 1972 (Source: Environment Canada 1975).

development. However, wind-driven water can penetrate far into the upper marsh margins, above the range of normal tides.

The southern gulf is usually ice-bound three to four months per year (Forward 1954). Shore fast ice is present by mid-September with breakup by the end of April. Although pack ice in the gulf appears in early January, disappearing three months later, ice may still be present as late as mid-May (Greenwood & Keay 1979). While ice presence limits wave activity during this period, it also plays an active role in coastal processes. This will be discussed further elsewhere.

1.2.5 Tidal Regime

The southern Gulf of St. Lawrence is classified as a microtidal environment, based on the low (< 2 m) tidal range (Davies 1964). The tides are influenced by the presence of two amphidromic points, one northwest of les Iles de la Madeleine and the other in the Northumberland Strait, southeast of Cape Richibucto (Farquaharson 1962). The resultant tides are varied in terms of range and shape of tidal curve.

The tidal regime may be classified according to the shape of the tidal curve, depicting the number of high and low tides per day. Following the method proposed by Defant (1961), the tidal regime within the southern Gulf of St. Lawrence varies between the three study areas. While South Richibucto Beach and Rustico/Brackley are classified as a mixed, mainly diurnal environment, Buctouche is distinctly diurnal. This is calculated from the tidal constituents for 1978 at Richibucto Bar, Rustico and Crossman Point, respectively (Marine Environmental Data Service (MEDS), Ottawa). This classification does not concur with that cited by the Canadian Hydrographic Service (1978), owing to the fact that an alternate method of calculation was employed in the latter case (D. St. Jacques, pers. comm.). Defant's (1961) classification is used in this study since it is more universally accepted. The inconsistency described above could cause problems where tidal regimes (i.e., as related to community heights, Section 3.4) are compared between regions using the different approaches. As a result of this discrepancy discovered in the course of this study, the tidal classification procedures of MEDS are currently under review.

Tidal data for the three study areas are based upon three separate tidal stations shown in Figures 1.4, 1.6 and 1.8. Crossman Point (Index No. 1815) and Richibucto Bar (Index No. 1825) are secondary ports. Here, only predicted tide level information is available. At Rustico, a reference port, both predicted and observed data is available. The relevant tide levels are shown in Table 3.4.

1.3 SITE SELECTION

While a survey over a broader geographical setting would have permitted a more detailed analysis of regional variability, time and financial constraints limited this study to three individual barriers. It is assumed that the areas chosen are representative of the southern Gulf of St. Lawrence, and that variations within and between sites illustrate a similar range difference found elsewhere.

The two major limiting factors in the selection of study area and transect locations were accessibility and the availability of appropriate aerial photo coverage. Although neither was a significant problem on the north shore of Prince Edward Island, both hampered study in New Brunswick. In particular, Buctouche Bar, N.B., is a privately owned beach and has been photographed (from the air) infrequently. In addition, access to the end is limited.

Selection of study areas was accomplished in two phases. In the first phase, preliminary air photo interpretation enabled transects to be located directly on the most recent photos available. These transects were selected to incorporate maximum variation in topography and apparent vegetation cover. While this choice limited statistical analysis of marsh variability by reducing the number of replicate samples, it was necessary to provide adequate ground detail for the aerial photo interpretation.

1.3.1 Dune de Buctouche, New Brunswick

The Dune de Buctouche lies at the southern end of nearly 200 km of spits and barriers along the eastern coast of New Brunswick. This compound recurved spit extends nearly 11 km along shore and was developed by coastwise progradation across a shallow embayment associated with a drowned river valley (Johnson 1925). The highly indented lagoon coast, the result of many washover deltas and spit-end recurves, contrasts sharply with the gently arcuate sea margin. Historical evidence suggests there was once an inlet where the spit is now joined to the mainland (Thibault 1978), although no inlets occur within the bar at present. In spite of preventative measures to reduce breaching, washovers have been reported since early times (Ganong 1908) and are still active at the narrow section. Elsewhere, dunes may reach a height of greater than 6 m. This is attributed in part to a slower rate of sea level use (relative to more northerly sites) providing a longer period over which sediment buildup in the supralittoral zone can occur (Owens 1974).

The lagoon is largely marine influenced, due to the low discharge of the three rivers flowing into the system. These are the Buctouche, Little Buctouche and Black Rivers. Depths of up to 14 m, have been charted in the central channel; but extensive flats are exposed on either side at low water (Thibault 1978). At the southern end of the spit, a 2 km wide inlet permits unrestricted access of Gulf waters to the lagoon shore. Tidal data from Crossman Point (Index No. 1815) represent conditions at this outer limit. However, because of lagoon shallowness, inaccuracies in time and depth increase northwards.

Sediment within the lagoon is predominantly sand, with muds and fines in the offshore (Thibault 1978). Fine sands, deposited by overwash and wind erosion, are common in deeper waters (< 1 m). Alongshore medium sands are dominant in a continual sequence of shore erosion and deposition on the spit. The upper lagoon acts as a sink for fine riverine sediments, while near the inlet, the bay is infilling landwards.

The four sites selected for profile analysis are representative of four different marsh/dune environments in the northern two-thirds of the system. Their locations are shown in Figure 1.4. Specifically these profiles (Figure 1.5) and their characteristics are:

BUC 1A:	Typical marsh/dune system, nearest to terrestrial influence.
BUC 1B:	Wide marsh with distinct lagoon ridge and marsh creek.
BUC 2A:	Site of past washovers, many water-filled pans, low dunes.
BUC 3A:	Narrow, high-duned profile, narrow low marsh zone.

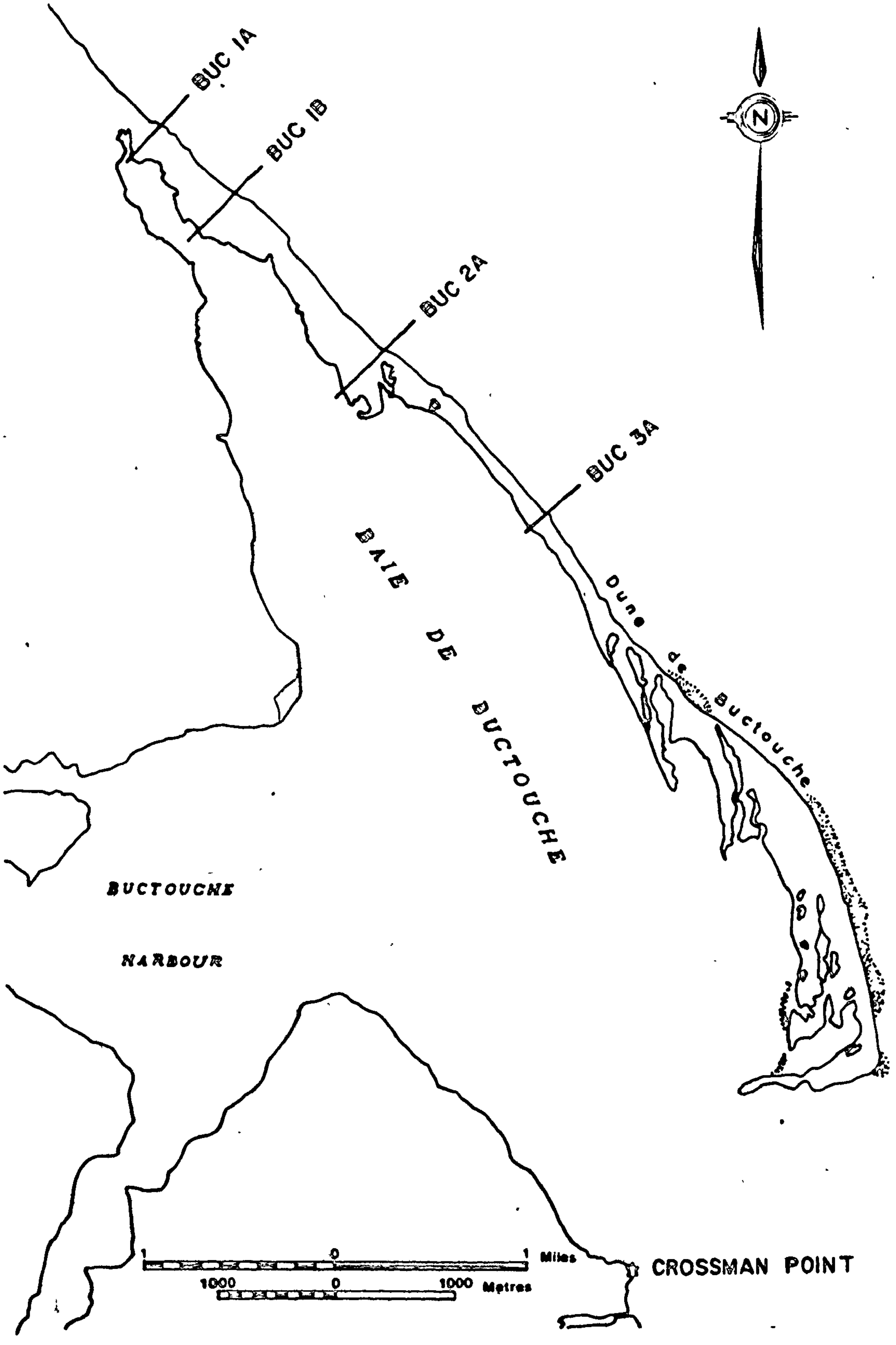

FIGURE 1.4 DUNE DE BUCTOUCHE, N.B.

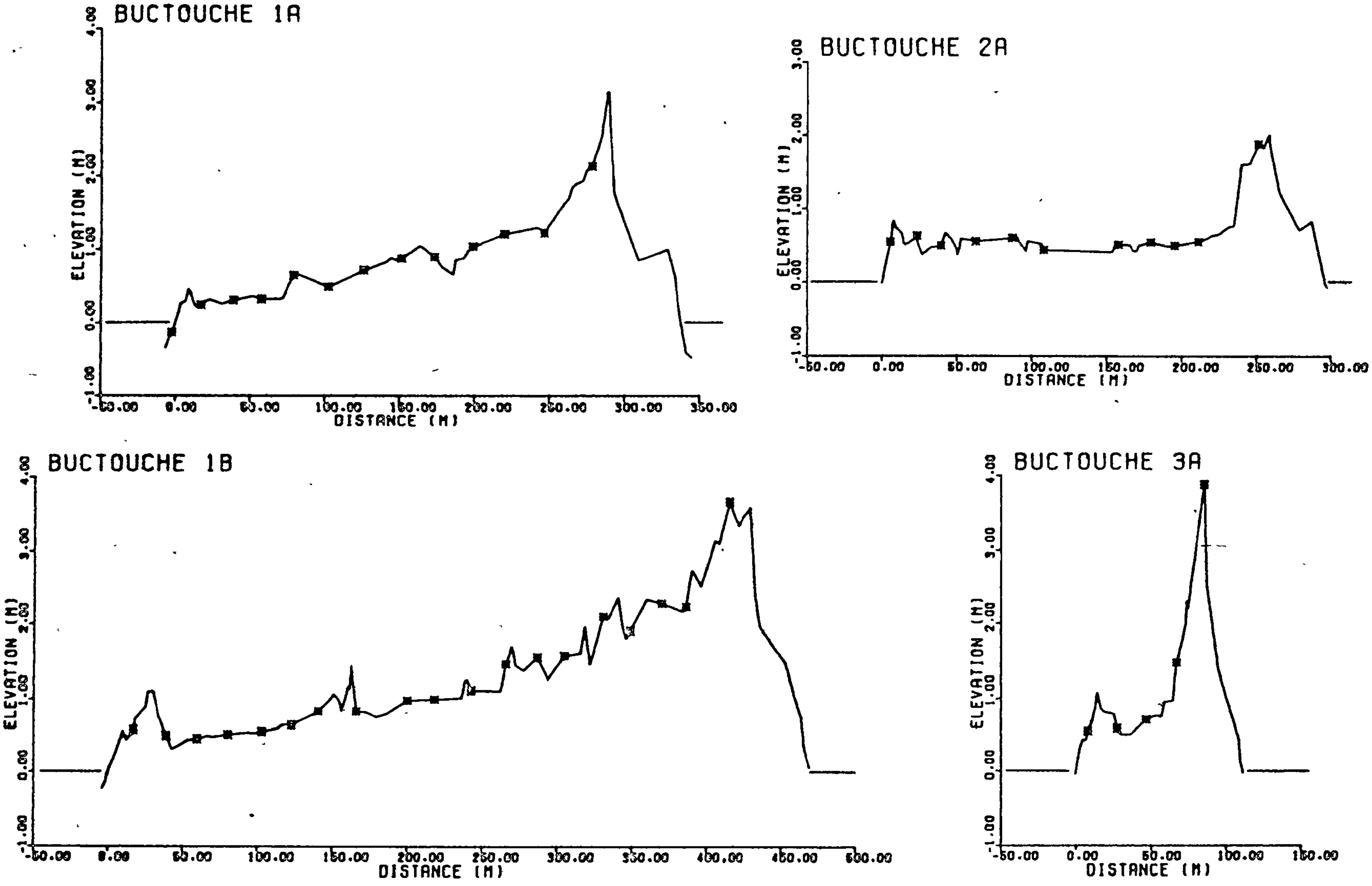

Figure 1.5: Surveyed profiles at Buctouche, N.B.

1.3.2 Rustico/Brackley Beach, P.E.I.

Much of the northern shore of Prince Edward Island is characterized by barrier island/spit formation, smoothing the otherwise irregular coastal pattern of drowned estuaries. Along the shore, alternating zones of erosion and accretion can be identified. Wide beaches and steep dunes up to 20 m high are characteristic of this area (Stanley & Simmons 1976). Natural processes within the central portion have been greatly influenced by man's activities, the most striking of these being road construction within the Prince Edward Island National Park boundaries.

Brackley marsh lies at the eastern end of the study area. Old washovers aligned with the strongest, persistent onshore winds, were closed in the 1950's when sand fencing and subsequently a paved road were constructed across the bar. Prior to this, sand had gradually been filling in the shallow lagoon, accompanied by landward migration of the dune front (Stanley & Simmons 1976). A wide marsh/lagoon, composed of shallow silts, has since developed to a width of more than 400 m. A dune ridge, containing material similar to that of the beach, is present, intermittently fringing the lagoon shore.

Rustico Island, in the western half, is characterized by a spit at the western end and a sandstone headland at the other. An inlet between Rustico Island and Brackley was closed in the late 1950's. Remnants of the inlet delta and tidal mouth spits can still be identified (Stanley & Simmons 1976). Once the inlet was permanently closed by a causeway, tidal flats (250 to 350 m wide) developed on the ocean side of the road. Since then, the western portion of Rustico Island has experienced rapid erosion and change in morphology. During a single storm event, 107 feet

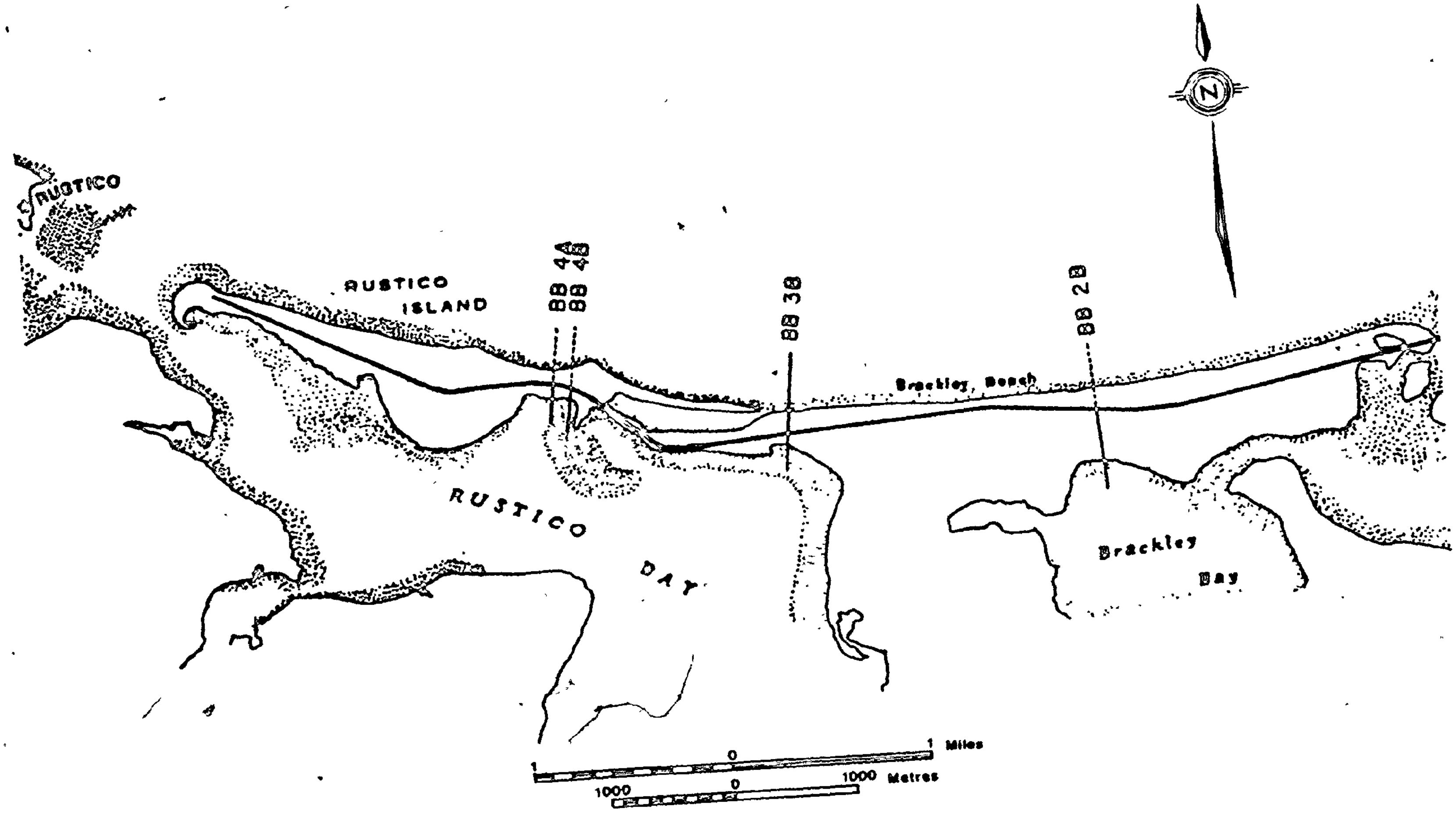

FIGURE 1.6 RUSTICO BAY / BRACKLEY BEACH, P.E.I.

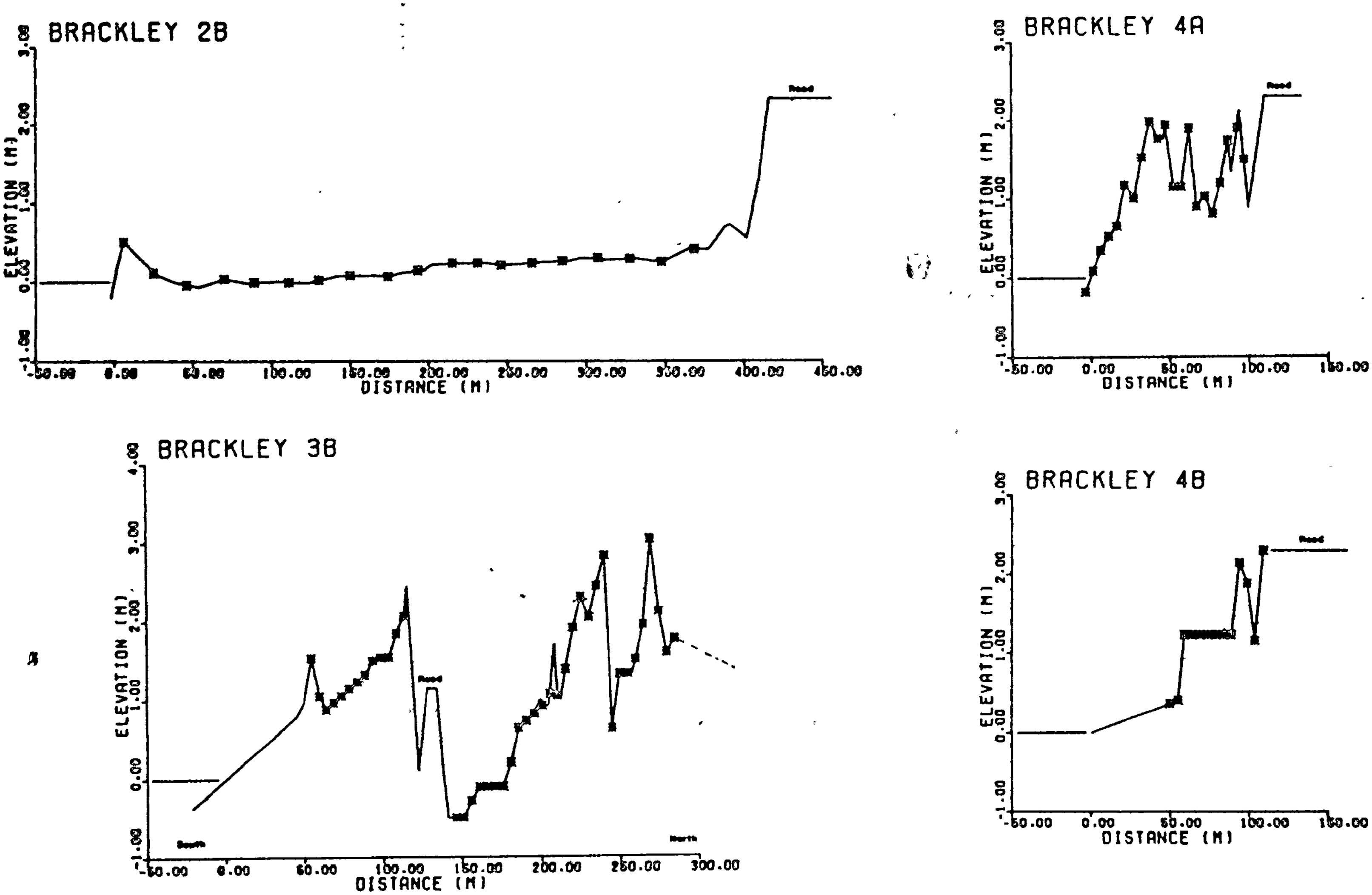

Figure 1.7: Surveyed profiles at Rustico/Brackley Beach, P.E.I.

of paved road were washed away over a two day period (P. Michael, pers. comm.). It has been predicted that Rustico Bay will soon be infilled; the bar is transgressing faster than the lagoon side is eroding (Stanley & Simmons 1976).

Figure 1.6 shows the location of four profiles. Characteristics of the transects (Figure 1.7) are summarized below.

BB 2B:	Wide marsh developed in lee of steep dunes on old washover fan. Paved road marks the upper limit of the marsh.
BB 3B:	Transect divided by road. South: Narrow lagoon marsh with wide invegetated flats grading into low dunes. North: Moist slack between road and vegetated dunes with multiple crests.
BB 4A:	Transition area between hummocky dunes and slack with very little marsh.
BB 4B:	Recent marsh developed in lee of spit near site of past inlet.

1.3.3 South Richibucto Beach, N.B.

South Richibucto Beach is the southern most spit in the Kouchibouguac barrier system. It extends southwards from Point Sapin to Cape Richibucto effectively enclosing the estuaries of three major rivers, Kouchibouguac, Kouchibouguacis and the Richibucto. South Beach is a series of recurved dune ridge, 6.7 km long with an average width of approximately 200 m. Dominant growth direction is westward although the distal end was once an island and is presently experiencing landward migration (McCann, Bryant & Seeley 1973). Where dune ridges overlap, a hummocky topography develops. At old washover sites, where dune buildup is active, dune crests are usually less than 3 m high. Elsewhere, dune ridges may be as high as 6 m (Owens 1974).

The spit has been breached a number of times at various locations, their position being determined by littoral drift, placement of shoals and the direction of river and inlet wave deflection (Keay 1975). Minor inlets tend to be short-lived, being dominated by the permanent inlets between segments of the Kouchibouguac system. Without sufficient ebb flow to maintain a channel, these temporary openings generally close within 5 to 10 years of opening (Bryant & McCann 1972). The inlet between North and South Richibucto Beaches, is maintained by breakwalls and regular dredging (Keay 1975). From the interpretation of aerial photographs and maps, the most recent breach in the barrier has been identified (Bryant and McCann 1972). Located near the western end, it is thought to have opened in 1930 and infilled 35 years later. The present-day width of the sand flats is greater than 600 m (Bryant 1972).

Four transects were selected from near the eastern end as accessibility was limited (Figure 1.8). Each transect (Figure 1.9) represents one of four environments. Specifically:

R 1A:	Steep dune face on wide marsh and shallow lagoon near terrestrial influences.
R 1B:	Undulating topography produced by a series of roads on the dune crest.
R 2A:	Wide marsh area characterized by many salt pans and steep fronting dune.
R 3A:	Narrow bar with correspondingly narrow marsh. Dune is steep and high with a blowout in the crest.

1.4 SUMMARY OF CHAPTERS

The main body of this text begins in Chapter 2, with a description of materials and methods used in this study. The details of sample collection, analyses, and interpretation are outlined. A comparison and

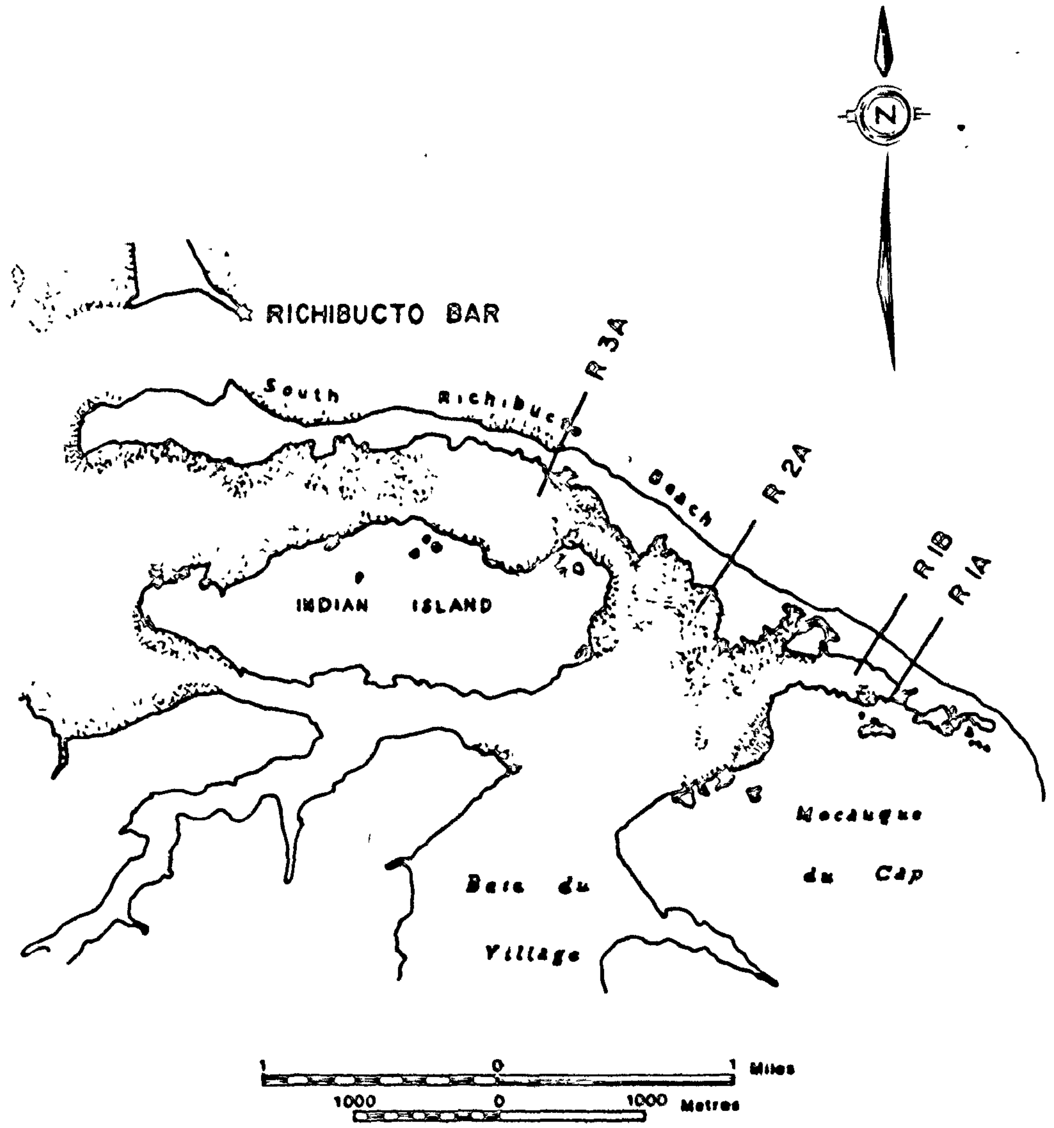

FIGURE 1.8 SOUTH RICHIBUCTO BEACH, N.B.

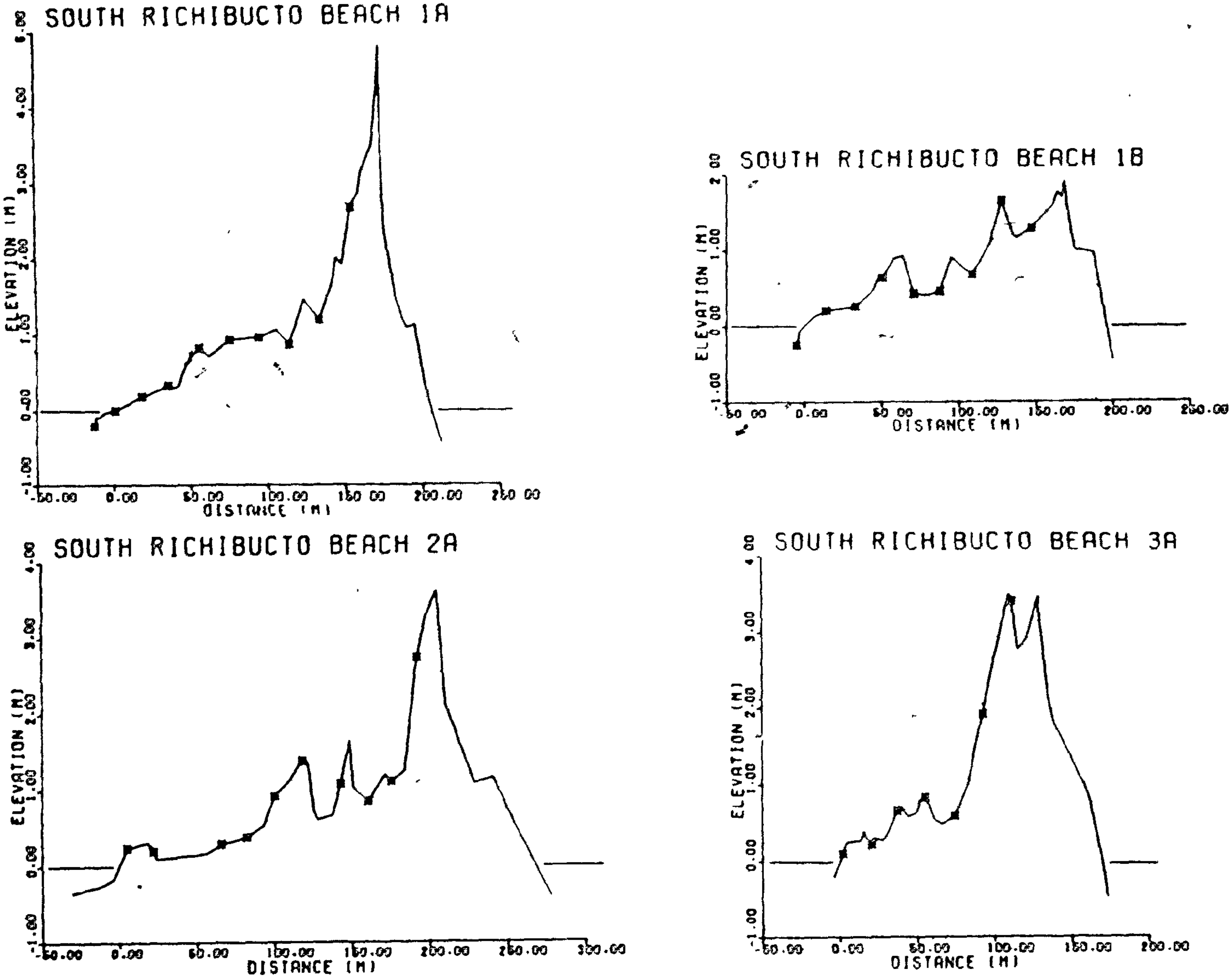

Figure 1.9: Surveyed profiles at South Richibucto Beach, N.B.

evaluation of two phytosociological methods, Braun-Blanquet Tabular Comparison and Two Way Indicator Species Analysis (TWINSPAN) is provided.

Chapter 3 describes the salt marsh environment, its formation, zonation and classification. A comprehensive literature review exposes the apparent lack of detailed community data for the study area. In an attempt to fill this void, an objective analytical technique is employed to delineate marsh communities and their component species. This information is consolidated in the form of an idealized marsh profile characteristic of the southern Gulf of St. Lawrence. Relationships between marsh communities and tide levels are described. A detailed examination of salt pan and pond formation, distribution and community composition is provided.

A literature review is undertaken in Chapter 4 to examine the benefits and limitations of the application of aerial photo interpretation to marsh studies. Photo communities are described, related to floristic communities and then their interpretation is extended through space and time.

This manuscript is concluded in Chapter 5 with a discussion of results and recommendations for further study.

CHAPTER 2

MATERIALS AND METHODS

2.1 DATA ACQUISITION

2.1.1 Profile Data

Transects were surveyed across the marsh/dune system from the lagoon edge to the open water shore. Each transect was oriented perpendicular to the foredune crest. In addition to recording elevational changes for the construction of a profile, major breaks in vegetation were noted, as were other morphological features (e.g., salt pans). Sample stations were identified every 20 m along the transect; the first station being located at the outer edge of the lagoon vegetation. At each station vegetation was sampled, as described in the next section, and sediment samples were taken for textural analyses. Figure 2.1 illustrates the procedure used for finger assessment of soil texture. Notes were made at each station describing the general environmental conditions, such as exposure to wind and wave attack, substrate stability and moisture availability. These were found to be highly variable within the dunes and dune slacks.

All profile data were referenced to the common datum of mean sea level. This was estimated from hourly predictions at the nearest tide gauge and water levels at the time of surveying. The profile data were then plotted with a 20 times vertical exaggeration to aid interpretation. Height and distance measures, relative to mean sea level, could be readily interpolated from the profile plots. All distance values were

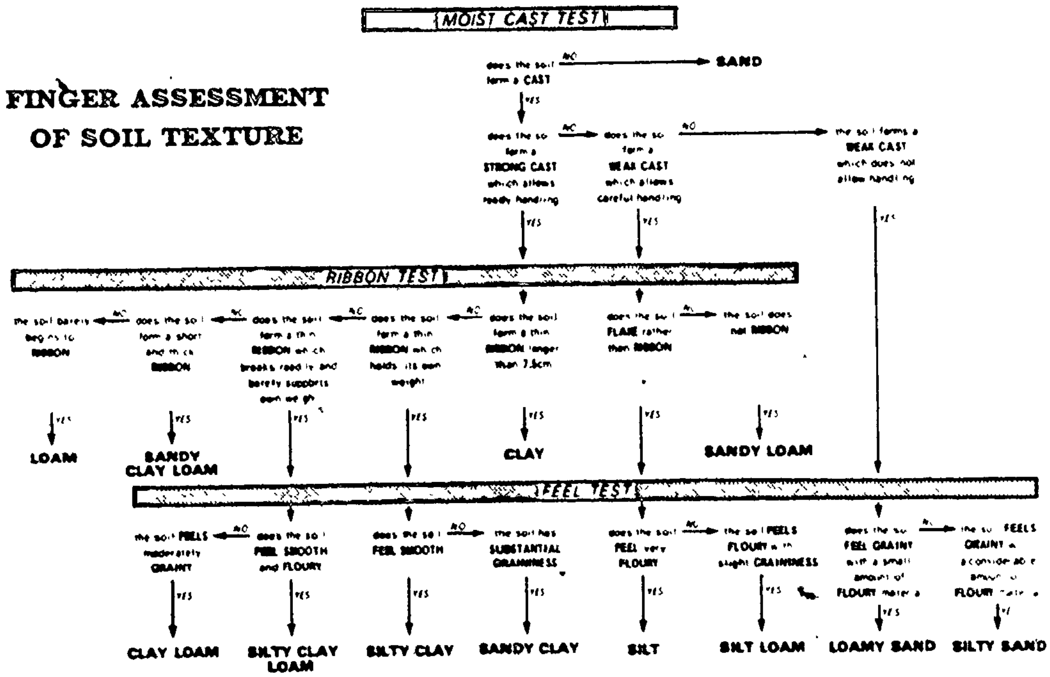

Figure 2.1: Method for finger assessment of soil texture (Bélisle 1980).

calculated along the horizontal with the zero point being the intersection of mean sea level and the marsh profile.

2.1.2 Vegetation Sampling

The vegetation sampling was designed to provide:

1) compilation of a comprehensive check list for typical vascular plant species;
2) collection of sufficient replicate samples for community analysis;
3) calculation of average cover values for communities and species to aid both botanical and aerial analyses; and
4) provision of suitable (and spatially defined) ground control for aerial photo interpretation.

A partial random sampling strategy along surveyed transects was adopted to meet these requirements. Locations of profiles were selected to give maximum variability in species and communities. They were recorded in the field on recent aerial photographs.

The transect approach to sampling is usually recommended for assesssing change of vegetation across a distinct environmental gradient (Kershaw 1973). Sample quadrats are taken along the transect in either a continuous fashion or at regularly spaced intervals. Although the former sampling provides a better measure of species/gradient relationships, the latter is more practical for sampling a number of transects.

To increase the number of replicate sites from each zone or community, five samples were taken at 20 m intervals in a random fashion around each sample station. Figure 2.2 illustrates the procedure. Using an imaginary grid with one axis coincident to the transect and the other perpendicular to it, such that the sample station has co-ordinates of (0,0), five pairs of random numbers provided the location of the sample sites. All odd numbers were assigned negative values, while even numbers were

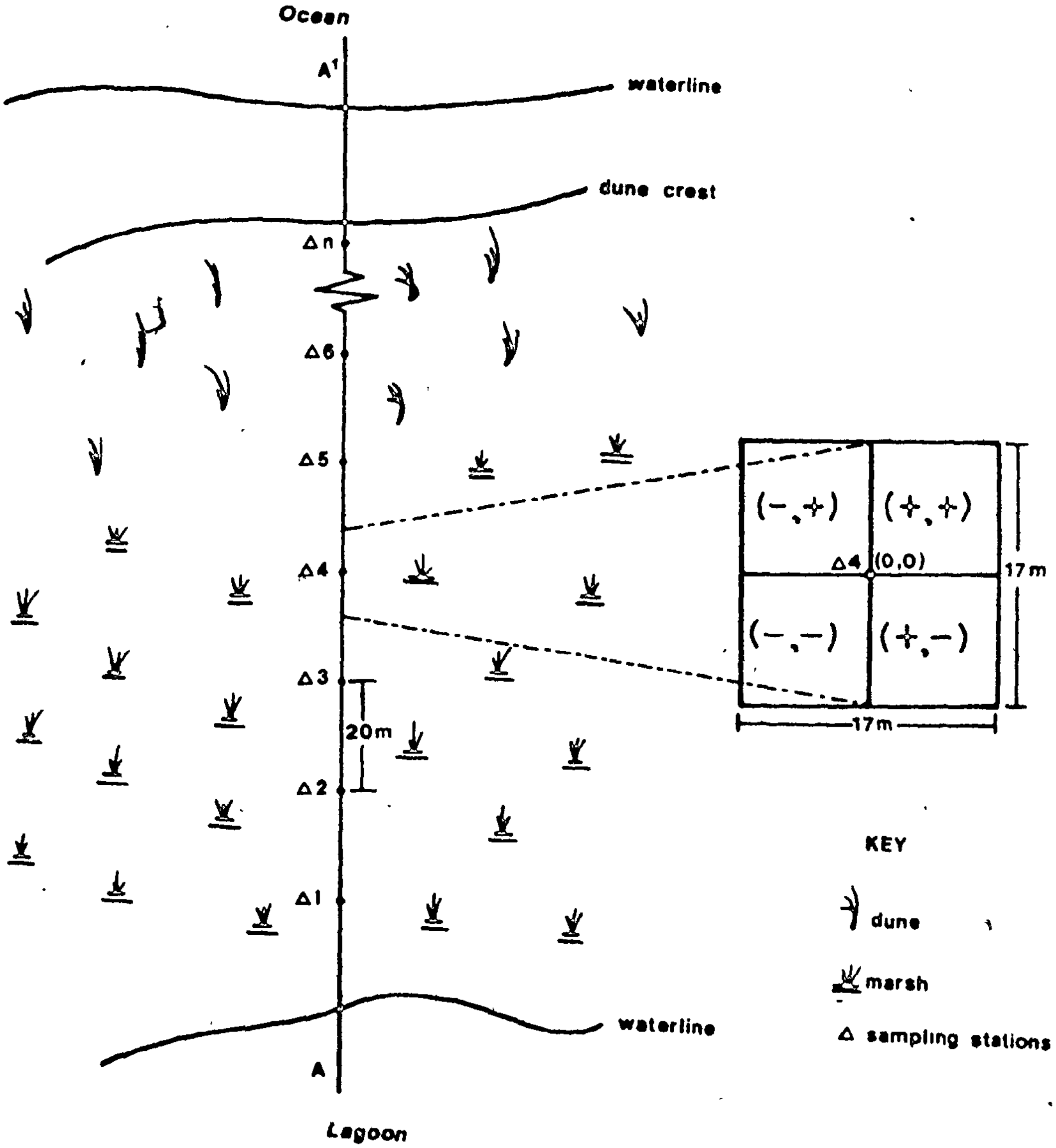

Figure 2.2: Sampling procedure for transect analyses. Five 1 m^2 quadrats, identified by pairs of random numbers, were sampled at each station.

positive. With this procedure a potential sampling area 17 m wide (-9 m to +8 m) along the transect is established. In addition to providing replicate samples, this method also enabled community variability perpendicular to the transect to be evaluated.

Based on the recommendations of previous studies in grass/herb communities (Cain 1932; Kuchler 1967; Poore 1955a), a one meter square (1 m^2) quadrat was selected for collecting vegetation data. Although some authors (e.g., Barbour et al. 1976) suggest a 0.25 m^2 quadrat for marsh species, the large size quadrat was felt to be more suited to the entire transect, which included low shrub and heath communities. However, not all were sufficiently small to fit entirely within the quadrat boundaries. This limitation was recognized and those species concerned (*Juniperus horizontalis*, *Hudsonia tomentosa* and *Myrica pensylvanica*) and their communities, were analyzed separately.

For each quadrat, total vegetation cover (expressed as a percentage) was estimated and, where required, separated into shrub and herb layers. Understory species were identified, listed and estimated for cover. Cover values were assigned according to the Domin Scale (Table 2.1). This is an easy to learn and consistent method of data recording, yet flexible enough to be readily converted into both average percent cover and the Braun-Blanquet scale. For community analysis by computer, Domin values were converted to average percent cover. Manual analyses used the data as collected. Within the Domin scale, the less abundant species (< 20%) are assigned values that reflect their distirbution. Values for litter cover (separating eelgrass cover and in situ material) and bare substrate were also recorded. Where litter accumulation was

TABLE 2.1: CONVERSION OF THE DOMIN SCALE FOR COVER ESTIMATION TO AVERAGE COVER (FOR TWINSPAN ANALYSIS) AND TO THE BRAUN-BLANQUET SCALE (AFTER KERSHAW 1973).

	DOMIN SCALE	AVERAGE COVER (PERCENT)	BRAUN-BLANQUET SCALE
Cover about 100%	10	99	5
Cover > 75%	9	88	4
Cover 50-75%	8	63	4
Cover 33-50%	7	42	3
Cover 25-33%	6	29	3
Abundant, cover about 20%	5	20	2
Abundant, cover about 5%	4	5	2
Scattered, cover small	3	3	1
Very scattered, cover small	2	3	1
Scarce, cover small	1	3	1
Isolated, cover small	X	1	+

appreciable, mat depth within each quadrat was recorded.

Plant samples were collected for later verification and pressed according to the method recommended by Savile (1973). Botanical nomenclature follows Fernald (1950). Other plant keys were used to assist identification, included Britton and Brown (1913), Dore and Roland (1942), Erskine (1960), Gleason and Cronquist (1963), Hale (1969), Petersen and McKenny (1968) and Roland and Smith (1969). A species checklist for marsh and dune vegetation encountered during the course of this study, is found in Appendix A.

2.1.3 Aerial Photography

Ground level photographs in black and white, colour and colour infrared were used extensively, along with detailed field notes, to record species, community and general environmental information. For comparison with aerial photographs, near-vertical photographs were taken of sampled 1 m^2 quadrats, from a height of 2 m.

All transects and adjacent areas were photographed from a low level (c. 150 m) fixed-wing aircraft. Time of the flights was planned to be coincident with mid to low tides. This was especially important for areas not recently included in standard aerial photo coverage.

A complete list of aerial photographs, interpreted for this study is contained in Appendix C. This list was compiled following a thorough search of the holdings of the National Air Photo Library (NAPL), Energy Mines and Resources, Ottawa, and the Maritime Resource Management Service (MRMS), Amherst, Nova Scotia. The list was completed prior to field studies, but additional photography has now been acquired for several areas. The photographs selected present a wide variation in terms of scale, film type, scale and season.

All aerial photographs were interpreted both as print and transparencies (where available) using a Bausch and Lomb Zoom 240R Stereoscope capable of up to 60 times magnification, which was mounted over a Richards light table. Comparison of two photographs and tracing of maps was carried out on a Bausch and Lomb Zoom Transfer Scope (ZTS-4).

2.2 VEGETATION ANALYSES

2.2.1 Introduction

To identify and understand the relationships between plant communities and their particular habitats, field vegetation data require rearrangement or grouping (Whittaker 1973). The two primary methods of grouping, classification and ordination, differ in their initial premises, although final output may be similar and/or complementary. Through classification procedures, samples can be grouped into units based on shared characteristics. From these groups, the ranges of environmental factors, species composition and community characteristics can be determined and the relationships between community types and habitat can be identified.

Alternatively, ordination is the procedure by which samples or sites are arranged in relation to one or more environmental gradients. These gradients may be identified directly from field data or may be derived by indirect means, such as, species correlation or sample similarity or a combination of both.

For this study, two different methods have been selected for analysis and comparison. The floristic-sociological or Braun-Blanquet approach identifies floristic composition as the optimal criterion by which to classify communities (Westhoff and van der Maarel 1973). Those species which best define plant-habitat relationships are identified as differential (or diagnostic) species and can be used to construct a multilevel hierarchy of plant groups, necessary for interpretation of intercommunity relationships.

The second method, an ordination procedure, is an indicator species analysis. The specific program used was TWINSPAN (Two-way Indicator Species Analysis) from the Cornell Ecology Program series (Hill 1979). Sites are classified by similarity of component species and the species are then grouped by ecological preference. The resultant ordination table approximates the output produced by the Braun-Blanquet method.

The Braun-Blanquet classification was completed prior to the TWINSPAN analyses. Groupings obtained through both methods were compared and modified to produce the final communities, described in Section 3.2.

2.2.2 The Braun-Blanquet Tabular Comparison Method

2.2.2.1 Theory

The Braun-Blanquet method defines an hierarchial set of plant groupings based on floristic composition. Each level reflects homogeneity in terms of scale and degree of environmental control.

The basic unit of description of the association, characterized by a set of relevés or sites, which correspond floristically with one another (Moore 1962). Fidelity, the degree to which a species is restricted to one group, is the most important criterion. It is even more important than quantitative characteristics, especially when combined with high constancy or frequency. However, to properly assign plant groups to the various levels in the hierarchy, (Division, Class, Order, Alliance, Suballiance, Association, Subassociation, Variant), a comprehensive regional botanical survey is required.

There is sufficient documentation in the literature to identify four or five marsh dune associations with some consistency. They were readily visible in the field and correspond to the major and readily identified marsh/dune zones. In the absence of a more complete framework, these associations served as the basis for the Braun-Blanquet analyses.

The associations and primary references are as follows:

1)	Spartinetum alterniflorae	Chapman 1940a&b, 1976, 1977 Ganong 1903 Grandtner 1966 Thannheiser 1981
2)	Spartinetum patentis	Chapman 1940a&b, 1976, 1977 Ganong 1903 Thannheiser 1981
3)	Juncetum gerardii	Chapman 1940a&b, 1976, 1977 Thannheiser 1981 Wallentinus 1973
4)	Juncetum baltici	Chapman 1940a&b, 1974, 1976, 1977 Grandtner 1966
5)	Ammophiletum breviligulatae	Chapman 1976 Grandtner 1968,1971a&b Lamoureux and Grandtner 1976 Thannheiser 1978

Within the level of association, subassociations and variants can be defined floristically. However, to be consistent and not falsely assign rankings to groups on the basis of this limited sample size, all plant units are assigned to the same level within the association. These shall be referred to as communities. In this study, common names will be used to denote derived communities and associations.

Prior to the analysis, the quadrat data were separated into the five associations based on the presence of one of the constant species; *Spartina alterniflora*, *S. patens*, *Juncus gerardii*, *J. balticus* or *Ammophila breviligulata*. The sampling methodology did not permit the exclusion of border relevés as recommended (Poore 1955b). These could, however, be identified individually from the transect data at a later time. Transition sites were initially grouped with the most similar association and were then reassessed and regrouped, if necessary, once all communities had been defined.

As an example, in the first analysis presence of *Juncus gerardii* was used to identify the Black Rush association. This was subsequently modified and incorporated with the Meadowgrass (Spartinetum patentis) association. The many similarities between these two units indicated this to be an appropriate decision.

For each of the three marshes, Buctouche, South Richibucto Beach and Brackley, associations were determined separately, but not independently, to ease the problem of data manipulation and the recognition of variability within community/species. As the selection of transects was made to include maximum variation of cover types, some communities were represented by very few, if any sites. Comparison of similar groups at each site and examination of field notes, was necessary to ascertain the validity of such units.

2.2.2.2 Procedure

The step-by-step procedure of tabular comparison is outlined in Tables 2.2 through 2.7. Although the method is described at length elsewhere (Kuchler 1967; Mueller-Dombois & Ellenberg 1974), a worked example is the most effective illustration of the problems and inconsistencies encountered during application. The Meadowgrass association at South Richibucto Beach has been selected for study.

The raw data table (Table 2.2) is produced directly from field notes and includes all sites, with or without vegetation. Species are grouped physiognomically and listed in alphabetical order. Sites, or relevés (quadrats) are arranged numerically and assigned a simplified relevé number. Percent constancy (or frequency) of each species is noted in the next to last column. The last column contains a new species ranking based on the percent constancy.

Abundant species (i.e., those considered characteristic of the association) and those species, which are so rare as to be of no use in the classification procedure are excluded from further analysis. The precise limits for exclusion are arbitrary, based on the researcher's knowledge and understanding of the communities. While Mueller-Dombois and Ellenberg (1974) suggest ten and sixty percent as limits for their lowland meadow association, in this study six and seventy percent are selected as limits for the grouping. This eliminates the following species from the analysis; *Spartina patens*, *Arenaria laterifolia*, *Myrica pensylvanica*, *Salicornia europaea*, *Suaeda maritima* and *Spartina pectinata*.

The constancy table (Table 2.3) rearranges the species in

TABLE 2.2 . RAW DATA TABLE FOR SOUTH RICHIBUCTO BEACH, N.B., MEADOWGRASS (*SPARTINA PATENS*) ASSOCIATION.

Relevé Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Transect	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1A	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B	1B
Station	1	2	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5	5	2	2	2	2	2	3	3	3	3	3	4	4	4	6	6	6
Quadrat	36	12	36	07	83	19	78	03	46	87	30	23	60	86	73	91	20	00	05	19	86	68	75	31	93	02	60	27	05	01	91	07	52	31	96	24
Total Cover %	40	100	95	30	95	80	95	95	80	95	95	60	80	75	70	70	75	50	95	25	100	100	95	100	80	100	80	95	75	95	40	70	70	80	70	70
Exposed Substrate	8		4	8	5	5												5	4	5											5	6	6			
Litter Cover*							4	4	6	4	4	7	5	6	7	7	6	7		8	X	X	4	X	5	X	6	4	6	4	8	4	5	5	6	7
Number of Species	2	1	1	1	1	2	3	1	2	1	3	7	5	5	5	4	3	1	4	4	3	3	2	2	1	4	2	2	6	7	7	6	6	5	4	6
GRASSES																																				
Ammophila breviligulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	5	5	3	-	-	-	-	-	-	-	-	-	-	4	4	4	-	4	5
Festuca rubra	-	-	-	-	-	-	-	-	-	-	-	4	-	4	4	6	-	-	-	-	-	-	-	-	-	-	-	-	2	4	4	4	-	-	-	2
Other grasses	-	-	-	-	-	-	-	-	-	-	-	4	-	5	5	5	-	-	-	3	-	-	-	-	-	-	-	-	-	-	4	4	4	-	4	4
Spartina alterniflora	5	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spartina patens	5	10	9	5	9	9	8	9	5	9	9	4	7	6	-	-	-	-	-	-	9	9	9	9	9	9	8	9	6	7	4	-	-	0	-	-
Spartina pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RUSH/SEDGE																																				
Carex silicea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-
Juncus gerardii	-	-	-	-	-	-	-	-	8	-	-	1	6	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
FORBS/SHRUBS																																				
Arenaria laterifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	5	2
Atriplex patula	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	2	-	1	-	-	2	3	-	-	-	-	-	-	-	-
Convolvulus sepium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	4	-	-	4
Glaux maritima	-	-	-	-	-	-	6	-	-	-	3	-	4	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	5	5	-	-	-	5	-	-
Lathyrus japonicus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	8	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	6	5
Limonium Nashii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	2	-	-	4	2	-	-	-	4	-	-
Myrica pensylvanica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantago species	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	4	3	-	-	4	-	-
Potentilla anserina	-	-	-	-	-	-	2	-	-	-	-	2	4	4	4	-	-	-	-	-	-	-	-	-	-	3	-	-	3	2	-	-	-	-	-	-
Salicornia europaea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solidago sempervirens	-	-	-	-	-	-	-	-	-	-	-	5	6	5	6	3	4	-	6	-	-	-	-	-	-	-	-	-	6	6	5	7	7	-	-	-
Suaeda maritima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

All cover values are Domin Scale unless otherwise indicated.
*Underlined litter values denote Eelgrass material.

...37

TABLE 2.2 . RAW DATA TABLE FOR SOUTH RICHIBUCTO BEACH, N.B., MEADOWGRASS (*SPARTINA PATENS*) ASSOCIATION (continued).

Relevé Number	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	Frequency %	New Order
Transect	1B	1B	1B	1B	1B	2A	2A	2A	2A	2A	2A	2A	2A	2A	2A	2A	2A	2A	2A	2A	3A	3A	3A	3A	3A	3A	3A	3A	3A	3A	3A	3A	3A		
Station	7	7	7	7	1	2	2	3	3	3	4	4	4	4	4	5	5	5	5	5	2	2	2	2	2	3	3	3	3	4	4	5	5		
Quadrat	96	20	51	14	74	47	00	53	22	91	57	84	75	38	69	57	91	84	67	36	45	56	34	86	46	32	76	07	12	96	24	13	97		
Total Cover %	60	65	70	40	75	100	70	100	20	70	50	80	75	95	80	70	30	100	70	75	75	0	0	80	75	75	75	75	65	20	50	100	80		
Exposed Substrate	6	6	6	4	6					6	8	5	6				5		4	3															
Litter Cover*	6	5		8			7	X	8		4	4	4	4	5	7	8		6	6	6	10	10	5	6	7	6	6	7	8	8	X	5		
Number of Species	3	3	6	6	4	3	3	3	1	2	4	5	5	3	3	4	5	2	5	3	8	0	0	3	2	4	3	5	4	1	4	1	4		
GRASSES																																			
Ammophila breviligulata	8	6	2	5	-	-	-	-	-	-	-	-	-	-	-	6	4	5	6	5	-	-	-	-	-	-	-	-	-	-	-	-	-	26	2
Festuca rubra	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	66
Other grasses	-	-	5	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	19	7
Spartina alterniflora	-	-	-	-	6	-	8	3	-	8	-	-	-	-	-	-	-	-	-	-	2	-	-	6	7	-	-	7	-	-	-	-	-	17	8
Spartina patens	-	-	-	-	4	5	5	9	8	5	4	9	8	9	8	5	-	-	-	-	6	-	-	7	6	5	8	5	5	5	6	9	8	71	-
Spartina pectinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
RUSH/SEDGE																																			
Carex silicea	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	14
Juncus gerardii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	13
FORBS/SHRUBS																																			
Arenaria laterifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
Aster species	-	4	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	12
Atriplex patula	-	-	-	-	-	-	-	2	-	-	-	2	3	-	-	-	-	-	-	-	4	-	-	-	-	-	-	4	-	-	-	-	-	16	9
Convolvulus sepium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	15
Glaux maritima	-	-	-	-	-	-	-	-	-	-	7	-	5	4	4	-	-	-	-	-	2	-	-	-	-	8	-	-	7	-	6	-	5	23	3
Lathyrus japonicus	5	-	6	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	10
Limonium Nashii	-	-	-	-	8	3	2	-	-	-	2	4	-	X	4	-	-	-	-	-	4	-	-	X	-	-	-	-	-	-	-	-	2	22	4
Myrica pensylvanica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
Plantago species	-	-	-	-	4	8	-	-	-	-	-	-	4	-	-	-	-	-	-	-	2	-	-	-	-	X	3	-	2	-	3	-	2	20	5
Potentilla anserina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	11
Salicornia europaea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	5	-	-	-	-	-	3	-
Solidago sempervirens	-	6	5	4	-	-	-	-	-	-	2	-	X	-	-	4	5	-	4	-	-	-	-	-	-	5	6	-	5	-	-	-	-	33	1
Suaeda maritima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	5	-	-	-	-	-	3	-

TABLE 2.3 : CONSTANCY TABLE FOR THE MEADOWGRASS ASSOCIATION, SOUTH RICHIBUCTO BEACH, N.B. SPECIES ARE LISTED IN DESCENDING ORDER OF CONSTANCY OR FREQUENCY.

Relevé Number		1	6	7	9	11	12	13	14	15	16	17	18	19	20	21	22	23	24	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
SPECIES	GROUP																																		
SOLI SEMP	C	-	-	-	-	-	5	6	5	6	3	4	-	5	-	-	-	-	-	-	-	-	6	6	5	7	7	-	-	-	-	6	5	4	-
AMMO BREV	C	-	-	-	-	-	-	-	-	-	-	8	5	5	3	-	-	-	-	-	-	-	-	-	4	4	4	-	4	5	8	6	2	5	-
GLAU MARI	B	-	-	⑤	-	3	-	4	-	-	-	-	-	-	-	-	-	-	-	③	-	-	⑤	⑤	-	-	-	⑤	-	-	-	-	-	-	-
LIMO NASH	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	④	-	②	-	-	④	②	-	-	-	④	-	-	-	-	-	-	⑧
PLAN SPEC	B	-	-	-	-	-	3	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	④	3	-	-	④	-	-	-	-	-	-	④
FEST RUBR	C	-	-	-	-	-	4	-	4	4	6	-	-	-	-	-	-	-	-	-	-	-	2	4	4	4	-	-	-	2	-	-	2	2	-
OTHE GRAS	C	-	-	-	-	-	4	-	5	5	5	-	-	-	3	-	-	-	-	-	-	-	-	-	4	4	4	-	4	4	-	-	5	4	-
SPAR ALTE	A	5	3	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
ATRI PATU	A	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	2	-	1	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
LATH JAPO	C	-	-	-	-	-	-	-	-	-	-	5	-	8	-	-	-	-	-	-	-	-	-	-	-	3	-	-	6	5	5	-	6	5	-
POTE ANCE		-	-	2	-	-	2	4	4	4	-	-	-	-	-	-	-	-	-	3	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-
ASTE SPEC	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	5	2	-	4	5	5	-
JUNC GERA	C	-	-	-	8	-	1	6	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
CARE SILI	C	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	4	-	-	-	-
CONV SEPI	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	4	-	-	4	-	-	-	-	-

Relevé Number		42	43	44	46	47	48	49	50	51	52	53	54	55	56	57	60	61	62	63	64	65	67	69
SPECIES	GROUP																							
SOLI SEMP	C	7	-	-	-	2	-	X	-	-	4	5	-	4	-	-	-	-	5	6	-	5	-	-
AMMO BREV	C	-	-	-	-	-	-	-	-	-	6	4	5	6	5	-	-	-	-	-	-	-	-	-
GLAU MARI	B	-	-	-	-	⑦	-	⑤	④	④	-	-	-	-	-	②	-	-	⑥	-	-	⑦	⑥	⑤
LIMO NASH	B	③	2	-	-	②	4	-	Ⓧ	④	-	-	-	-	-	④	X	-	-	-	-	-	-	②
PLAN SPEC	B	⑥	-	-	-	-	-	④	-	-	-	-	-	-	-	②	-	-	Ⓧ	3	-	②	③	②
FEST RUBR	C	-	-	-	-	-	-	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	-	-
OTHE GRAS	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
SPAR ALTE	A	-	8	3	8	-	-	-	-	-	-	-	-	-	-	2	6	7	-	-	7	-	-	-
ATRI PATU	A	-	-	2	-	-	2	3	-	-	-	-	-	-	-	4	-	-	-	-	4	-	-	-
LATH JAPO	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
POTE ANCE		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ASTE SPEC	C	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-
JUNC GERA	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CARE SILI	C	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CONV SEPI	C	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-

decreasing order of frequency. Relevés containing only those species which have been eliminated are also removed.

Although no two species will necessarily have the same distribution, similar distributions or amplitudes can be identified. The degree of similarity required for differentiating species is also arbitrary, although the presence of at least fifty percent in the relevés intended for grouping is a satisfactory criterion. In addition, these species present in other relevés should be less than ten percent. This latter criterion is not strictly applied in the current analysis. However, justification for their inclusion can be found in the comparison of field data from the three marshes. Species not identified as differentiating species and showing no particular affinity to any species group are excluded from subsequent analysis (e.g., *Potentilla anserina*).

In the South Richibucto data, three distinct groups of related species can be identified. Each set of differential species is annotated (underlined) to simplify the compilation of the extract table. Group A, consists of *Spartina alterniflora* and *Atriplex patula* although their relationship is less than ideally defined. Both species are frequently simple species, occurring only with *Spartina patens*. As field investigations have indicated that the two species may appear together more frequently than those data show, all occurrences of either species singly or together, are grouped as a set.

Group B, containing *Glaux maritima*, *Limonium Nashii*, and *Plantago* species, appears to overlap with some components of Group C, specifically *Solidago sempervirens* and *Festuca rubra*. Subsequent arrangement will indicate whether these are transition sites between the two communities or a misidentification or misclassification of differential species.

There is an indication that Group C could possibly be further subdivided with *Juncus gerardii* in one group and *Ammophila breviligulata*, *Carex silicea* and *Lathyrus japonicus* in the other. However, this division will be considered later.

All sites containing differential species are entered into the extract table (Table 2.4). Block outlines around members of each group highlight community composition. At this stage the data are regrouped and a new relevé sequence is established in decreasing, then increasing order of differential species for each group. This is to show relevés in order of diagnostic/floristic similarity. Excluding Group A from this particular reordering owing to its low number of component species, the rest of the relevés are arranged such that the sites most characteristic of Group B are located together on one side of the table, with the sites most representative of Group C on the other side.

Samples within each group containing equal numbers of differential species are ordered according to number of non-diagnostic species for that group which they contain. Sites containing differential species from two or more subsets are incorporated into the group displaying the greatest affinity. This regrouping is written as the orderly extract table (Table 2.5).

Once again the data are re-examined for differential species within the delineated communities. *Juncus gerardii* is identified as a differentiating species, defining a community in which *Ammophila breviligulata*, *Lathyrus japonicus*, *Aster* species and *Convolvulus sepium* are not components. The improved sequence numbering reflects this and the

TABLE 2.4 : EXTRACT TABLE FOR MEADOWGRASS ASSOCIATION SOUTH RICHIBUCTO BEACH, N.B. NON-DIFFERENTIAL SPECIES ARE ELIMINATED FROM THE TABLE, OTHERS ARE GROUPED.

Relevé Number	1	6	7	9	11	12	13	14	15	16	17	18	19	20	21	22	23	24	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
GROUP A																																				
SPAR ALTE	5	3	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	8
ATRI PATU	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	2	-	1	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GROUP B																																				
GLAU MARI	-	-	6	-	3	-	4	-	-	-	-	-	-	-	-	-	-	-	3	-	-	5	5	-	-	-	5	-	-	-	-	-	-	-	-	-
LIMO NASH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	2	-	-	4	2	-	-	-	4	-	-	-	-	-	-	8	3	2
PLAN SPEC	-	-	-	-	-	3	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	4	3	-	-	4	-	-	-	-	-	-	4	8	-
GROUP C																																				
SOLI SEMP	-	-	-	-	-	5	6	5	6	3	4	-	5	-	-	-	-	-	-	-	-	6	6	5	7	7	-	-	-	-	6	5	4	-	-	-
AMMO BREV	-	-	-	-	-	-	-	-	-	-	8	5	5	3	-	-	-	-	-	-	-	-	-	4	4	4	-	4	5	8	6	2	5	-	-	-
FEST RUBR	-	-	-	-	-	4	-	4	4	6	-	-	-	-	-	-	-	-	-	-	-	2	4	4	4	-	-	-	2	-	-	2	2	-	-	-
OTHE GRAS	-	-	-	-	-	4	-	5	5	5	-	-	-	3	-	-	-	-	-	-	-	-	-	4	4	4	-	4	4	-	-	5	4	-	-	-
LATH JAPO	-	-	-	-	-	-	-	-	-	-	5	-	8	-	-	-	-	-	-	-	-	-	-	-	3	-	-	6	5	5	-	6	5	-	-	-
ASTE SPEC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	5	2	-	4	5	5	-	-	-
JUNC GERA	-	-	-	8	-	1	6	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
CARE SILI	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	4	-	-	-	-	-	-
CONV SEPI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	4	-	-	4	-	-	-	-	-	-	-
GROUP A	1	1	-	-	1	-	-	-	-	-	-	-	-	-	2	2	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
GROUP B	-	-	1	-	1	1	1	-	1	-	-	-	-	1	-	-	1	-	2	-	-	2	3	1	-	-	3	-	-	-	-	-	-	2	2	1
GROUP C	-	-	-	1	-	4	2	3	4	4	3	1	4	3	-	-	-	-	-	-	-	2	2	5	6	6	1	4	6	3	3	6	6	-	-	-
NUMBER OF SPECIES	1	1	1	1	2	5	3	3	5	4	3	1	4	4	2	2	1	1	2	1	1	4	5	6	6	6	4	4	6	3	3	6	6	3	2	2
New Sequence	5	6	29	37	31	45	38	44	46	47	42	36	48	39	1	2	30	12	19	13	14	23	17	52	54	53	16	51	55	40	43	57	56	11	24	9

Relevé Number	44	46	47	48	49	50	51	52	53	54	55	56	57	60	61	62	63	64	65	67	69
GROUP A																					
SPAR ALTE	3	8	-	-	-	-	-	-	-	-	-	-	2	6	7	-	-	7	-	-	-
ATRI PATU	2	-	-	2	3	-	-	-	-	-	-	-	4	-	-	-	-	4	-	-	-
GROUP B																					
GLAU MARI	-	-	7	-	5	4	4	-	-	-	-	-	2	-	-	8	-	-	7	6	5
LIMO NASH	-	-	2	4	-	X	4	-	-	-	-	-	4	X	-	-	-	-	-	-	2
PLAN SPEC	-	-	-	-	4	-	-	-	-	-	-	-	2	-	-	X	3	-	2	3	2
GROUP C																					
SOLI SEMP	-	-	2	-	X	-	-	4	5	-	5	-	-	-	-	5	6	-	5	-	-
AMMO BREV	-	-	-	-	-	-	-	6	4	5	6	5	-	-	-	-	-	-	-	-	-
FEST RUBR	-	-	-	-	-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	-	-
OTHE GRAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
LATH JAPO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ASTE SPEC	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-
JUNC GERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CARE SILI	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CONV SEPI	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
GROUP A	2	1	-	1	1	-	-	-	-	-	-	-	2	1	1	-	-	2	-	-	-
GROUP B	-	-	2	1	2	2	2	-	-	-	-	-	3	1	-	2	1	-	2	2	3
GROUP C	-	-	1	-	1	-	-	3	4	1	4	1	-	-	-	1	1	-	1	1	-
NUMBER OF SPECIES	2	1	3	2	4	2	2	3	4	1	4	1	5	2	1	3	2	2	3	3	3
New Sequence	3	7	22	32	25	20	21	40	50	35	49	34	18	10	8	26	33	4	27	28	15

TABLE 2.5 : ORDERLY EXTRACT TABLE FOR THE MEADOWGRASS ASSOCIATION, SOUTH RICHIBUCTO BEACH, N.B.

Relevé Number	21	22	44	64	1	6	46	61	43	60	41	24	27	28	69	34	30	57	26	50	51	47	29	42	49	62	65	67	7	23	11	48	63	56	54
GROUP A																																			
SPAR ALTE	3	2	3	7	5	3	8	7	8	6	6	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ATRI PATU	2	2	2	4	-	-	-	-	-	-	-	1	2	3	-	-	-	4	-	-	-	-	-	-	3	-	-	-	-	-	1	2	-	-	-
GROUP B																																			
GLAU MARI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5	5	2	3	4	4	7	5	-	5	8	7	6	6	-	3	-	-	-	-
LIMO NASH	-	-	-	-	-	-	-	-	2	X	8	-	-	-	2	4	2	4	2	X	4	2	4	3	-	-	-	-	-	4	-	4	-	-	-
PLAN SPEC	-	-	-	-	-	-	-	-	-	-	4	-	-	-	2	4	4	2	-	-	-	-	-	8	4	X	2	3	-	-	-	-	3	-	-
GROUP C																																			
SOLI SEMP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	2	6	-	X	5	5	-	-	-	-	-	6	-	-
AMMO BREV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5
FEST RUBR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
OTHE GRAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-
LATH JAPO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ASTE SPEC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JUNC GERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CARE SILI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CONV SEPI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Improved Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35

Relevé Number	18	9	13	20	37	52	17	38	14	12	15	16	19	55	53	35	31	33	32	36	40	39
GROUP A																						
SPAR ALTE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ATRI PATU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GROUP B																						
GLAU MARI	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LIMO NASH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLAN SPEC	-	-	-	5	-	-	-	-	-	3	-	-	-	-	-	-	3	-	-	-	-	-
GROUP																						
SOLI SEMP	-	-	6	-	-	4	4	6	5	5	6	3	5	4	5	-	5	7	7	-	4	5
AMMO BREV	-	-	-	3	8	6	8	6	-	-	-	-	3	6	4	4	4	4	4	5	5	2
FEST RUBR	-	-	-	-	-	3	-	-	4	4	4	6	-	-	4	-	4	-	4	2	2	2
OTHE GRAS	-	-	-	3	-	-	-	-	5	4	5	5	-	-	-	4	4	4	4	4	4	5
LATH JAPO	-	-	-	-	5	-	5	-	-	-	-	-	8	-	-	6	-	-	3	5	5	6
ASTE SPEC	-	-	-	-	-	-	-	4	-	-	-	-	-	4	-	5	-	5	-	2	5	5
JUNC GERA	-	8	6	-	-	-	-	-	-	1	5	5	-	-	-	-	-	-	-	-	-	-
CARE SILI	-	-	-	4	4	-	-	-	-	-	-	-	3	-	3	-	3	6	-	-	-	-
CONV SEPI	-	-	-	-	-	-	-	-	-	3	-	-	-	3	-	-	-	4	4	4	-	-
Improved Sequence	36	53	54	37	38	39	40	41	42	55	56	57	43	44	45	46	47	48	49	50	51	52

change is further expressed in the improved sequence table (Table 2.6).

Species and sites not included in the analysis are re-entered into the improved sequenced table (Table 2.6) and a final check of site order is made. With the addition of *Salicornia europaea* and *Suaeda maritima* relevé #57 no longer appears to be in the correct location. These two species are characteristic of salt pans and protected shores and although low in abundance are ecologically significant. For this reason the species are reordered to include *Salicornia europaea*, *Suaeda maritima* within the *Spartina alterniflora* group. *Atriplex patula* is removed from this community and listed as an "other" species. Its affinity with the *Spartina alterniflora* community is unclear.

The position of the *Juncus gerardii* community is altered to reflect its real ecological position, between the upper meadow communities and the dune fringe grasses.

Several sites (#18, 37, 54 and 56) are eliminated from the Meadowgrass association. They contain no 'typical' meadow or marsh species and are more representative of dune communities. Their position along dune margins, according to field notes, verifies this.

The differentiated table (Table 2.7) represents the final refinement of species and sites. All relevant habitat data are incorporated and each site group named according to this information. Communities are named according to their diagnostic species. The final set of columns displays a tabulation of species frequency in each of the communities.

From the differentiated table, community composition and the relationships between communities can be readily identified. If an extensive botanical survey were available for this area, groups and subsets

TABLE 2.6 : IMPROVED SEQUENCE TABLE FOR THE MEADOWGRASS ASSOCIATION, SOUTH RICHIBUCTO BEACH, N.B.; INCLUDES ALL SPECIES.

Relevé Number	21	22	44	64	1	6	46	61	43	60	41	24	27	28	2	3	4	5	8	10	25	45	66	68	69	34	30	57	26	50	51	47	29	42	49
GROUP A																																			
SPAR ALTE	3	2	3	7	5	3	8	7	8	6	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
ATRI PATU	2	2	2	4	-	-	-	-	-	-	-	1	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	3
GROUP B																																			
GLAU MARI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5	5	2	3	4	4	7	5	-	5
LIMO NASH	-	-	-	-	-	-	-	-	2	X	8	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	2	4	2	X	4	2	4	3	-
PLAN SPEC	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	4	2	-	-	-	-	-	8	4
GROUP C																																			
SOLI SEMP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	2	6	-	X
AMMO BREV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FEST RUBR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	2	-	-
OTHE GRAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LATH JAPO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ASTE SPEC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JUNC GERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
CARE SILI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CONV SEPI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHERS																																			
SPAR PATE	9	9	9	5	5	5	3	5	6	5	7	4	9	8	9	10	9	5	9	9	9	9	8	5	9	8	7	6	9	9	8	4	6	5	8
POTE ANSE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	3	-	-	-	3	-
AREN LATE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MYRI PENS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SALI EURO	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-
SUAE MARI	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
SPAR PECT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Relevé Number	62	65	67	7	23	11	48	63	56	54	18	20	37	52	17	38	14	19	55	53	35	31	33	32	36	40	39	9	13	12	15	16
GROUP A																																
SPAR ALTE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ATRI PATU	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GROUP B																																
GLAU MARI	8	7	6	6	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
LIMO NASH	-	-	-	-	4	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLAN SPEC	X	2	3	-	-	-	-	3	-	-	-	5	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	3		
GROUP C																																
SOLI SEMP	5	5	-	-	-	-	-	6	-	-	-	-	-	4	4	6	5	5	4	5	-	5	7	7	-	4	5	-	6	5	6	3
AMMO BREV	-	-	-	-	-	-	-	-	5	5	5	3	8	6	8	6	-	5	6	4	4	4	4	4	5	5	2	-	-	-	-	-
FEST RUBR	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	4	-	-	4	-	4	-	4	2	2	2	-	-	4	4	6
OTHE GRAS	-	-	5	-	-	-	-	-	-	-	-	3	-	-	-	-	5	-	-	-	4	4	4	4	4	4	5	-	-	4	5	5
LATH JAPO	-	-	-	-	-	-	-	-	-	-	-	-	5	-	5	-	-	8	-	-	6	-	-	3	5	5	6	-	-	-	-	-
ASTE SPEC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	4	-	5	-	5	-	2	5	5	-	-	-	-	-
JUNC GERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	6	1	5	5
CARE SILI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	3	-	3	6	-	-	-	-	-	-	-	-	-
CONV SEPI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	4	4	4	-	-	-	-	3	-	-
OTHERS																																
SPAR PATE	5	5	6	8	9	9	9	8	-	-	-	-	-	5	-	-	6	-	-	-	-	4	-	-	-	-	-	5	7	4	-	-
POTE ANSE	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	2	4	-
AREN LATE	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
MYRI PENS	-	-	-	-	-	-	-	7	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SALI EURO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SUAE MARI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPAR PECT	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 2.7 : FINAL DIFFERENTIATED TABLE FOR THE MEADOWGRASS ASSOCIATION, SOUTH RICHIBUCTO BEACH, N.B.

Transect	3A	3A	1B	1B	2A	1A	1A	2A	3A	2A	3A	2A	1A	1A	1A	1A	1A	1A	1B	1B	1B	1B	2A	3A	3A
Station	2	3	2	2	3	1	2	3	2	2	2	1	2	2	2	2	3	3	2	2	3	3	3	4	5
Quadrat	45	07	86	68	53	36	19	91	46	00	86	74	12	36	07	83	03	87	93	31	60	27	22	96	13
Height (M) above MSL	.23	.66	.21	.21	.28	-.20	.01	.28	.22	.18	.22	.23	.01	.01	.01	.01	.18	.18	.21	.21	.27	.27	.28	.84	.59
Distance[1] (M) from MSL	20	37	14	14	66	-13	1	66	20	22	20	5	1	1	1	1	19	19	14	14	33	33	66	55	74
Texture	Silt						Sandy Loam											Loamy Sand							
% Cover (per $1m^2$)	75	75	100	100	100	40	80	70	75	70	80	75	100	95	30	95	95	95	80	100	80	95	20	20	100
Exposed Substrate						8	5	6				6		4	8	5									
Litter Cover[2]	6	6	X	X	X				6	7	5						4	4	5	X	6	4	8	8	X
Litter Depth[3] (cm)	X	1.5	14	13	5		7.5		9	1.5	9	X	14	13	7.5	5	11.5	11.5	10	10	2.5	2.5	14	4	4
SPECIES	GLASSWORT		CORDGRASS/MEADOWGRASS TRANSITION										MEADOWGRASS												
TRANSITION AND SALT PANS																									
Spartina alterniflora	2	7	3	2	3	5	3	8	7	8	6	6	-	-	-	-	-	-	-	-	-	-	-	-	-
Salicornia europaea	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Suaeda maritima	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MEADOW																									
Glaux maritima	2	-	-	-	-	-	-	-	-	2	X	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Limonium Nashii	4	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Plantago species	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UPPER MEADOW																									
Juncus gerardii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SAND DUNES AND DUNE MARGINS																									
Ammophila breviligulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solidago sempervirens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other grasses	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Festuca rubra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lathyrus japonicus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex silicea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Convolvulus sepium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHERS																									
Spartina patens	6	5	9	9	5	5	3	5	6	5	7	4	10	9	5	9	9	9	9	9	8	9	8	5	9
Atriplex patula	4	4	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	3	-	-	-
Potentilla anserina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arenaria laterifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of Species	8	5	3	3	3	2	2	2	2	3	3	4	1	1	1	1	1	1	1	2	2	2	1	1	1

[1] Distance is calculated as horizontal distance from the normal position of mean sea level on the profile.

[2] Underlined figures indicate Eelgrass litter.

[3] Litter depth is averaged over $1m^2$ quadrat. X - indicates trace quantities.

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TABLE 2.7: FINAL DIFFERENTIATED TABLE FOR THE MEADOWGRASS ASSOCIATION, SOUTH RICHIBUCTO BEACH, N.B.(continued).

Transect	3A	1B	1B	1B	2A	2A	2A	1B	2A	2A	3A	3A	3A	1A	1A	1B	2A	3A	1A	1A	1A	1A	1A
Station	5	6	3	3	4	4	4	3	2	4	3	3	4	3	3	2	4	3	3	4	4	4	4
Quadrat	97	31	01	02	38	69	57	05	41	75	32	12	24	30	78	75	84	76	46	60	91	73	23
Height (M) above MSL	.59	.51	.27	.27	.37	.37	.37	.27	.18	.37	.66	.66	.84	.18	.18	.21	.37	.66	.18	.33	.33	.33	.33
Distance¹(M) from MSL	74	89	33	33	83	83	83	33	22	83	37	37	55	19	19	14	83	37	19	36	36	36	36
Texture									Loamy Sand												Sand		
% Cover (per 1m²)	80	90	95	100	95	80	50	75	100	75	75	65	50	95	95	95	80	75	80	80	70	70	60
Exposed Substrate																							
Litter Cover²	5	5	4	X	4	5	8	6		6	6	7	8	4	4	4	5	6	5	5	7	7	7
Litter Depth³ (cm)	1.5	4	2.5	5	2.5	2.5	4	4	X	4	X	5	2	4	13	6.5	4	2.5	2.5	2.5		4	2.5
SPECIES	SEA MILKWORT																		BLACK RUSH				
TRANSITION AND SALT PANS																							
Spartina alterniflora	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salicornia europaea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Suaeda maritima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MEADOW																							
Glaux maritima	5	5	5	3	4	4	7	5	-	5	8	7	6	3	6	-	-	-	-	4	-	-	-
Limonium Nashii	2	4	2	2	X	4	2	4	3	-	-	-	-	-	-	4	4	-	-	-	-	-	-
Plantago species	2	4	4	-	-	-	-	-	8	4	X	2	3	-	-	-	-	3	-	-	-	-	3
UPPER MEADOW																							
Juncus gerardii	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	6	5	5	1
SAND DUNES AND DUNE MARGINS																							
Ammophila breviligulata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solidago sempervirens	-	-	6	-	-	-	2	6	-	X	5	5	-	-	-	-	-	-	-	6	3	6	5
Other grasses	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	5	5	4
Festuca rubra	-	-	4	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4
Lathyrus japonicus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex silicea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Convolvulus sepium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHERS																							
Spartina patens	8	9	7	9	9	8	4	6	5	8	5	5	6	9	8	9	9	9	5	7	-	-	4
Atriplex patula	-	-	-	-	-	-	-	-	-	3	-	-	-	1	-	-	2	-	-	-	-	-	-
Potentilla anserina	-	-	2	3	-	-	-	3	-	-	-	-	-	-	2	-	-	-	-	4	-	4	2
Arenaria laterifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of Species	4	5	7	4	3	3	4	6	3	5	4	4	4	3	3	2	3	2	2	5	4	5	7

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TABLE 2.7: FINAL DIFFERENTIATED TABLE FOR THE MEADOWGRASS ASSOCIATION, SOUTH RICHIBUCTO BEACH, N.B. (continued).

Transect	1A	2A	1A	1B	1A	1A	2A	2A	1B	1B	1B	1B	1B	1B	1B	GLASSWORT		CORDGRASS/ MEADOWGRASS TRANSITION		MEADOWGRASS		SEA MILKWORT		BLACK RUSH		MEADOWGRASS/ MARRAM TRANSITION	
Station	5	5	5	7	4	5	5	5	6	4	4	4	6	7	7												
Quadrat	19	57	20	96	86	05	67	91	96	91	52	07	24	14	51												
Height (M) above MSL	.81	.91	.81	.69	.33	.81	.91	.91	.51	.67	.67	.67	.51	.69	.69												
Distance^1(M) from MSL	56	101	56	109	36	56	101	101	89	52	52	52	89	109	109												
Texture								Sand																			
% Cover (per 1m^2)	25	70	75	60	75	95	70	30	70	40	70	70	70	40	70												
Exposed Substrate	5			6		4	4	5		5	6	6		4	6												
Litter Cover^2	8	7	6	6	6		6	8	6	8	5	4	7	8													
Litter Depth^3 (cm)		4	10	13	4				6.5	2.5	5	2.5		4													
SPECIES	MEADOWGRASS/MARRAM TRANSITION															Frequency %	Average Cover %	Frequency %	Average Cover %	Frequency %	Average Cover %	Frequency %	Average Cover %	Frequency %	Average Cover %	Frequency %	Average Cover %
TRANSITION AND SALT PANS																											
Spartina alterniflora	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	23	100	26	-	-	-	-	-	-	-	-
Salicornia europaea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	20	-	-	-	-	-	-	-	-	-	-
Suaeda maritima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	13	-	-	-	-	-	-	-	-	-	-
MEADOW																											
Glaux maritima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	3	-	-	-	-	78	23	20	5	-	-
Limonium Nashii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	5	30	25	-	-	61	4	-	-	-	-
Plantago species	5	-	-	-	-	-	-	-	-	3	-	-	-	-	-	50	3	10	5	-	-	50	10	20	3	13	12
UPPER MEADOW																											
Juncus gerardii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	3	100	27	-	-
SAND DUNES AND DUNE MARGINS																											
Ammophila breviligulata	3	6	8	6	-	5	6	4	4	4	4	4	5	5	2	-	-	-	-	-	-	-	-	93	17	-	-
Solidago sempervirens	-	4	4	6	5	5	4	5	-	5	7	7		4	5	-	-	-	-	-	-	33	17	80	20	80	19
Other grasses	3	-	-	-	5	-	-	-	4	4	4	4	4	4	5	-	-	-	-	-	-	6	20	60	15	60	8
Festuca rubra	-	3	-	-	4	-	-	4	-	4	-	4	2	2	2	-	-	-	-	-	-	11	4	60	5	53	4
Lathyrus japonicus	-	-	5	-	-	8	-	-	6	-	-	3	5	5	6	-	-	-	-	-	-	-	-	-	-	47	26
Aster species	-	-	-	4	-	-	4	-	5	-	5	-	2	5	5	-	-	-	-	-	-	-	-	-	-	47	13
Carex silicea	4	-	-	-	-	3	-	3	-	3	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33	9
Convolvulus sepium	-	-	-	-	-	-	-	-	3	-	4	4	4	-	-	-	-	-	-	-	-	-	-	-	-	27	6
OTHERS																											
Spartina patens	-	5	-	-	6	-	-	-	-	4	-	-	-	-	-	100	25	100	34	100	75	100	53	60	22	20	18
Atriplex patula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	5	30	3	23	3	17	3	-	-	-	-
Potentilla anserina	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	3	60	4	7	5
Arenaria laterifolia	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	20
Number of Species	4	4	3	3	5	4	4	4	5	7	6	6	6	6	6												

of those groups could be assigned to specific levels in the Braun-Blanquet hierarchy. Without this framework within which to place the analysis, however, it is best to assign each group to a non-specific community.

Differentiated tables are available for all associations but have not been included here. Summary tables (Appendix B3) and descriptions in Section 3.2 identify community composition and characteristics.

2.2.3 Two-Way Indicator Species Analysis (TWINSPAN)

2.2.3.1 Theory

The theory, methodology and interpretation of the Two-Way Indicator Species Analysis (TWINSPAN) has been described in detail elsewhere (Hill 1979). Only the key points will be outlined here.

The basic function of TWINSPAN is the production of an ordered two-way table by the identification of differential species. A differential species may be defined as one which shows a clear ecological preference and thus may be used to identify a particular set of environmental conditions. In this respect, TWINSPAN resembles the Braun-Blanquet method. However, according to the Braun-Blanquet approach both species and samples (or sites) are classified at the same time. TWINSPAN first classifies the samples using the species as attributes. Once this site classification is completed, species are grouped according to their preferred occurrence within certain sample units.

The ordination or classification itself consists of three separate dichotomization procedures, each one a refinement of the previous. The primary ordination uses a reciprocal averaging technique to identify the direction of variation in the data set (Hill 1973). In this technique species are assigned a score reflecting their position along a rough initial gradient (relating to e.g., water, salinity, altitude). In the TWINSPAN analysis the species score is based upon the percent cover of each species at each site. Stand scores are defined by averaging the species scores for all those species occurring at that site. These stand or sample scores are then used as weights to produce an improved species calibration. The new species scores are the averages of the stand scores for the sites in which they occur. The new species scores are then used to further calibrate the stands. These iterative calculations eventually result in a stable, optimal solution. Here, it is presented as the primary ordination. The name reciprocal averaging reflects the condition that the species scores are averages of the stand scores and reciprocally, the stand scores are the averages of species scores.

The primary ordination is then divided at the middle to produce a crude dichotomy of the samples. From this, differential species, those which prefer one side of the division or the other, can be identified. The second ordination, the refined ordination,is then constructed on the basis of the preferential species. Once again the ordination is divided.

The third ordination is the indicator ordination, based on a few of the most highly differential species. In most cases, the refined ordination provides the final dichotomy. The indicator species derived from the third ordination are used solely to describe the final communities succinctly.

The data is presented as an ordered two-way table, from which site and species groups can be identified. Synecological relationships between species groups and habitats are expressed in the two-way table (Table 3.2 and Appendix B1). A hierarchy can also be constructed to illustrate the hierarchial relationships between communities (Figure 3.21 and Appendix B2).

2.2.3.2 Application

A TWINSPAN analysis was carried out for each of the marshes (Buctouche, Brackley and South Richibucto Beach) individually and also for the combined data set. The latter analysis was used as the basis for the definition of plant communities (Section 3.2) as within and between marsh variability was minimized. However, the individual analyses identified specific variations in community composition. These were noted and discussed where thought to be significant. In addition, the individual analysis revealed similarities and differences in habitat and occurrence, that otherwise might have gone unnoticed.

The resultant hierarchies and ordinations for the three marshes are presented in Appendices B1 and B2. The combined analysis is discussed and illustrated in Section 3.2.3 (Figure 3.21 and Table 3.2). Interpretation of the ordinations and identification of significant communities was based on the knowledge of both the data set and the TWINSPAN methodology. Occasionally, some communities, underrepresented in the individual analysis, were reclassified (e.g., Sea Milkwort community, South Richibucto Beach). This will be further discussed elsewhere (Section 3.2).

The TWINSPAN program offers a number of input parameters which may be varied to suit the needs of the individual analysis. These parameters include omission of samples and/or species, pseudospecies cut levels and the number of divisions in the hierarchy. These parameters were varied individually to determine the most suitable for this analysis, however not all combinations were so tested.

Neighbouring dune and non-marsh sites were originally included in the analyses. However, as there were insufficient sites to accurately define the composition of dune communities, the scatter introduced by these dune samples tended to mask the underlying relationships between the marsh sites and species.

When the dune sites were omitted from the final analyses their component species were likewise eliminated or, at least, reduced. These species include *Ammophila breviligulata*, *Lathyrus japonicus*, *Hudsonia tomentosa*, *Myrica pensylvanica* and *Carex silicea*. All other species were included regardless of their frequency of occurrence. It was often found that the diagnostic species were those species having a very low occurrence (e.g., *Salicornia europaea*).

The use of pseudospecies enables quantitative values for each species to be used as differential species and indicators. Quantitative data (e.g., percent cover) expressed as a percent can be rescaled using selected cut-off values. Although other sets of cut-off values were tested, the limits of 0, 20 and 75 percent were determined and incorporated into the final analyses to provide maximum information. These were thought to best represent the major variations in species occurrence, i.e., very dense (> 75 percent), frequent (20 to 75 percent) and occasional (< 20 percent). The pseudospecies corresponding to these three ranges are identified as 3, 2 and 1, respectively (Appendices B1 and B2).

Five divisions were determined as optimal for the individual marsh analyses. In the combined analysis, six divisions were required to separate the data into significant groups.

2.2.4 Discussion

Both the Braun-Blanquet and TWINSPAN analyses produce ordered tables grouping together sets of species and sets of sites which behave in a similar manner. Both approaches require the identification of certain differential species, those species whose occurrence can be related to a specific (set of) environmental condition(s). While the two methods are very similar each offer its own advantages.

The TWINSPAN program provides a highly objective means of classification. The criteria by which sites (and species) are assigned to particular groups is consistent within each analysis. The decision to group sites and species in the Braun-Blanquet analysis is less precisely defined and subject to analyst interpretation. As a result, while the TWINSPAN produces repeatable results (given the same data set and input parameters), the final differentiated table of the Braun-Blanquet method may vary between analysts.

In addition, the objective nature of TWINSPAN enabled transition sites to be more precisely classified. Transition communities were often defined on the basis of the occurrence of a number of species, characterized by low frequency and cover.

The differential species identified by each method are similar. The significance of those species whose frequency is high, but not constant, were better described in the TWINSPAN analysis. These tended to be species, such as *Limonium Nashii*, whose occurrence represented a low order (second or third level division) differential, defining large, broad plant groupings.

Within the Braun-Blanquet analysis it was difficult to incorporate cover data consistently. However, summary tables (Appendix B3) showing average cover and frequency for each species within each community, were easily produced. TWINSPAN provided pseudospecies by which this quantitative data could be analyzed. Pseudospecies were often differential or indicator species for the higher order communities, defining subtle differences in species cover between these small groups.

To carry out the analysis, the Braun-Blanquet approach was time-consuming and required great care to ensure that columns and rows were copied in the appropriate sequence. Once the site data was coded and input for the TWINSPAN analysis, data manipulation (e.g., omission of specific sites or species) was simple. In addition, the data are currently in compatible format for further analyses by computer (e.g., DECORANA), which will be attempted at a later time.

The interpretation of individual communities was much easier on the Braun-Blanquet analysis where environmental information and the original site numbers were provided in the final table. The current TWINSPAN printout format does not provide for site names other than a sequential numbering system. This necessitated a cross-referencing system between the original site name and new TWINSPAN site number, which complicated the interpretation of communities and their habitats.

While the final communities produced by the Braun-Blanquet and TWINSPAN methods were very similar, some differences were recognized. This was especially noticeable in the transition communities which were generally poorly defined in the former analysis. In general, TWINSPAN produced more discrete communities; the Braun-Blanquet communities were not sufficiently refined.

Both analyses were considered in the description of marsh communities, although the TWINSPAN framework is used for the discussion (Section 3.2). By using both methods, the author gained an appreciation of the relationships within and between sites and species.

CHAPTER 3

THE MARSH ENVIRONMENT

3.1 DEVELOPMENT, STRUCTURE AND CLASSIFICATION

3.1.1 Development of Maritime Salt Marshes

Salt marshes are most commonly found on stable or emerging coasts. Where sedimentation rates exceed subsidence, narrow marshes may temporarily develop along submerging shores (Chapman 1974). On any coastline, marsh formation is restricted to those areas where physiographic conditions dictate a protected environment (Steers 1974). These generally fall into one of three categories; estuaries, embayments or spits/offshore bars or islands. Where wave energies have been dissipated by broad expanses of tidal flat, marshes may also be found on open coastlines (Ranwell 1972).

In the case of barriers, the marshes have a unique relationship with the barrier/dune system. As a spit grows in length, protection from wave action increases until conditions suitable for marsh formation are reached. Successive marshes develop as the spit continues its extension, producing a distinct series of marshes of different ages (see Figure 3.1). Similar development and age variation occur where marshes have formed in the lee of both simple and complex offshore bars (Figures 3.2 a and b). The zonal pattern depicted in the simple case will be considered in more detail in connection with vegetation zonation.

There are a number of stages in the formation of a marsh, regardless of its location. Each marsh begins with a mud or sand flat.

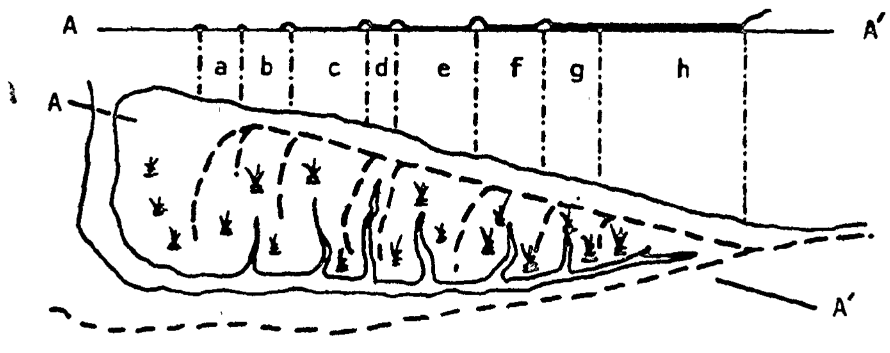


Figure 3.1: Marsh development behind a spit, in plan and profile view. Marshes form between the recurves, marsh 'h' being the oldest and 'a', the youngest (Chapman 1974).

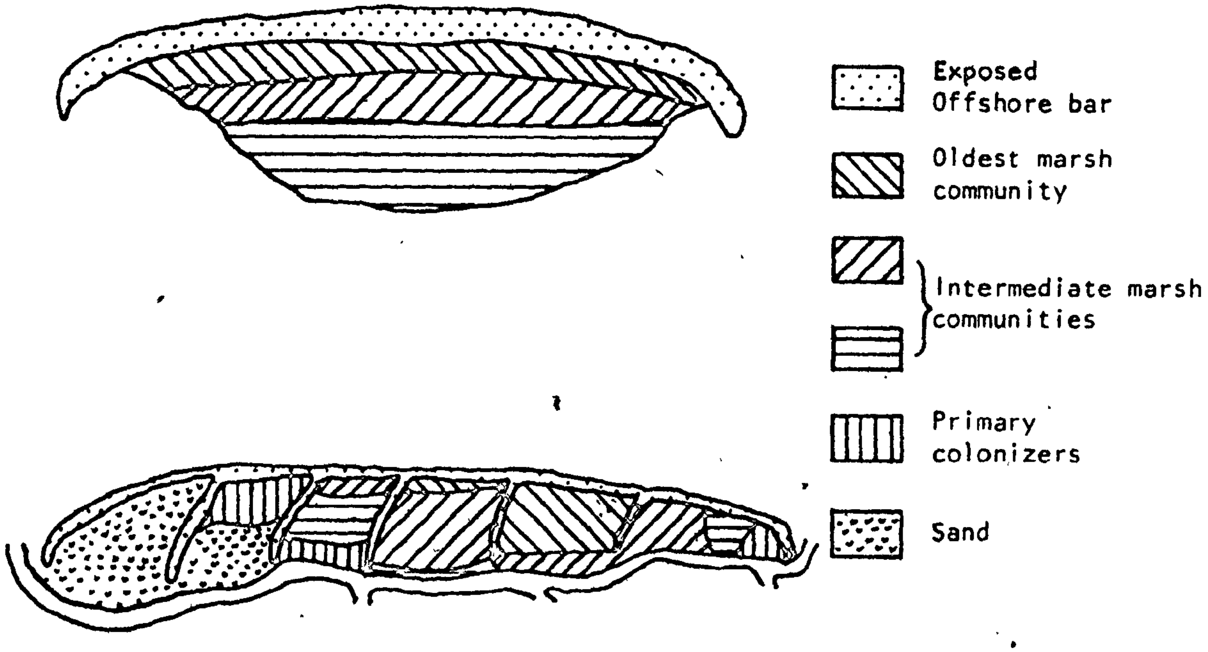


Figure 3.2a: Marsh development in the lee of an offshore bar or barrier. The oldest, highest marsh is adjacent to the bar (Chapman 1974).

Figure 3.2b: Marsh development behind a complex bar. Marsh growth is along shore in both directions and landwards (Chapman 1974).

Algae or, if conditions are suitable a sublittoral species such as eelgrass may be present. The algae help to stabilize the substrate and act somewhat as a sediment trap. As the surface level becomes higher, pioneer marsh species appear.

Pioneer species must be able to tolerate daily submergence by tidal waters. These are usually a grass species (*Spartina* or *Puccinellia*) or another salt tolerant herb (*Salicornia* species) (Chapman 1974). *Spartina*, in particular, is an excellent filter, its dense root mat binding the substrate while the stiff leaves filter sediment during the tidal cycle (Stuckey 1980a). Wayne (1976) has shown that *Spartina alterniflora* is capable of reducing wave energy by as much as 92 percent, illustrating its effectiveness as a baffle. The lowest marsh community on the profile is frequently monospecific, there being few species adopted to the frequency of submergence that is experienced (Ranwell 1972).

As the marsh surface rises, more species invade. This further increases the rate of accretion until tidal influence is minimal. Succeeding communities are more complex (containing more species), as conditions become less severe. At the upper limit of tidal influence a pseudo-static condition is reached and transition is to terrestrial, or where there is freshwater input, swamp species.

3.1.2 Factors Affecting Zonation of Salt Marsh Species

Within the marsh, species occupy very narrow zones in terms of environmental differences. At the most general level, species distribution within the coastal system is influenced by:

1) air temperature, most often species are cold sensitive;
2) the protected shoreline, where tender seedlings can establish;
3) shallow shores, to permit extensive marsh development and the growth of broad communities;
4) currents, to aid seed dispersal;
5) salt water, although not all species are obligate halophytes, many exhibit optimum growth in the presence of sodium chloride (Wiehe 1935);
6) tidal range, limits the range of communities; and
7) substrate, to determine drainage and nutrient availability (Chapman 1977).

These factors are not independent. Ranwell (1972) describes a tradeoff between water temperature/water quality and position on the profile. Low marsh species are able to tolerate more frequent flooding in warmer climates and areas where water is cleaner. In these areas the increased frequency of inundation is compensated by photosynthesis during submergence periods. Competition is also reduced within the intertidal zone. Those species tolerant of, but not dependent upon, wet, saline conditions, which are also unable to compete successfully with the more terrestrial species, may be found within the low marsh. Here, competition is sufficiently reduced to permit the establishment of these species (Ranwell 1972). At a more detailed level, different ecophenotypes of a given species may be characteristic of specific habitat conditions. As many as four forms of *Spartina alterniflora* have been identified in southern U.S. marshes (Reimold et al. 1973). These are related to their low marsh, high marsh, reduced marsh or creek side position.

Many hypotheses have been offered to explain marsh zonation. Harshberger (1909) was among the first, relating vegetation formations in New Jersey to tide levels. The first quantitative results relating the vertical plant distribution to tide levels were obtained by Johnson and York (1915) working in New York. By establishing the exact position of each species with reference to tidal limits, a submergence/emergence ratio for each species could be determined. This identified the degree to which vegetation was dependant upon tide level. Competition between species was also thought to limit distribution, especially in the case of lower marsh species where photosynthesis is limited by flooding during daylight hours. Penfound and Hathaway (1938) found a difference in elevation of 7.5 cm could produce a change in Louisiana plant communities. Reed (1947) considered distribution limited by two factors; tidal regime at the lower end and competition with non-salt tolerant species at the upper marsh border. Hinde (1954) and Adams (1963) reached similar conclusions working in San Francisco Bay and North Carolina, respectively. Tidal regime was the primary cause with salinity, degree of aeration of the soil, and character of the substrate secondary concerns.

After a number of extensive studies, Chapman (1937, 1938, 1940a&b, 1974, 1976,1977) lists no less than ten interdependent factors affecting species distribution. These include tides, salinity, drainage, aeration, watertable, rainfall, soil, evaporation, temperature and biota. However, tides are considered the most important. Most recent authors agree with this, although the exact nature of the controlling mechanism (e.g., salinity, submergence, water quality) is not fully understood (Ranwell 1972; Redfield 1972).

The pattern of zonation seen in marshes is a horizontal expression of successional trends, as well as a response to an environmental gradient (Chapman 1974). In the marsh example, the dominant gradient is related to tides, submergence and salinity. Through time, the marsh level is built up and successively less hydric species colonize. In New England and eastern Canada, *Spartina alterniflora* at the lowest marsh level, is replaced by *S. patens*, which is in turn succeeded by *Juncus* at the upper marsh fringe. In general, this vertical pattern or succession, is identical to the horizontal arrangement of species across a marsh profile. Where secondary colonization occurs or the environmental gradient varies from the normal situation, (e.g., presence of freshwater spring or deep sand patches), changes in the succession can be identified (see Figures 4.20 & 4.21).

3.1.3 Classification

Salt marshes extend along the east coast of North America, from the St. Lawrence to northern Florida (Frey & Basan 1978). Limited marsh development has occurred around the coast of Newfoundland and part way up the Labrador coast (W. Glooschenko, pers. comm.). Although distribution and species composition has yet to be defined, most marshes appear to be similar to those found elsewhere in the Gulf of St. Lawrence (E. Hiscock, pers. comm.).

Marshes have been categorized into three groups based on substrate and vegetation differences (Chapman 1974; Johnson 1925). Their distribution is shown in Figure 3.3.

(i) Coastal Plain Marshes: Marshes of this type have developed in front of a soft rock upland. At the upper margin, transition is to freshwater swamp, but in the southern most expressions, mangroves may back the marsh. Floristically there is a greater diversity of species, some exhibiting different ecophenotypes, than in the northern groups (Duncan 1974).

(ii) New England Marshes: These marshes are formed in front of a hard rock upland and are characterized by a deep peat substrate. *Spartina alterniflora* is the primary

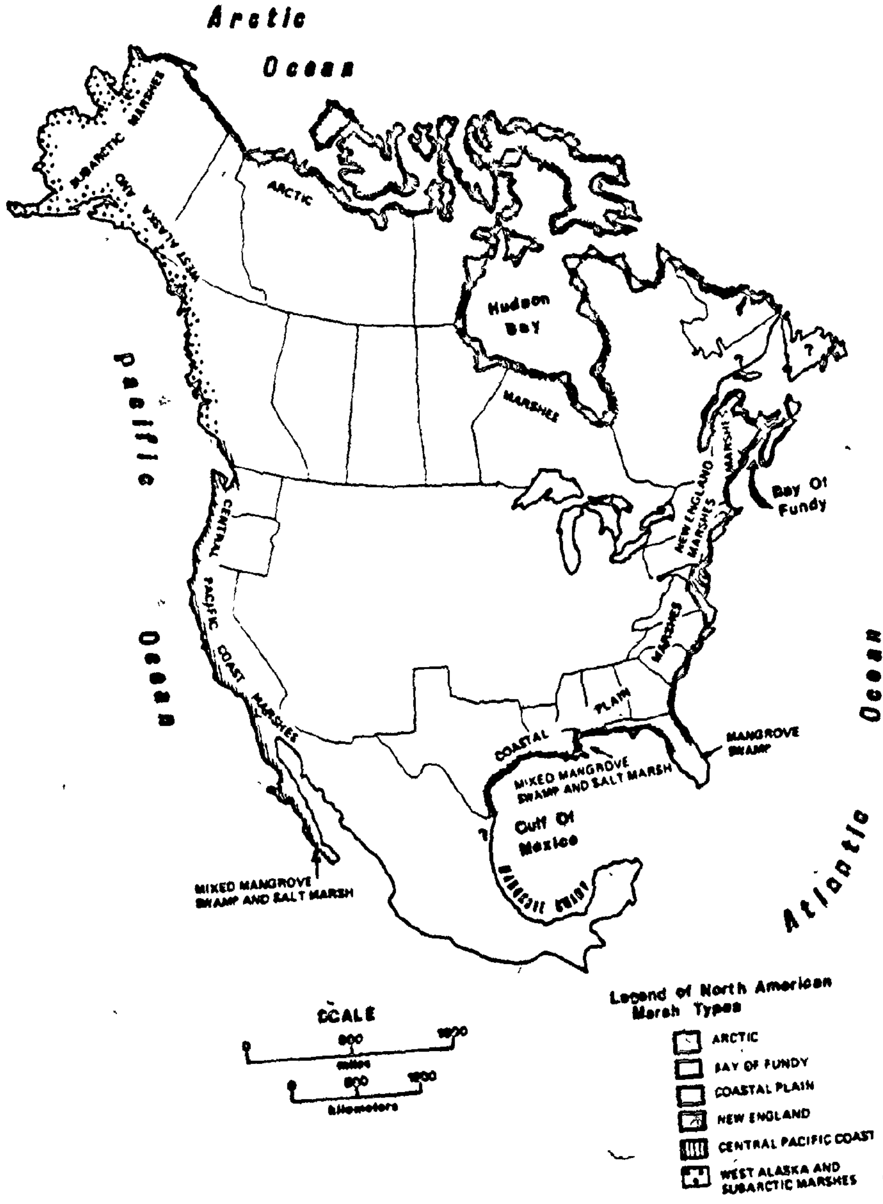


Figure 3.3: Distribution of coastal salt marshes in North America by marsh type. Salt marshes within the southern Gulf of St. Lawrence are generally considered Fundy Type, although the species composition and tidal range are similar to that found in New England (Frey & Basan 1978).

colonizer with *Spartina patens* and *Distichlis spicata* equal dominants further up the profile (Redfield 1972). The upper marsh is generally in transition to reed swamp.

(iii) Bay of Fundy Marshes: The fundamental difference between this to the preceding type is the substrate. Fundy type marshes are built upon deep red silts and muds. Johnson (1925) cites mud depths of up to 24 m on the Tantramar Marsh, N.S. Chapman (1974) suggests further research to determine the nature of the depositional environment.
Puccinellia species are cited as important colonizers on the upper marsh with *Juncus balticus* at the upper marsh border where there is a transition to bog (Ganong 1903). Chapman (1937) found *Spartina patens* eliminated in favor of *Puccinellia* where the former had been mown for hay.
There is evidence to suggest that the original 'type site' for the Fundy marsh category is not representative of other marshes in eastern Canada. The deep silts and muds and large tidal range described for Fundy types, are not characteristic of the predominantly sandy, microtidal environment of the southern Gulf of St. Lawrence.

For the purpose of further discussion, New England and Fundy types will be considered together, but specified whenever referenced. Frey and Basan (1978) concur with the grouping of these two types, citing similarity in tidal regime, species and zonal boundaries as evidence. Recently, the similarity in vegetation between the New England and Fundy types has been described (Godfrey & Snow 1978; P.J. Godfrey, pers. comm.).

3.2 VEGETATION OF THE SOUTHERN GULF OF ST. LAWRENCE

3.2.1 Literature Review

In comparison with other areas, the salt marsh vegetation in Eastern Canada has received little attention. The first comprehensive analysis of marsh associations was undertaken in 1903 by Ganong, who focused upon the typical 'Fundy' marsh. Since that time only a few studies have been compiled, each one concentrating on a different area. As this paper was nearing completion a recent publication, the result of a five year study, on marsh and dune associations in eastern Canada was acquired (Thannheiser 1981). In it, no less than twenty-five different associations were identified, each one having as many as four variants.

Table 3.1 lists the major publications on marsh vegetation in eastern Canada (excluding Labrador and Newfoundland). Approximate tide ranges are indicated for each association or zone identified, as are the dominant species and their associates. Similar data from several New England sites have been included for comparison.

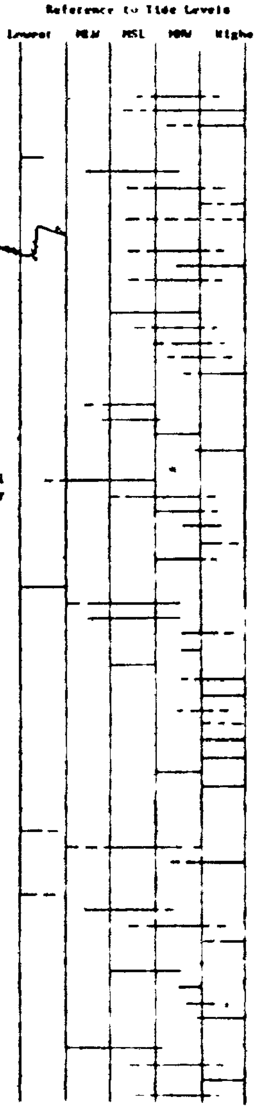
At all Canadian sites, described prior to Thannheiser's(1981) study, there appears to be only four major associations consistently identified. Although these are all labelled differently, their compositions are similar. The four associations are as follows:

1) The pioneer (Nichols 1918) or Glabra (Johnson 1925) zone, also known as the Spartinetum (Chapman 1937; Ganong 1903; Grandtner 1966; Reed & Moisan 1971) is identified at each site with *Spartina alterniflora* (sometimes referred to by historical name) always being present.
Rarely accompanied by other species, *Potentilla egedii*, *Limonium Nashii*, *Triglochin maritima*, *Puccinellia lucida* and *Salicornia europaea* are listed as associates at two sites.

2) A salt meadow (Nichols 1918) or Patens zone (Johnson 1925), dominated by *Spartina patens*, (*S. juncea*), is identified at most sites. Associated species are highly variable and include *Limonium* species, *Plantago* species, *Puccinellia maritima*, *Juncus Gerardii*, *Distichlis spicata*, and *Triglochin maritima*.

3) The highest marsh association is usually described as a Juncetum, with *Juncus balticus* as the dominant. Occasionally present are combinations of the following: *Agrostis alba*, *Scirpus campestris*, *Eleocharis palustris*, *Potentilla* species, *Lathyrus palustris*, *Festuca rubra*, *Arenaria laterifolia* and *Solidago sempervirens*.

TABLE 3.1: SUMMARY OF SALT MARSH ASSOCIATIONS AND THEIR DOMINANT SPECIES, CHARACTERISTIC OF ATLANTIC CANADA AND NEW ENGLAND.



REFERENCE	ZONE/ASSOCIATION	DOMINANTS	ASSOCIATES
EASTERN CANADA*			
Ganong, 1903 Fundy, N.S.	Spartinetum	*Spartina stricta*	
	Salicornietum	*Salicornia herbacea, Suaeda maritima*	*Spergularia borealis, Atriplex hastata*
	Staticetum	*Spartina juncea, Statice Limonium carolinianum*	*Plantago maritima, Puccinellia maritima, Juncus gerardi*
Nichols, 1915 N.Cape Breton, N.S.		*Zostera marina*	*Ulva species*
	Pioneer	*Spartina glabra alterniflora*	
	Salt meadow	*Spartina patens*	*Distichlis spicata, Triglochin maritima, Plantago decipiens*
	Salt meadow	*Juncus balticus littoralis*	*Agrostis alba, Scirpus campestris, Eleocharis palustris, Potentilla pacifica*
	Pans	*Salicornia europaea, Spergularia canadensis*	*Glaux maritima, Puccinellia maritima*
Johnson, 1922 Fundy, N.S.	Glabra zone	*Spartina glabra*	
	Patens zone	*Spartina patens, statice*	
	Salicornia zone	*Salicornia herbacea, Suaeda linearis*	
Chapman, 1937 Nova Scotia	Spartinetum	*Spartina alterniflora*	*Salicornia europaea*
	Salicornietum	*Salicornia europaea, Suaeda maritima*	
		Spartina patens	
	Juncetum	*Juncus Gerardii*	
	Juncetum	*Juncus balticus littoralis*	
Grandtner, 1966 Magdalen Islands	Salicornietum	*Salicornia europaea*	
	Spartinetum	*Spartina alterniflora, Potentilla egedii*	*Limonium Nashii, Triglochin maritima, Puccinellia lucida*
	Caricetum	*Carex paleacea* [illegible] *Glaux maritima*	*Ranunculus Cymbalaria*
	Juncetum	*Juncus balticus, Lathyrus palustris, Festuca rubra*	*Potentilla egedii, Arenaria lateriflora, Solidago sempervirens*
Reed & Moisan, 1971 St. Lawrence Estuary	Spartinetum	*Spartina alterniflora*	*Salicornia europaea*
	Spartinetum patentis	*Spartina patens*	
	Forbs	*Limonium Nashii, Spergularia canadensis*	*Glaux maritima, Suaeda maritima, Plantago species*
	Forbs	*Atriplex patula, Potentilla anserina*	*Hordeum jubatum*
		Carex paleacea, Juncus [illegible]*, J. balticus*	
	Pans	*Salicornia europaea, Spartina alterniflora*	*Calamagrostis, Carex species, Myrica gale*
Thannheiser, 1981 Southern Gulf of St. Lawrence	Zosteretum marinae	*Zostera marina*	*Ruppia maritima*
	Salicornia europaea Gesellschaft	*Salicornia europaea*	*Suaeda maritima, Spartina alterniflora*
	Spartinetum alterniflorae	*Spartina alterniflora*	*Suaeda maritima, Salicornia europaea, Spartina patens*
	Spartinetum patentis	*Spartina patens*	*Spartina alterniflora, Limonium Nashii, Plantago spp. Atriplex spp*
	Limonietum nashii	*Limonium nashii*	*Spartina patens, Puccinellia americana, Plantago maritima*
	Puccinellietum americanae	*Puccinellia americana*	*Limonium Nashii, Spartina patens, Spartina alterniflora*
	Distichlidetum spicatae	*Distichlis spicata*	*Spartina patens, Spartina alterniflora, Limonium Nashii*
	Plantago maritima Gesellschaft	*Plantago maritima*	*Glaux maritima, Potentilla egedii*
	Puccinellietum ambiguae	*Puccinellia ambigua*	*Plantago maritima, Spergularia canadensis, Glaux maritima*
	Caricetum paleaceae	*Carex paleacea*	*Triglochin maritima, Juncus Gerardii, Spartina patens*
	Scirpetum americani	*Scirpus americanus*	*Plantago maritima, Eleocharis halophila, Agrostis stolonifera*
	Juncetum gerardii	*Juncus gerardii*	*Agrostis stolonifera, Potentilla egedii Festuca rubra*
	Suaedetum maritimae	*Suaeda maritima*	*Spartina alterniflora, Salicornia europaea*
	Potentilla egedii	*Potentilla egedii*	*Festuca rubra, Agrostis stolonifera, Juncus balticus*
NEW ENGLAND			
Johnson & York, 1915 New York	Zostera zone	*Zostera marina*	*Ruppia maritima, algae*
	Spartinetum	*Spartina glabra*	
		Various monocots & dicots	
Johnson, 1925 New England	Zostera zone	*Zostera marina*	
	Glabra zone	*Spartina glabra*	
	Patens zone	*Spartina patens, Distichlis spicata*	
	Juncus zone	*Juncus gerardii, Solidago sempervirens*	
Miller & Egler, 1950 Connecticut	Lower border	*Spartina alterniflora*	
	Lower slope	*Spartina patens*	*Distichlis spicata, Salicornia europaea*
	Upper slope	*Juncus gerardii*	*Distichlis spicata*
	Upper border	*Panicum virgatum*	*Spartina pectinata*
Redfield, 1972 New England		*Spartina alterniflora*	
		Spartina patens, Distichlis spicata	
		Juncus gerardii	*Limonium carolinianum, Plantago maritima, Solidago sempervirens, Aster species*
	Pans	*Salicornia Species*	

*excluding Newfoundland and Labrador

—— usual range

---- occasional range

4) The fourth association consistently recorded is that identified with salt pans. The Salicornietum contains *Salicornia europaea*, with *Suaeda* species, *Spergularia* species and *Atriplex hastata*.

Locally, unique associations have been identified. These include a Caricetum on the Magdalen Islands (Grandtner 1966), Juncetum with *J. Gerardi* at Nova Scotia (Chapman 1937) and two forb communities in the St. Lawrence Estuary (Reed & Moisan 1971).

However, the variability and complexity of salt marsh associations in the southern Gulf of St. Lawrence, previously neither appreciated nor documented, is revealed in the list of vegetation units described by Thannheiser (1981). Although the communities defined by Thannheiser were not considered during the analyses of the following data, they will serve as a measure of comparison for the final results.

The record of tidal ranges for each association is not as variable as are the vegetation units; several communities occur with the same limits. This reflects the influence of non-tidal factors. These include salinity, substrate texture (muddiness), nutrient supply and species distribution (Thannheiser 1981). Communities previously described, correspond to some of those defined by Thannheiser (1981) and have similar, if not identical, tidal ranges.

Four similar associations have been defined in typical New England marshes (Johnson 1925; Johnson & York 1915; Miller & Egler 1950; Redfield 1972). However, at these more southerly latitudes, *Juncus gerardii* replaces *J. balticus* at the upper levels.

Tidal ranges for each association in both eastern Canada and New England appear to have similar limits. The zone dominated by

Spartina alterniflora is distributed around mean sea level. The lower boundary of the *S. patens* zone lies within the range of mean high water, while the upper limit is below the range of highest water. The Juncetum occupies the highest marsh level, only wetted by extreme tides and storms. Distribution of pan communities is slightly more variable, situated between mean sea level and the highest marsh sites. At this rather general level of vegetation analysis, the relationships between marsh association and tidal range are well defined.

It is apparent that within the salt marshes of the southern Gulf of St. Lawrence, similarities in community composition exist. Early studies describing the vegetation were simplistic, identifying only the major zones. The complexity and variability of plant communities is now recognized; however, documentation is still sparse, especially with regard to distribution and frequency of occurrence.

In the following analyses, a detailed classification of salt marsh communities within the southern Gulf of St. Lawrence will be produced. The description of each community will include; component species and their frequency and density; habitat conditions, both general and site specific and discussion outlining the regional distribution of each community. Comparisons will be made along and between surveyed profiles within each marsh, as well as between the three marshes. A model of the typical marsh profile will be derived. The relationships between certain communities and tide levels will also be defined. Subsequently,predicted and observed tidal data will be incorporated into the analysis (Section 3.3).

Prior to aerial photographic interpretation, an analysis of this type is imperative, especially where such data are (as far as is known) non-existent. In addition to furnishing adequate ground information, a necessity for most aerial interpretations, this procedure will provide the basis for further botanical and ecological descriptions and analyses.

3.2.2 Community Descriptions

General marsh communities, typical of the three study areas within the southern Gulf of St. Lawrence, have been defined. A TWINSPAN analysis using the complete data set, excluding the dune sites, identified forty-eight separate groupings at the sixth level. These were subsequently regrouped into twenty-six communities, as shown in Table 3.2. The significance of each group was determined by inspection of individual sites within the hierarchial framework. Attention was paid to the habitat variability within and between the three marshes, and along individual transects.

A TWINSPAN analyses was completed for each marsh separately. The communities derived therein were compared with those defined above to identify the homogeneity of each community within and between study sites. Where significant variation was identified, reference to the individual and composite marsh analyses has been made. The classification hierarchies and ordinations for the three individual marsh analyses are found in Appendices B1 and B2. Summary tables outlining the frequency (percent) and density (percent) within a 1 m^2 quadrat for each species grouped by community are also contained within the Appendix B3.

Nomenclature for each community reflects the differential species

TABLE 3.2 : ANNOTATED TWO-WAY TABLE FOR THE COMPLETE DATA SET. MAJOR COMMUNITIES WILL BE DISCUSSED IN DETAIL.

MARSH ZONES	DUNELETS		FRINGE				
MARSH COMMUNITIES	LYME-GRASS	MEADOWGRASS / MARRAM	RUSH / MARRAM II	BALTIC RUSH III	RUSH / MARRAM I	BALTIC RUSH II	
☆	11111	111334	111111333333344	22222222333333333333	1333333333	122233333333333333333344444444	
	16666	55555194	489000016122334416	99999999000000062445	2233334430111244555	:75690012335555566666801126666	
	30123	34789323	677024725668091278	03456789034567395561	7925671555789048234	326311261375678901234870212467	
6 ASTE SPEC	-----	--------	--1---------------	--1-------1----1----	111111111----1-11--	--11--------11---1-------11121	000000
11 CONV SEPI	-1---	--------	------------------	--------------------	-------------------	---1------------------1-------	000000
18 IRIS SPEC	-----	--------	------------------	---2-12-------------	-------------------	------------------------------	000000
1 ACHI LANU	-----	--------	------------------	-1------------------	---11-11----------2	------------------------------	000001
5 AREN LATE	-----	--------	------------------	-----1-11----------2	----------1--1--1--	--------1---------------------	000001
10 CARE SILI	-----	--------	-1---1-----111---1	-1------------11----	111111111111-11----	------------------------------	000001
22 MYRI PENS	-----	--------	----2-----2-22----	-1-1------22--22232-	----------22222--11	--22----222-------------------	000001
31 SONC ARVE	-----	--------	------------------	--111-----1--1-1----	----------------2-1	-1---1------------------------	000001
35 SPER MARI	-----	--------	---1--------------	--------------------	---112-1-----------	------------------------------	000001
38 TRIF SPEC	-----	--------	-11--1------------	2121-221---11222---2	2211122111-----2-1-	----2---------------1---------	000001
39 VICI AMER	-----	--------	------------------	-----11------------1	----------1----1111	-----------------1-1----------	000001
19 JUNC BALT	-----	--------	111221111111111212	2222222222222221222-	11-1111112111121-1-	1-11222111233333222232-2221222	000010
4 AMMO BREV	-2222	21222212	222222122222221122	--------------1-1---	--2211111-11111----	-1--1--111-----------111111111	000011
17 HUDS TOME	-----	--------	------1-----------	--------------------	-------------------	------------------------------	000011
24 OTHE GRAS	-----	11------	--11--------------	--------------------	1----11-1----------	1-211--------------1-11-1111-1	000100
34 SPAR PECT	-2-22	--1-----	------------------	1------1------------	-------------------	------------------------------	000100
15 FEST RUBR	-----	------11	--1--------111----	----------------11--	-1-1-------1-1-1---	-211----111----111---1-1---1-1	000101
13 ELEO SPEC	-----	--------	------------------	--------------------	-------------------	------------------------------	00011
30 SOLI SEMP	-----	-11--111	----------111-----	-------------------1	111111-1-1-1221-222	221211-221111222222222-2112111	0010
25 POTE ANSE	-----	--------	------------------	2-------------------	-------------------	------------------------------	00110
3 AGRO ALBA	-----	--------	------------------	1------1--111112---1	-------------------	----------------1-------------	00111
2 AGRO REPE	-----	--------	------------------	1--11----11--1------	-------------------	------------------------------	0100
28 SCIR AMER	-----	--------	------------------	-----1----2---------	-------------------	------------------------------	0101
20 JUNC GERA	-----	--------	------------------	--------------------	-------------------	------------------------------	011
14 ELYM AREN	32111	--------	------------------	--------------------	-------------------	------------------------------	1000
21 LIMO NASH	-----	--------	------------------	--------------------	-------------------	------------------------------	100100
33 SPAR PATE	-----	121-1--2	------------------	--------------------	-------------------	-2----------------------------	100101
7 ATRI PATU	-----	--------	------------------	-------------------1	----------------1-1	------------------------------	100110
29 SCIR MARI	-----	--------	------------------	--------------------	-2-----------------	------------------------------	100111
27 SALI EURO	-----	--------	------------------	--------------------	-------------------	------------------------------	1010
32 SPAR ALTE	-----	--------	------------------	--------------------	-------------------	------------------------------	10110
37 SUAE MARI	-----	--------	------------------	--------------------	-------------------	------------------------------	10111
26 PUCC MARI	-----	--------	------------------	--------------------	---------------1---	------------------------------	1100
23 PLAN SPEC	-----	---1--2-	------------------	--------------------	-------------------	------------------------------	1101
9 CARE PALE	-----	--------	------------------	--------------------	-------------------	------------------------------	1110
16 GLAU MARI	-----	--------	------------------	--------------------	-------------------	------------------------------	1111
	00000	00000000	000000000000000000	00000000000000000000	0000000000000000000	000000000000000000000000000000	
	01111	11111111	111111111111111111	11111111111111111111	1111111111111111111	111111111111111111111111111111	
	0000	00000000	000000000000000000	00000000000000000000	0000000000000000000	000000000000000000000000000000	
	0000	00000000	000000000000000000	11111111111111111111	1111111111111111111	111111111111111111111111111111	
	0000	11111111	111111111111111111	00000000000000000000	0000000000000000000	111111111111111111111111111111	
	0111	00000000	111111111111111111	00000000000000000000	1111111111111111111	000000000000000000000000000000	

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TABLE 3.2: ANNOTATED TWO-WAY TABLE FOR THE COMPLETE DATA SET. (continued).

MARSH ZONES	FRINGE		MEADOW			
MARSH COMMUNITIES	BALTIC RUSH I (TYPICAL)	SEA MILKWORT/ BALTIC RUSH	BLACK RUSH II (TYPICAL)	SEA MILKWORT II	PLANTAIN	
☆	11111112222244444	22 4 22	333 11223344	2212222222222222	14111	
	111222222233333444778889999906666775666603314	55^7888899955	111777889 11777688800	6614883578886778	42575	
	679134568013482498912343456914578019245636914	2485068901278	015347367728634894512	169682592345081	5736.	
6 ASTE SFEC	----1112-1-11111221--111112--1-111-1---212-	-------------	---------------------	----------------	-----	000000
11 CONV SEPI	---2111--211211-1111---1-1-11111--1-212211-1-	-------------	---------------------	----------------	-----	000000
18 IRIS SPEC	-----1---111-1-------------------------------	-------------	---------------------	----------------	-----	000000
1 ACHI LANU	-----------------111-------------------------	-------------	---------------------	----------------	-----	000001
5 AREN LATE	---	-------------	---------------------	----------------	-----	000001
10 CARE SILI	-------1--------11-----------------1--------1	-------------	---------------------	----------------	-----	000001
22 MYPI PENS	-----------------1-----------------2---------	-------------	---------------------	----------------	-----	000001
31 SONC ARVE	-------------------------------------11------	11-----------	---------------------	----------------	-----	000001
35 SPER MARI	------1----------1----------1----------------	-------------	---------------------	----------------	-----	000001
38 TRIF SPEC	---1122--1---1-121----1-------2-111----------	-------------	---------------------	----11-------1--	-----	000001
39 VICI AMER	---	-------------	---------------------	----------------	-----	000001
19 JUNC BALT	222222212112222212222222211221-22-2221222122-	2221-121--122	--2--------21--------	22--2---1------2	-----	000010
4 AMMO BREV	-----------1--11---------------11---------11-	-------------	--------------1121---	----------------	-----	000011
17 HUDS TOME	---	-------------	---------------------	----------------	-----	000011
24 OTHE GRAS	11222212222221212222222221111-2221222222122--	-112222-22222	1-2112112---1--1--2--	2---------------	-----	000100
34 SPAR PECT	---1-111-1-11--1-11-----1---2211-11--1------1	---1---------	--1------------------	----22----------	-----	000100
15 FEST RUBR	122111-11111-11111-1-1111111---1-11122--1-121	121-111-11111	2121211121--1121--111	-1------------1-	1-12-	000101
13 ELEO SPEC	---	-------------	---------------------	-------21-------	-----	00011
30 SOLI SEMP	12212112211112-111111-21-1-111222222----22111	---1---------	122-1-221221-21-12222	--2-1--------1--	-----	0010
25 POTE ANSE	211----11-----------121-2323-----------------	11-2221222211	11122211--112---21111	21-11------1----	-----	00110
3 AGRO ALBA	---	-------------	----------------11---	11-2-112--222-11	-----	00111
2 AGRO REPE	---	-------------	---------------------	----------2-----	-----	0100
28 SCIR AMER	---	22-1---------	---------------------	-------1111--1-1	-----	0101
20 JUNC GERA	---------------------------1--2--------------	---11--121---	22-2221221-2-----2---	---2---1--1-----	--1-1	011
14 ELYM AREN	---	-------------	---------------------	----------------	-----	1000
21 LIMO NASH	----------1----------------------------------	--2----------	-----------1--------11	-------------1--	12121	100100
33 SPAR PATE	---	222----------	1111121--222222112222	-212121211------	-1332	100101
7 ATRI PATU	---	-------------	---------------------	----------------	-----	100110
29 SCIR MARI	---	-------------	---------------------	----------------	-----	100111
27 SALI EURO	---	-------------	---------------------	----------------	-----	1010
32 SPAR ALTE	---	-------------	---------------------	----------------	22---	10110
37 SUAE MARI	---	-------------	---------------------	----------------	-----	10111
26 PUCC MARI	-------------------------1-------------------	-------------	---------------------	----------------	2-1--	1100
23 PLAN SPEC	-----------------------------------1---------	-------------	1-----1--------------1	---------1111-222	111-2	1101
9 CAPE PALE	---	-----------11	---------------------	22--1---1-11----	-----	1110
16 GLAU MARI	---1------------------------------1--1-----	1-2--21111122	11-1-1----1112-1-1-21	2222222322222222	-----	1111
	000000000000000000000000000000000000000000000	0000000000000	000000000000000000000	0000000000000000	11111	
	111111111111111111111111111111111111111111111	1111111111111	111111111111111111111	1111111111111111	00000	
	000000000000000000000000000000000000000000000	1111111111111	111111111111111111111	1111111111111111	00000	
	111111111111111111111111111111111111111111111	0000000000000	000000000000000000000	1111111111111111	00000	
	111111111111111111111111111111111111111111111	0000000000000	111111111111111111111	0000001111111111	00001	
	111111111111111111111111111111111111111111111	0001111111111	000000000111111111111	0011110000000111	00110	

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TABLE 3.2: ANNOTATED TWO-WAY TABLE FOR THE COMPLETE DATA SET. (continued).

MARSH ZONES	MEADOW						
MARSH COMMUNITIES	PLANTAIN	SEA MILKWORT I (TYPICAL)	SEDGE	BLACK RUSH I	BULRUSH II	MEADOWGRASS (TYPICAL)	
	11412233	1222224 122222344444444 11344 24	222222	13	22222222222222344	1111111111111222	
☆	55266766	777777527345837345566675666779446651	444334	126677718	22222223333344736	56661222233333444112	
	14829156	923456325741078806701517567788123403	178890	56408901240	12356890345656553	8990125368902567689290	
6 ASTE SPEC	--------	------------------------------------	------	-----------	-----------------	----------------------	000000
11 CONV SEPI	--------	------------------------------------	------	-----------	-----------------	----------------------	000000
18 IRIS SPEC	--------	------------------------------------	------	-----------	-----------------	----------------------	000000
1 ACHI LANU	--------	------------------------------------	------	-----------	-----------------	----------------------	000001
5 AREN LATE	--------	------------------------------------	------	-----------	-----------------	----------------------	000001
10 CARE SILI	--------	------------------------------------	------	-----------	-----------------	----------------------	000001
22 MYRI PENS	--------	------------------------------------	------	-----------	-----------------	----------------------	000001
31 SONC ARVE	--------	------------------------------------	------	-----------	-----------------	----------------------	000001
35 SPER MARI	--------	------------------------------------	------	-----------	-----------------	----------------------	000001
38 TRIF SPEC	--------	------------------------------------	------	-----------	-----------------	----------------------	000001
39 VICI AMER	--------	------------------------------------	------	-----------	-----------------	----------------------	000001
19 JUNC BALT	--------	--------------------1------1--------	------	---1-------	-----------------	----------------------	000010
4 AMMO BREV	--------	------------------------------------	------	-----------	-----------------	----------------------	000011
17 HUDS TOME	--------	------------------------------------	------	-----------	-----------------	----------------------	000011
24 OTHE GRAS	--------	---------------------2--------------	------	-----------	-----------------	----------------------	000100
34 SPAR PECT	1-------	-------------2----------------------	------	-----------	-----------------	----------------------	000100
15 FEST RUBR	------21	---------------------------1--------	------	-----------	-----------------	-1--------------------	000101
13 ELEO SPEC	--------	------------------------------------	------	-----------	-----------------	----------------------	00011
30 SOLI SEMP	--------	--------1------112221------2--------	------	1111---1---	-----------------	1---------------------	0010
25 POTE ANSE	--------	-------------11--------------1------	121---	---1-------	-----------------	----------------------	00110
3 AGRO ALBA	--------	---1----111-1-----------------------	-111--	-----------	-----------------	----------------------	00111
2 AGRO REPE	--------	--1111------------------------------	------	-----------	-----------------	----------------------	0100
28 SCIR AMER	--------	-------1--111---------------------1-	--1---	-----------	-----------------	----------------------	0101
20 JUNC GERA	1-------	--------------------------------2221	-1----	----21122-2	-----------------	----------------------	011
14 ELYM AREN	--------	------------------------------------	------	-2-------2-	-----------------	------1---------------	1000
21 LIMO NASH	1-111111	1-11-11-2------1------121121211111-1	------	-----------	-----------------	1-11--11111111--------	100100
33 SPAR PATE	-1211112	11111-23222212212222222233233332322-	222322	32332322312	32232222232222222	3333331333333333333333	100101
7 ATRI PATU	--------	------1---------1-------------------	------	-----------	-----------------	--1---1---1-1---------	100110
29 SCIR MARI	--------	------------------------------------	------	-----------	1-211-1--212-----	----------------------	100111
27 SALI EURO	----11--	-11---2-----------------------------	------	-----------	----11-----------	----------------------	1010
32 SPAR ALTE	--------	1-----1-----------------------------	------	-----------	-----------------	--------1-------------	10110
37 SUAE MARI	--------	------1-----------------------------	------	-----------	-----------------	----------------------	10111
26 PUCC MARI	---21---	-1----------------------------------	------	-----------	-----------------	----------------------	1100
23 PLAN SPEC	22222222	111121111---2---1111211-111-1-------	------	-----------	-----------------	----2-----------------	1101
9 CARE PALE	--------	---------1--------------------------	212112	-----------	-----------------	----------------------	1110
16 GLAU MARI	----1212	322222121223222222-2122-111-1111112-	---1-1	--1--------	-----------------	--1-------------------	1111
	11111111	111111111111111111111111111111111111	111111	11111111111	11111111111111111	1111111111111111111111	
	00000000	000000000000000000000000000000000000	000000	00000000000	00000000000000000	0000000000000000000000	
	00000000	000000000000000000000000000000000000	111111	11111111111	11111111111111111	1111111111111111111111	
	00000000	111111111111111111111111111111111111	000000	00000000000	00000000000000000	1111111111111111111111	
	11111111	000000000000000000000001111111111111	000000	11111111111	11111111111111111	0000000000000000000000	
	00011111	000000011111111111111110000000001111	000111	00000000000	11111111111111111	0000000000000000000000	

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TABLE 3.2: ANNOTATED TWO-WAY TABLE FOR THE COMPLETE DATA SET. (continued).

MARSH ZONES	MEADOW		LOW MARSH								
MARSH COMMUNITIES	MEADOWGRASS (TYPICAL)	ORACH	CORDGRASS/ MEADOWGRASS	GLASS-WORT III	GLASS-WORT II	1	SEA BLITE	CORDGRASS II (TYPICAL)	CORDGRASS I		
☆	2222233333334	1111111111111222222333333444	344444	11224	1111412	22	1143	1111222222	1111111123334444	11	
	2344577778996	1112223334444011111278999033	55723355	33105	8888320	11	4454	2289000001	58899999906772233	88	
	7123334691579	7894571890127671384723469049	186296745	34658	0123202	45	3499	231283347897	455912567909013603	46	
6 ASTE SPEC	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000000
11 CONV SEPI	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000000
18 IRIS SPEC	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000000
1 ACHI LANU	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000001
5 AREN LATE	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000001
10 CARE SILI	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000001
22 MYRI PENS	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000001
31 SONC ARVE	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000001
35 SPER MARI	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000001
38 TRIF SPEC	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000001
39 VICI AMER	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000001
19 JUNC BALT	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000010
4 AMMO BREV	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000011
17 MUCS TOME	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000011
24 OTHE GRAS	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000100
34 SPAR PECT	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	000100
15 FEST RUBR	-------------	------------1---------------	---------	-----	-------	--	----	------------	------------------	--	000101
13 ELEO SPEC	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	00011
30 SOLI SEMP	-------------	---------------------------1	---------	-----	-------	--	----	------------	------------------	--	0010
25 POTE ANSE	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	00110
3 AGRO ALBA	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	00111
2 AGRO REPE	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	0100
28 SCIR AMER	-------------	----------------------------	---------	-----	-------	1-	----	------------	------------------	--	0101
20 JUNC GERA	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	011
14 ELYM AREN	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	1000
21 LIMO NASH	----------1--	----------------------------	-1--1--1-	-----	-------	--	----	------------	------------------	--	100100
33 SPAR PATE	3333333333333	2332333333333322333333332333	132222222	12222	---1---	--	----	------------	------------------	--	100101
7 ATRI PATU	-------------	11-111111111-112-11-11111111	---------	11121	-----1-	12	1112	--11--------	------------------	--	100110
29 SCIR MARI	-------------	----------------1-----------	---------	-----	-------	22	----	-----------1	------------------	--	100111
27 SALI EURO	-------------	--------------121-----------	---------	1-122	1121211	11	----	------------	------------------	12	1010
32 SPAR ALTE	-------------	-111-1-----11---1--1-11---1-	112222222	33212	32232--	22	222-	111211111111	232222222222223333	22	10110
37 SUAE MARI	-------------	----------------------------	---------	1--12	111111-	-1	2122	------------	------------------	--	10111
26 PUCC MARI	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	1100
23 PLAN SPEC	-------------	----------------------------	11-------	-----	-------	-1	----	------------	--------1---------	--	1101
9 CARE PALE	-------------	----------------------------	---------	-----	-------	--	----	------------	------------------	--	1110
16 GLAU MARI	-------------	--------------------1-------	---------	-----	-------	--	----	------------	------------------	--	1111
	1111111111111	1111111111111111111111111111	111111111	11111	1111111	11	1111	111111111111	111111111111111111	11	
	0000000000000	0000000000000000000000000000	000000000	11111	1111111	11	1111	111111111111	111111111111111111	11	
	1111111111111	1111111111111111111111111111	111111111	00000	0000000	00	0000	111111111111	111111111111111111	11	
	1111111111111	1111111111111111111111111111	111111111	00000	0000000	11	1111	000000000000	000000000000000000	00	
	0000000000000	0000000000000000000000000000	111111111	00000	1111111	00	1111	000000000000	000000000000000000	11	
	0000000000000	1111111111111111111111111111	001111111	00011	0000011	01	0001	000000000000	111111111111111111	00	

1. BULRUSH I

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TABLE 3.2: ANNOTATED TWO-WAY TABLE FOR THE COMPLETE DATA SET. (continued).

☆ Site Numbers

1- 49	Buctouche	1A
50-112		1B
113-159		2A
160-171		3A
172-266	Brackley	2B
267-291		3BSouth
292-309		3BNorth
310-348		4A
349-368		4B
369-393	South Beach	1A
394-422		1B
423-447		2A
448-470		3A

```
MARSH ZONES                 LOW         MARSH
MARSH COMMUNITIES        GLASS-WORT  SEA LAVENDER

                      ☆  11112 44444444
                         89990 44552352
                         70481 89014125

SPECIES GROUPS
     6 ASTE SPEC         ----- --------    000000
    11 CONV SEPI         ----- --------    000000
    18 IRIS SPEC         ----- --------    000000
     1 ACHI LANU         ----- --------    000001
     5 AREN LATE         ----- --------    000001
    10 CARE SILI         ----- --------    000001
    22 MYRI PENS         ----- --------    000001
    31 SONC ARVE         ----- --------    000001
    35 SPER MARI         ----- --------    000001
    38 TRIF SPEC         ----- --------    000001
    39 VICI AMER         ----- --------    000001
    19 JUNC BALT         ----- --------    000010
     4 AMMO BREV         ----- --------    000011
    17 HUDS TOME         ----- --------    000011
    24 OTHE GRAS         ----- --------    000100
    34 SPAR PECT         ----- --------    000100
    15 FEST RUBR         ----- --------    000101
    13 ELEO SPEC         ----- --------    00011
    30 SOLI SEMP         ----- --------    0010
    25 POTE ANSE         ----- --------    00110
     3 AGRO ALBA         ----- --------    00111
     2 AGRO REPE         ----- --------    0100
    28 SCIR AMER         ----- --------    0101
    20 JUNC GERA         ----- --------    011
    14 ELYM AREN         ----- --------    1000
    21 LIMO NASH         ----- 11112222    100100
    33 SPAR PATE         ----- --------    100101
     7 ATRI PATU         ----- --------    100110
    29 SCIR MARI         ----- --------    100111
    27 SALI EURO         12211 -------1    1010
    32 SPAR ALTE         22211 21222222    10110
    37 SUAE MARI         ----- ----1--1    10111
    26 FUCC MARI         ----- -------1    1100
    23 PLAN SPEC         ----- -------2    1101
     9 CARE PALE         ----- --------    1110
    16 GLAU MARI         ----- --------    1111

                         11111 11111111
                         11111 11111111
                         11111 11111111
                         00000 11111111
                         11111 00000001
                         00011 0000111
```

or the transitional nature of the unit. Although there are obvious hierarchial relationships between some of the communities, no attempt has been made to assign a ranking to any group. Communities identified by the same differential species and given the same name are further identified by a numerical value. This value relates to the community position within the ordination, and while it is not meant to implicitly infer height above sea level, in many cases it does. Communities identified as the typical form are those having consistent composition and occurrence in all three study areas.

Communities are listed in the approximate order of their profile position, beginning at the lagoon edge. Typical community habitat and particular preferences of component species are identified. Seasonal information is incorporated where necessary.

3.2.2.1 Cordgrass

Two Cordgrass communities have been identified, the distinction between them being based upon the density of the dominant, and usually sole, species, *Spartina alterniflora* (formerly known as *S. stricta* and *S. glabra*). While density frequently reflects habitat conditions, it is more often related to the composition and cover of nearby communities (e.g., Glasswort). Other component species, all of which occur infrequently, include orach, seaside plantain and salt marsh bulrush.

Cordgrass, as defined by this community, has been identified as the pioneer species of salt marshes in eastern North America (Chapman 1974). Its abilities to withstand long periods of submergence and reproduce vegetatively permit colonization across much of the intertidal zone, suffering few effects of the harsh conditions existent here. In addition to frequent inundation by icy waters during winter months, these also include considerable erosion from ice scour (Redfield 1972). Perpetually flooded sites are not suitable for cordgrass; the species cannot tolerate its roots in standing water. Stuckey (1980a) suggests an optimal six hour exposure period between tides. Daily flooding is generally considered a requisite for cordgrass establishment and growth (Chapman 1974). In an analysis of exposure periods, Thomas (1969) identified 18.5 and 88 percent as the lower and upper limits, respectively. (Exposure limits will be discussed further in Section 3.3.) While cordgrass may not occupy highly saline salt pans or ponds, it is frequently found around the border where there is regular flushing by tidal waters. In this environment, the Cordgrass community is often intermixed with other typical salt pan communities such as Glasswort or Bulrush.

The coarse blue-green leaves, most frequently less than 2m in height, act to reduce wave energy and wave heights during flood periods (Wayne 1976). The dense, fibrous root mat serves to bind substrate material, preventing erosion while the stiff leaves increase the marsh level by filtering water-borne sediment (Figure 3.4). Pale flowers are borne on a panicle above the leaves in late July to mid-August. Cordgrass is a highly variable species in terms of growth (height, colour and density), dependent upon local environmental conditions (Stuckey 1980a). Different ecophenotypes of this species are common at more southerly latitudes, but are rarely observed or described near the northern limit of the species where climatic/environmental conditions are more severe. However, Martin (1975) has identified two forms in Nova Scotia, the more vigorous

Figure 3.4: CORDGRASS COMMUNITY, Brackley, P.E.I. August.

The marsh level is built up by the deposition of fine sediment and algae around the cordgrass stalks. At high tide this community is inundated.

Two separate phases of the Cordgrass community (corresponding to the Cordgrass I and II communities) are recorded at Buctouche and related directly to habitat. In an open shore position, recorded at transects 1A, 1B and 2A, average cover is 20 percent with heights reaching 20 cm. At 1B and 2A, the Cordgrass community is found inland, in the lee of the low dune ridge bordering the lagoon. Average density at these sites, sometimes adjacent to salt pans, is 75 percent and growth is markedly more vigorous, plants reaching heights of 30 to 40 cm. It is these sites with which orach is most closely associated. Rafted and bleached eelgrass litter forms a mat 5 to 8 cm deep, entwined around the cordgrass stalks (see also Figures 3.20, 4.2, 4.3 and 4.4). Eelgrass (*Zostera marina*) is washed up from its subtidal habitat, most frequently, during storm activity, and when rafted, delineates high water levels. Litter material, associated with cordgrass peripheral to salt pans, is generally transported inland through a series of coalescing and interconnecting pans and ponds. Frequently, a wide wrack zone, devoid of living vegetation but composed of an exceptionally deep (25 cm) litter mat, is recorded above and within the Cordgrass community. This is observed at sites characterized by a gently sloping intertidal zone grading into the low marsh and a dense eelgrass community immediately offshore.

The Cordgrass community is only recorded along one transect (2B) at Brackley. Density is highly variable, from 5 to 80 percent and distribution across the sandy, inland marsh is patchy. Shore sites are frequent but not sampled. Individual plants rarely exceeded 20 cm in height and die-back across the entire marsh surface was noted. This may be attributed to ice-shearing or water-impoundment. While sites were not differentiated by density in the separate Brackley analysis, sufficient site numbers provided by the inclusion of all marsh quadrats, in combination with the additional sixth level, enabled the Brackley sites to be assigned to the Cordgrass I and II communities.

The Cordgrass community (identified as Cordgrass II) rarely occupies a continuous zone of more than a few metres at South Beach. However, it is frequently found interspersed with Glasswort, Meadowgrass and several transition communities. In this location, the cordgrass occurrence is usually associated with minor depressions in an overall hummocky marsh surface. Compared to the other marshes, cordgrass at South Beach is very dense within these depressions, the average being 79 percent. Growth is correspondingly more vigorous, with heights of 60 cm often attained.

3.2.2.2 Sea Lavender

In its typical form, the Sea Lavender community contains two species; one being its namesake, *Limonium Nashii*, the other, cordgrass. Occasionally, other species, such as sea blite, seaside plantain and goose grass are recorded within this community.

Although sea lavender is common throughout the southern Gulf, the community itself is recorded only at South Richibucto Beach, N.B. At transect 3A, the Sea Lavender replaces the usual shore community, Cordgrass. The species is known to prefer habitats where tidal flooding is daily (Stuckey 1976b). Growing on or near the shore at South Beach, it is well within the range of frequent inundation. At Bideford River, P.E.I., Thomas (1969) identified sea lavender at heights slightly above mean sea level. Although occasionally seen around salt pans or as remnants at higher elevations within the meadow, it is never found away from salt water.

As a perennial, sea lavender is known to inhabit the same location for a number of years, the leathery rosette of basal leaves remaining until the new spring growth is well established. The species takes its name from the panicle of tiny, pale blue flowers, borne up to 60 cm above the leaves during August. Where sea lavender is dense, the entire marsh surface takes on a lavender colour during the flowering season (Figures 3.5, 4.2, 4.3 and 4.4).

Deep, eelgrass litter mats are common at both transects 2A and 3A, often up to 20 cm in depth and occupying 95 percent of the sample quadrat. Two distinct drift lines, composed of eelgrass buried beneath 15 cm of sand were seen at 2A. Between these ridges, growth was extremely dense, although the drift lines themselves were devoid of vegetation.

3.2.2.3 Glasswort

Three Glasswort communities have been identified at all three marshes. Glasswort (*Salicornia europaea*), sea blite (*Suaeda maritima*) and cordgrass are common to the latter two variants. In the second community, orach and meadowgrass are constants. Glasswort I contains only glasswort and cordgrass. Because of the variability in species composition and density, the combined analysis provides a better classification of the different communities than does the analysis by individual marsh. In the latter case, all glasswort sites may be grouped together with little regard for other constituent species and their density (c.f. Appendix B2.3, South Richibucto Beach).

Figure 3.5: SEA LAVENDER COMMUNITY, Pokemouche, N.B. August.

Sea lavender is mixed with cordgrass, producing a distinctive pattern. Seaside goldenrod can be seen in the foreground.

All three communities are often associated with salt pans, although Glasswort I may grow within the cordgrass zone where it is somewhat protected.

Glasswort is an annual, usually growing less than 30 cm tall. Its form is highly variable, from very branched to single stemmed and can tolerate very high salinities (Stuckey 1975b). During the fall (August until November) the usually green plant turns bright red. Although its distribution is often limited, occasionally extensive patches are recorded and accentuated in the autumn months.

Sea blite is most common on muddy substrates. It is a low inconspicuous plant, occurring mostly around salt pans on saline soils. Thomas (1969) recorded exposure limits of 84 and 97 percent for sea blite. In comparison, glasswort appears to grow at slightly lower elevations. Similar values for glasswort are 70 and 96 percent. As orach has been reported at slightly higher elevations, along with meadowgrass, a zonation of these species bordering the salt pans might be anticipated.

The distribution of Glasswort I is restricted to Brackley 2B where it appears sporadically across the undulating sand flats, protected from direct wave attack, but well within reach of daily inundation (Figure 3.6). The cordgrass within this community is sparse and stunted (less than 12 cm in height) in comparison with other cordgrass individuals. Dense stands of Glasswort I are recorded, but infrequently and generally of very limited distribution.

Glasswort II and III are the typical salt pan communities, recorded at all three marshes (Figure 3.7). While forms II and III are usually found within the cordgrass and meadowgrass communities respectively,

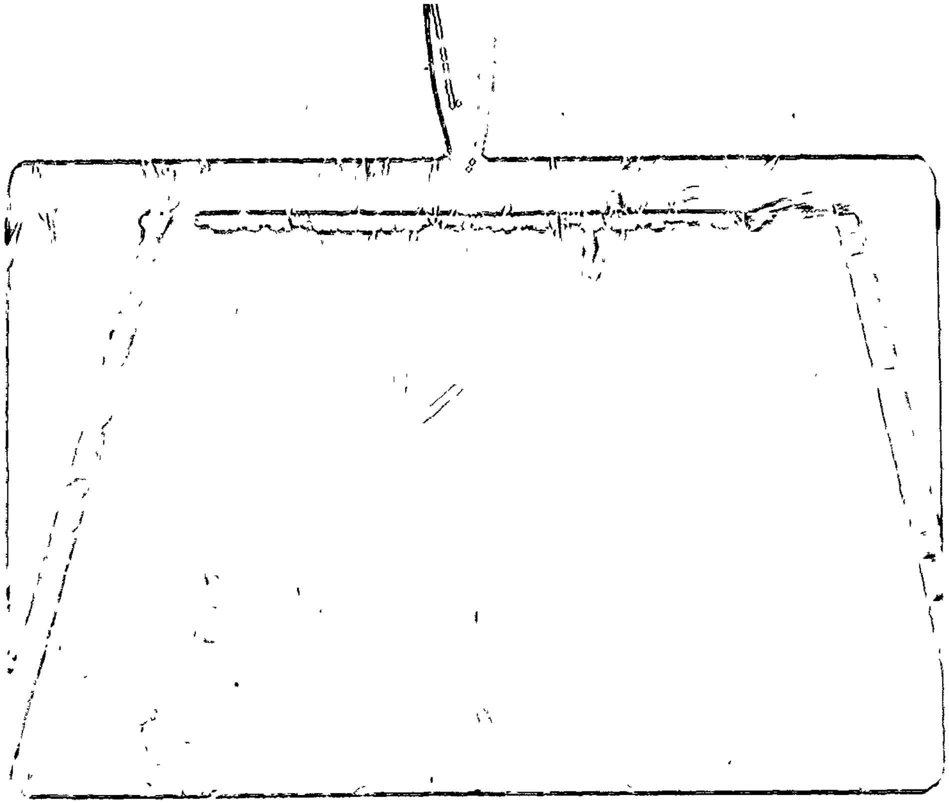


Figure 3.6: GLASSWORT I COMMUNITY, Brackley, P.E.I. August.

Occasionally, dense stands of glasswort are recorded. The frame is 1 m^2. At high tide, this site is flooded.

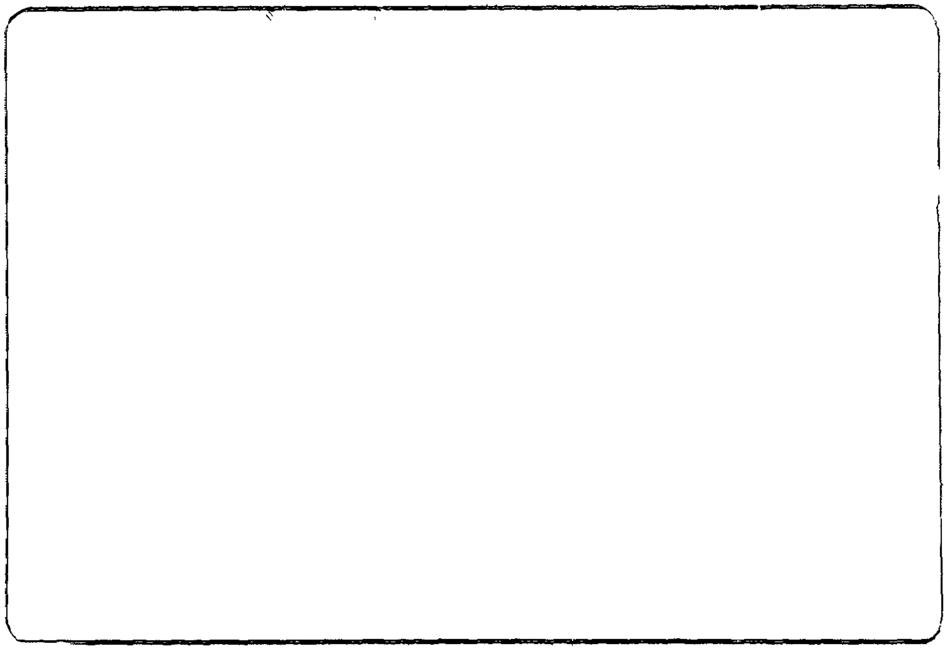


Figure 3.7: GLASSWORT III COMMUNITY, South Beach, N.B. August.

This is the typical 'pan edge' community; a combination of glasswort, sea blite, meadowgrass and cordgrass (in flower).

they are sometimes recorded in the reverse position. Meadowgrass (and its close associate orach) and cordgrass occurrence are the main differentiating species. Depending upon exact quadrat placement, either or both of these species may be missed resulting in misclassification of the site. Within the individual marsh analysis (Appendix B2), such sites have been reassigned on the basis of field notes. The analysis of the three marshes combined produced fewer misclassifications of this type. However, an additional community, Sea Blite, was identified, incorporating some sites that had created confusion elsewhere.

Density of the Glasswort community is highly variable and reflects the species composition (primarily meadowgrass and cordgrass) and the placement of the quadrat over the pan or pond edge. In general the community is very dense but rarely covers more than a few square meters. Within the Glasswort II and III communities at Buctouche and South Beach, cordgrass individuals are very vigorous, reaching 1m in height. This particular growth form is seen only at pan and creek edges.

3.2.2.4 Sea Blite

The Sea Blite community, containing cordgrass, orach and sea blite, appears to be a variation of the Glasswort community, without the glasswort. For further discussion the Sea Blite community will be considered with the Glasswort. Distribution is widespread but the number of recorded sites is few. Typically, sea blite is found at the borders of salt pans, in the vicinity of one of the Glasswort communities.

3.2.2.5 Cordgrass/Meadowgrass

Cordgrass and Meadowgrass are the primary constituents, usually found in equal quantities, and occasionally accompanied by sea lavender and seaside plantain.

As the boundary between the Cordgrass (or Sea Lavender) and Meadowgrass communities is, in most cases, very distinct, this transition community has a limited distribution. Recorded only at Buctouche and South Richibucto Beach, the latter group of sites is related to the irregularities in the marsh surface described with the Cordgrass community (Figures 4.2, 4.3 and 4.4).

3.2.2.6 Meadowgrass

Like the Cordgrass, the Meadowgrass community is frequently monospecific, with *Spartina patens*, formerly *S. juncea* (Britton and Brown 1913) being its lone constituent. Occurring throughout the study area, a second species, sea lavender, is often associated with this community, but only near the lower boundary. In this analysis the meadowgrass-sea lavender combination is not classified as a community, although additional sampling may emphasize its unique character.

At each transect, Meadowgrass appears to form a wide continuous zone between the upper Cordgrass and lower Baltic Rush boundaries. However, closer examination reveals a number of other communities scattered within this one, all having meadowgrass as a component species. While these communities vary between marshes and transects the Meadowgrass itself is a consistently recognized community.

Density at each marsh varies between 10 and 100 percent with the average between 76 and 94 per cent. Where the Meadowgrass community is well represented, a trend showing decreasing density with increasing marsh height is observed. This suggests the prevalence of more favourable conditions within the lower meadowgrass zone. Inundation by tidal waters within the Meadowgrass community is regular, but infrequent at the higher levels. Meadowgrass itself has minimum and maximum exposure limits of 88 and 99 percent, as identified by Thomas (1969) in Prince Edward Island.

Through the growing season, meadowgrass changes in appearance. The bright green, slender, 0.5 to 1.0 m tall stalks, are initially upright (Figure 3.8), but are soon flattened by the wind and tides, as well as by their own weight (Stuckey 1978b). This produces a 'cowlick' appearance over much of the Meadowgrass zone part way through the growing season (Figure 3.9). A deep litter mat can be readily accumulated during the summer season. The following spring (late May), new growth appears through the litter, the old material being very resistant to decay and often remaining for several years. New growth first appears where inundation is more frequent, i.e., at wetter sites, as does flowering. Blooming occurs sporadically across the Meadowgrass zone from late June until October. Singly the 10-15 cm long flower spikes are inconspicuous, but when patches of meadowgrass are blooming coincidently, the marsh has a red to purplish cast.

Depth of the litter mat varies between transects and marshes and is often greater than 10 cm. Litter may be either well-compacted or loose. At the seaward edge, eelgrass material is frequently mixed with the meadowgrass debris. Along the Brackley transect 2B, three divisions, based on litter mat, are observed. Between stations #9 and #10 the average depth is 15 cm. At stations #13 and #14, 9 cm is the average and the minimum depth of 5 cm is recorded at station #16, near the upper community border. This minimum depth is associated with areas having

Figure 3.8: MEADOWGRASS COMMUNITY, Brackley, P.E.I. June.

Early spring growth is sparse. The water level during this period of extreme high tides is clearly visible where the litter mat is flattened.

Figure 3.9: MEADOWGRASS COMMUNITY, Brackley, P.E.I. July.

Meadowgrass is flattened under its own weight and by the action of wind and water during the mid season. This produces the characteristic cowlick.

a higher proportion of barren or litter covered ground. In this circumstance the mature and 'less-dense' meadowgrass has blown over under its own weight.

3.2.2.7 Orach

Scattered within the lower portion of the Meadowgrass community, the Orach community has been identified. Its component species include orach (*Atriplex patula*), meadowgrass and occasionally, cordgrass. The occurrence of cordgrass with orach, but not with the monospecific meadowgrass, suggests that this community may be associated with minor elevational differences across the entire meadowgrass zone. Exposure records from Bideford River show meadowgrass and orach to have nearly identical ranges (Thomas 1969). Within this community and elsewhere, orach is frequently seen growing on and through eelgrass wrack at the level of highest water (Figure 3.10).

Orach is a highly variable annual species with several varieties intergrading in appearance. Leaf shape varies from lanceolate to triangular and may be purple to green in colour. While individuals may reach heights of up to 1.5 m, more frequently the low, 30 cm tall orach is barely visible beneath the meadowgrass.

The Orach community is only identified at South Richibucto Beach according to the individual marsh analysis. Elsewhere, the orach sites are grouped with the Meadowgrass community. From the classification using all marsh sites together, it becomes apparent that the Orach community is ubiquitous both within the three study areas and within the lower Meadowgrass community. The Orach community never forms a distinct zone.

Figure 3.10: ORACH COMMUNITY; Buctouche, N.B. July.

Near the lower Meadowgrass boundary, the Orach community occupies scattered sites, frequently on eelgrass mats.

3.2.2.8 Bulrush

Salt marsh bulrush was only recorded along the Brackley Marsh, 2B transect. While two Bulrush communities were identified in the analysis using all sites (Table 3.2), three distinct communities were defined when only the Brackley sites were included (Appendix B2.2). This latter set of communities, designated Bulrush I, II and III, are more representative of the Brackley transect and will, therefore, be described here.

Salt marsh bulrush is indicative of brackish conditions (Dore and Roland 1942) and is frequently found away from direct salt water influence. At Brackley it is commonly recorded growing in standing water in ponds across the upper marsh surface.

The first Bulrush community contains orach, glasswort, sea blite with vigorous cordgrass, 30 cm in height, surrounding the pans and ponds. Bulrush is seen in the center of the pans where water remains ponded for long periods of time (Figure 3.11). This suggests brackish conditions within the pond (and pond water) and a highly saline substrate at the edge where the water level fluctuates frequently. It is only the presence of the bulrush that differentiates this community from the Glasswort community recorded at the pond margins.

Further inland, the second bulrush community contains fewer species than the first. Meadowgrass, cordgrass and glasswort are the only accompanying species. The depressions which this group surrounds are either water filled or dry and covered with meadowgrass debris, of depths up to 8 cm.

Although not reflected floristically, the third Bulrush community characterized by bulrush and meadowgrass, represents two distinct

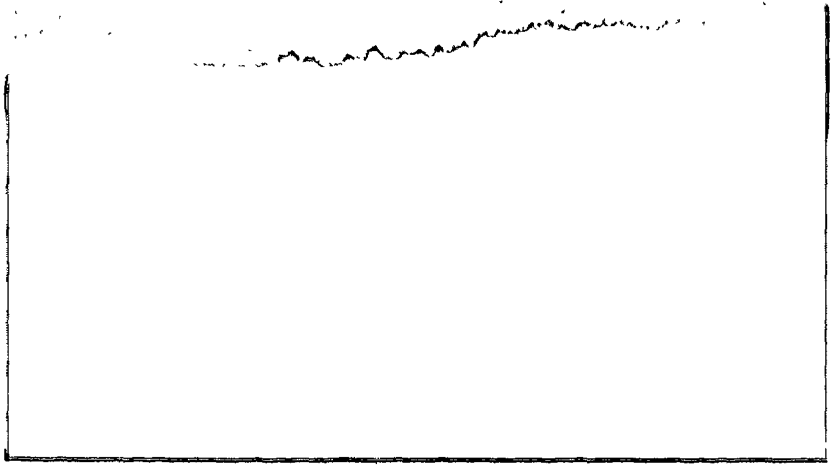


Figure 3.11: BULRUSH COMMUNITY, Brackley, P.E.I. July.

Salt marsh bulrush is found in the middle of salt ponds within the meadow. Its broad leaves and inflorescence contrast with the meadowgrass.

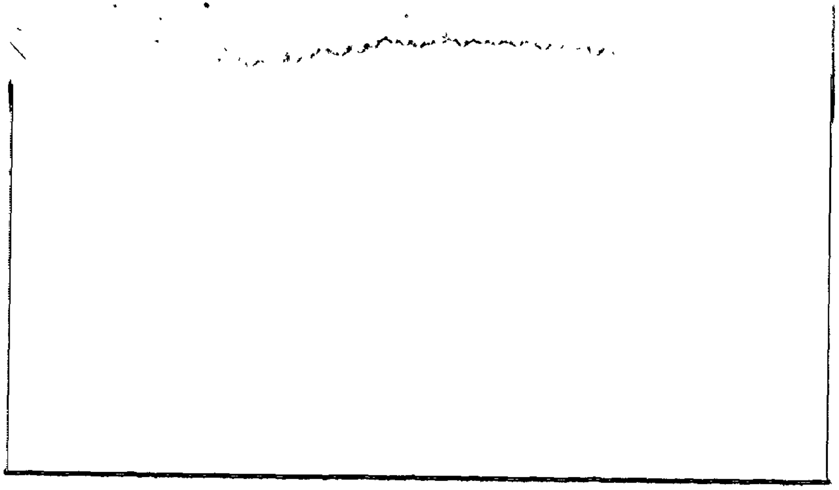


Figure 3.12: BULRUSH COMMUNITY, Brackley, P.E.I. July.

The Bulrush community can be found within the water-filled vehicle tracks.

habitats. The first, is linear, water filled pans produced by vehicle tracks deeply incised (13 cm) into the marsh surface (Figure 3.12). They are found between 215 m and 230 m from the shore. Further into the marsh, the bulrush intermixes with the meadowgrass. Patches, devoid of vegetation but blanketed with meadowgrass litter (up to 8 cm in depth) and occupying up to 45 percent of each quadrat, are associated with these sites.

3.2.2.9 Sedge

The Sedge community, characterized by *Carex paleacea*, silverweed, bentgrass, meadowgrass and, occasionally, sea milkwort, black rush and three square, closely resembles the Sea Milkwort II community in many respects. However, within this community, the sedge forms a dense stand, 10 to 20 m in diameter, with clearly defined boundaries. The Sedge community has a very limited distribution, as does the species. While it is only recorded from Brackley sites, field notes indicate minor presence at both Buctouche and South Beach.

Sedge is common in the upper reaches of the salt marsh, where the soil is more brackish. At Brackley, it is found mixed with the Milkwort community. Grandtner (1966) describes a Caricetum paleacea on les Iles de la Madeleine where soils are partly anaerobic.

Sedge is a variable species, hybridizing with other *Carex* species, but usually growing to less than 1 m in height (Fernald 1950). New growth occurs early in the spring, with rapid development and flowering occurring between June and August. By the first of June (observed 1980 & 1981) sedge had reached a height of 40 cm. This is very distinctive against the undeveloped meadowgrass (Figure 3.13).

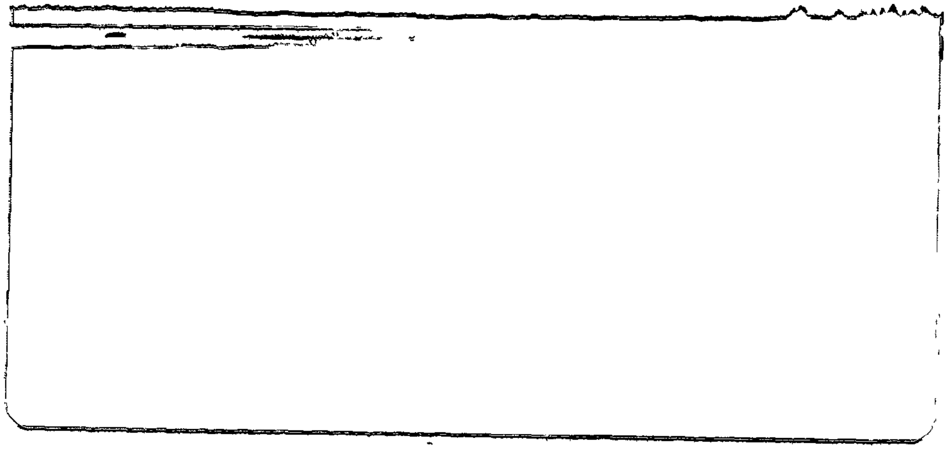


Figure 3.13: SEDGE COMMUNITY, Brackley, P.E.I. June.

Sedge is one of the first species to develop on the marsh in the spring. Meadowgrass is just beginning to show green, but by mid season the meadowgrass will dominate the marsh and the sedge will be an understory species.

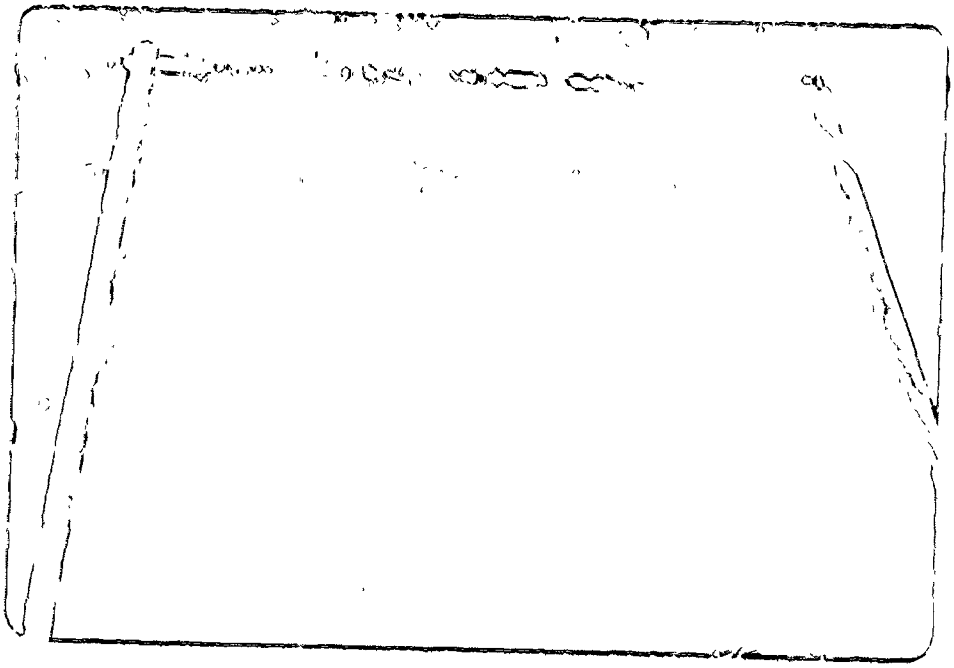


Figure 3.14: SEA MILKWORT COMMUNITY, Rustico, P.E.I. July.

Occasionally sea milkwort froms dense stands, as seen here.

3.2.2.10 Sea Milkwort

Two variations of the Sea Milkwort Community have been identified. The first is characterized by meadowgrass, sea lavender, seaside plantain and sea milkwort (*Glaux maritima*). Several additional species including three-square rush, seaside goldenrod and couchgrass are occasionally present. Recorded along virtually every transect, the Sea Milkwort I community is located immediately above the Meadowgrass community, often mixing with it in the form of ovoid patches up to 15 m in diameter. Occasionally, sea milkwort forms a monospecific stand several meters in diameter (Figure 3.14).

The second Sea Milkwort community contains similar species, with the exception of sea lavender. Bentgrass and sedge are two additional characteristic species. Distribution of the Sea Milkwort II community is limited to sites at Brackley where both milkwort units are recorded. In most cases, the second community is found at higher elevations.

While sea milkwort, a low-growing succulent perennial with inconspicuous pink and white blossoms, may often go unnoticed, the reduced meadowgrass density, common to both sites, combined with the upper marsh position, are good indicators. Similar to meadowgrass, Thomas (1969) has identified 86 and 96 percent as the mean lower and upper exposure limits for sea milkwort.

Bentgrass, *Agrostis alba*, is frequent only at Brackley sites within the Milkwort community. The species shows great variability in habitat and appearance. It is frequently found at upper levels of brackish and salt marshes, but is only visible when in flower. During the mid to late summer (June to September), the purple to bronze panicles are readily seen against the predominantly green marsh surface.

Minor differences exist in the composition of the Sea Milkwort community between Brackley and South Beach. At the latter site, meadowgrass is more dense and more frequent while sea milkwort occurs with greater frequency and density within the Brackley sites. Seaside plantain shows great variability and will be discussed further below.

In the Brackley marsh analysis one additional community, Fescue, has been identified, but only for four sites along the 2B Transect. These four sites so designated have been assigned, in the combined analysis, to the following communities: Sea Milkwort (2 sites), Plantain (1) and Black Rush (1). Neighboring sites have similarly been classified with these and the Baltic Rush communities. The species composition of individual quadrats is not in itself distinctive. However, their collective composition which is different from all other sites, combined with their position within the marsh demands a separate category for their description. These sites are all located on the lee side of low dunes, situated on the lagoon shore. Sparse marram and sea lyme grass top the dune crest. Immediately landward of this community, cordgrass and the associated pan communities are recorded. Component species include meadowgrass, sea lavender, red fescue, baltic rush, seaside goldenrod, sea milkwort and marram. This relatively narrow (19 m) and steeply dipping strip represents a condensed sequence of communities from the Meadowgrass through the Rush/Marram group.

This community, or sequence of communities, is not only influenced by normal tidal effects, but is also exposed to wave wash and salt spray.

3.2.2.11 Seaside Plantain

The Seaside Plantain community highlights the occurrence of seaside plantain (*Plantago* species) in combination with meadowgrass and sea lavender (Figure 3.15). With the exception of Buctouche 2A sites, this community appears to be composed of isolated sites representing minor variations in cover and composition of the Sea Milkwort community. At Buctouche, the Seaside Plantain community occupies a distinct zone.

Seaside Plantain, as defined herein, refers to two highly integrated species, *Plantago juncoides* and *P. oliganthos*. The two species exhibit great variability in leaf shape and length, depending upon their environment. The preferred substrate is waterlogged, although a wide range, from well drained sands to organics, is tolerated (Stuckey 1980b). Under optimal conditions, plantain forms a dense, 10 cm tall, grass-like mat. Elsewhere, individuals up to 30 cm in height, are found as scattered clumps throughout many of the preceeding communities.

Usually found near the upper limit of tidal influence, seaside plantain may inhabit salt pan edge sites and/or those under regular salt spray. Exposure limits of 86 and 96 percent have been recorded (Thomas 1969).

3.2.2.12 Black Rush

Two Black Rush communities have been identified. The first is almost exclusive to sites at Buctouche and appears to be a reduced community, containing only a fraction of the species occurring in the second. Along transects where two Black Rush communities have been identified, the second is always at a higher elevation than the first. The former

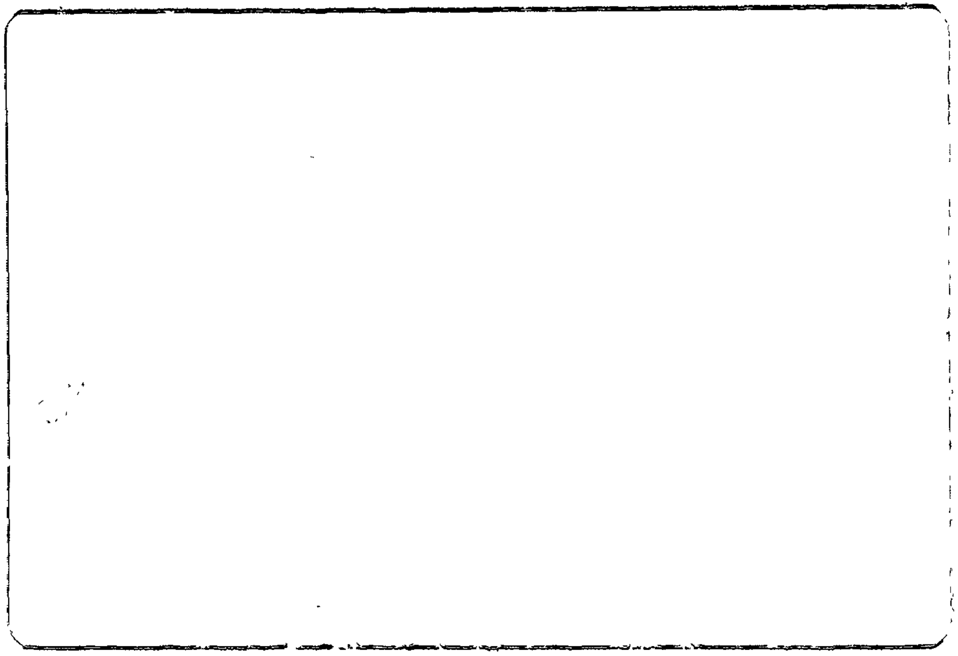


Figure 3.15: SEASIDE PLANTAIN COMMUNITY, South Richibucto Beach, N.B. August.

Like the sea milkwort, seaside plantain may be found in dense communities. Here it is seen with sea lavender.

Figure 3.16: BLACK RUSH COMMUNITY, Buctouche, N.B. July.

The Black Rush community, found fringing the low dunes, is very distinctive when flowering.

community is the typical form, recorded throughout South Beach.

The lower Black Rush community is characterized by three species, meadowgrass, goldenrod (*Solidago sempervirens*) and black rush (*Juncus gerardii*). The second community contains, in addition to the above, silverweed (*Potentilla anserina*), red fescue (*Festuca rubra*) and other grasses. Sea milkwort is also common, although it has limited cover, as does the meadowgrass. This composition reflects the drier and 'fresher' nature of the habitat.

The community distribution has two forms. The first form, occurring as isolated stands within and above the Sea Milkwort and/or Meadowgrass communities, has very limited cover. Individual stands are rarely more than 2 m in diameter. Elsewhere and more frequently, the Black Rush community forms a discontinuous fringe around the upper level of the meadow (Figure 3.16). The two variations of this community often but not always, reflect the two distribution patterns.

Black rush is most common just below the level of extreme high water (Stuckey 1978a). Mud or peat are the preferred substrates, although sand is tolerated. Where conditions are favourable, the slender, wiry stems may grow to a height of 90 cm. Flowering occurs in late June, followed by the appearance of seed clusters borne at the tops of stems. In late summer, the black rush zone has a reddish/brown appearance.

Red fescue is a polymorphous species, variants being dependent upon their habitat. Although the species is nearly the same height as the black rush, the red to green panicle, appearing in July, is very distinctive, as is the straw-coloured plant in the late summer (Figure 4.5).

The species identified herein as 'other grasses' refers to a number of grasses observed only in the juvenile state. Accurate identification was not possible, although it seems likely that one of the species was *Poa palustris*. The grasses were recorded as low growing (less than 10 cm), green to glaucous blades with a scattered distribution. Further identification is beyond the scope of this work.

Silverweed is a low growing member of the rose family, producing small yellow flowers in June and July. While the upper leaf surface is leathery green, it takes its name from the silvery appearance of the underside. This is highly conspicuous when ruffled by a slight breeze. Locally, where the substrate is sandy and the long stolons can run freely over the marsh surface, silverweed may form dense, monospecific stands (Figure 3.17) (Stuckey 1976a).

Like the other members of this community, seaside goldenrod is an indicator of the upper limit of saltwater influence. It is usually found just above the range of the highest tides (Erskine 1960) and while goldenrod cannot survive submergence for long periods, occasional wettings are tolerated (Johnson 1925). Thomas (1969) cites exposure values of 99.9 and 97 percent for seaside goldenrod at Bideford River, P.E.I.

3.2.2.13 Baltic Rush

In its typical form, components of the Baltic Rush community include seaside goldenrod, red fescue, other grasses, asters (*Aster* species), bindweed (*Convolvulus sepium*), clover (*Trifolium* species), freshwater cordgrass (*Spartina pectinata*) and silverweed, in addition to baltic rush, *Juncus balticus*. Two other Baltic Rush communities have been identified, one of which contains baltic rush, seaside goldenrod,

Figure 3.17: Silverweed, Buctouche, N.B. July.

Silverweed, a component of the Baltic Rush community, is sometimes recorded as a dense, monospecific stand. This is most common on sandy substrates.

red fescue and marram, with a few other occasional species, including bayberry (*Myrica pensylvanica*). The third Baltic Rush community contains rush, red top, clover, bayberry and some additional species.

The typical form, Baltic Rush I, is common throughout the study area as is Baltic Rush II. At sites where both forms occur, there is evidence to suggest that the latter is found at slightly higher elevations than the first. This would account for the increase in marram content. The third variant is specific to Brackley and predominantly 3B north where it is also identified as the Rush/Bayberry community. Forms I and II are usually seen fringing the dunes at the upper marsh border and grading into dune transition communities (Figure 3.18). Dune slacks and damp overwash sites are also common habitats. The third form is found largely in an artificially created slack between a high dune crest and steep-sided causeway. The low occurrence of typical halophytic species, including goldenrod, in addition to the presence of freshwater cordgrass suggest the marine influence at this site might be less than elsewhere. There is no ready access to tidal waters. Thomas (1969) has identified exposure limits of 97 and 100 percent for baltic rush on P.E.I. and sites from up to 40 m above sea level have been reported (Erskine 1960).

Baltic rush is a highly conspicuous species throughout the entire year. Between May and September, the flowers and eventually, the seed heads mature near the tops of the 1 m tall stalks, turning brown or black. In the early spring and late fall, the stalk itself appears black and whitish-grey in colour, respectively (Figures 3.13 and 3.19).

In the field, density of baltic rush is frequently overestimated when observed from afar. This may be attributed to its sparse

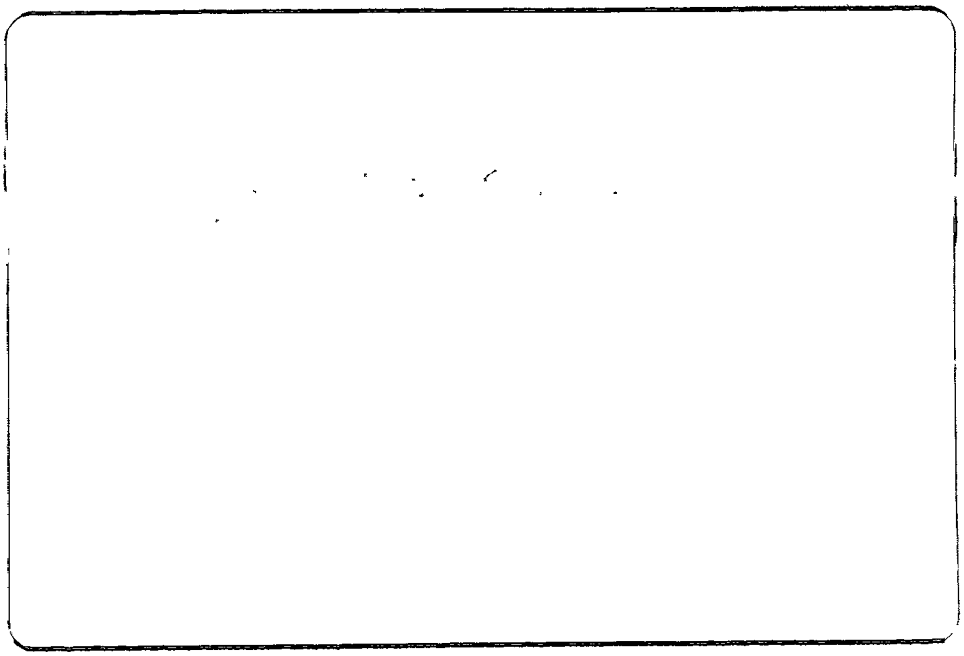


Figure 3.18: BALTIC RUSH COMMUNITY, Brackley, P.E.I. July.

The brownish-green rush community is common to dune slack and upper marsh habitats. At higher elevations this community grades into the Rush/Marram community.

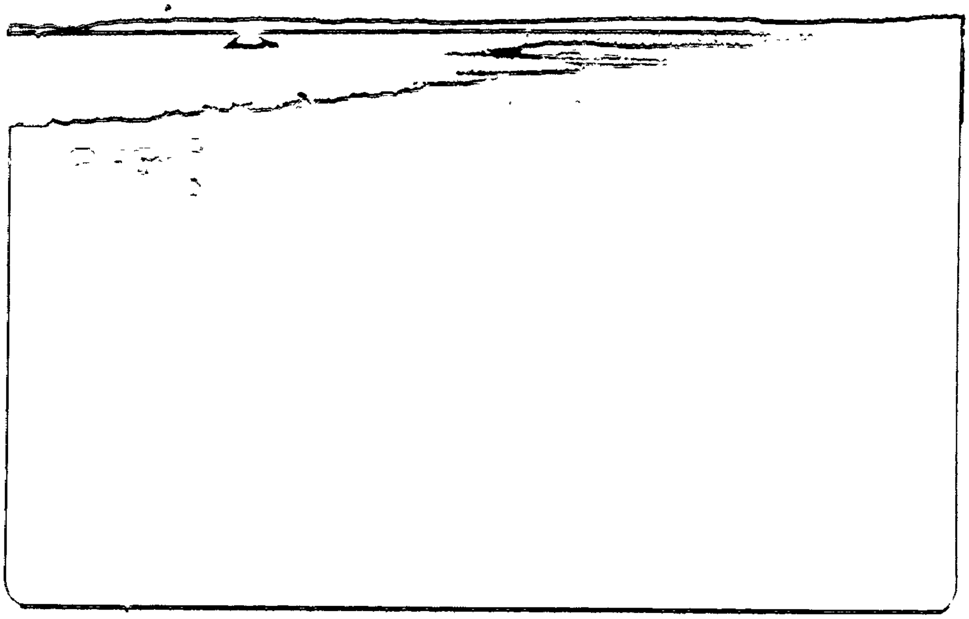


Figure 3.19: BALTIC RUSH COMMUNITY, Brackley, P.E.I. June.

In the early spring, the baltic rush stalks remaining from the previous year appear black. Note the water level during this spring high water (HHW) phase.

but regular distribution within a relatively narrow zone and its dark colour against the lighter green of dunes and meadow. Average density of the Baltic Rush community ranges between 60 and 97 percent, with density decreasing with height.

Aster species include A. *nova-belgii* and A. *laurentianus*, both highly variable and inconspicuous species. Clover incorporates a number of species as well, not differentiated for this study. Species include *Trifolium arvense*, T. *pratense* and T. *repens*.

Freshwater cordgrass, formerly *Spartina Michauxiana*, is frequently dominant over extensive areas at the heads of salt marshes. Generally the tallest widespread marsh species, it often reaches heights of 2 m when flowering during July to September. Thomas (1969) reports exposure limits almost identical to those for the baltic rush.

Bayberry is one of the few non-halophytic species common to the marsh zone. While the stiffly branched low (less than 2 m) shrub does not grow out onto the marsh within range of tidal inundation, it is frequently found mixed with the Baltic Rush community in dune slacks and minor depressions. The dark green leaves form a solid layer under and around which grow many of the low herbs, such as clover, asters and bindweed. Conditions here are favourable, in terms of moisture, nutrients and shelter, for growth of these species. The density and number of species recorded for communities containing bayberry (e.g., Baltic Rush III) are very much dependent upon placement of the quadrat at the time of sampling. A single bayberry plant could easily fill an entire 1 m^2 quadrat.

3.2.2.14 Rush/Marram

Two transitional Rush/Marram communities have been defined. Both contain marram (*Ammophila breviligulata*) and baltic rush in varying amounts. In the first community both species are approximately equal, whereas marram is obviously the dominant in the second group. The density of baltic rush is less than that found in the Baltic Rush communities. Rush/Marram I also contains sea beach sedge (*Carex silicea*), seaside goldenrod, clover and asters, to name the major associates. The other community contains several of these species, but only sporadically. Neither their frequency nor density is high. Average community density for both groups varies between 31 and 83 percent. The latter is representative of sites (predominantly at Brackley) where bayberry is recorded. Otherwise, most sites have a density of less than 50 percent.

Where the two communities are identified along a single transect (Buctouche and Brackley), the second is usually found at higher elevations, surrounding and topping low sandy dune ridges on the marsh surface. This transition community represents the uppermost limit of the salt marsh and saltwater influence. At higher elevations, typical dune vegetation (marram, beach pea, and sea beach sedge and occasionally, bayberry) dominates away from the influence of tidal flooding (Stuckey 1975a), (Figure 3.18).

The two Rush/Marram communities defined at Buctouche, correspond to those described here. However, the Rush/Marram group identified at Brackley is a composite of the two. Also incorporated into the Rush/Marram I is an additional community, Goldenrod, identified only at Brackley by the occurrence of seaside goldenrod, vetch, bayberry, clover and a few other of the more terrestrial species. This community is recorded only at one transect (4A) where, interspersed with dune communities, it occupies nearly the entire profile. The occurrence of orach within the community reflect its lagoon shore position.

The Rush/Marram I community identified at South Beach has been classified here with one of the Baltic Rush communities. This may be attributed to the greater density of baltic rush (compared to marram) and the frequency of seaside goldenrod.

3.2.2.15 Meadowgrass/Marram

The Meadowgrass/Marram community is a distinctive transition zone between marsh and dune vegetation. At most sites, the rush communities serve as a buffer zone between the halophytic meadowgrass and salt intolerant marram. Along transects where no rush community is observed, (e.g., Buctouche 2A, and South Beach 1A and 2A) this transition zone , containing meadowgrass, marram and red fescue, is recorded.

Elsewhere, it has been recorded in the lee of the low dune bordering the lagoon. Salt spray and occasional wave overwash are typical conditions at these sites. The presence of seaside goldenrod and plantain reflect the limited tidal influence.

3.2.2.16 Sea Lyme Grass

Two Sea Lyme Grass communities may be defined on the basis of the Buctouche marsh analysis. The first is identified by the presence of meadowgrass and lyme grass (*Elymus arenarius*) (Figure 3.20). This community is not defined in the total marsh classification. The second community contains marram, freshwater cordgrass and sea lyme grass and reflects the composition of neighbouring communities.

Figure 3.20: SEA LYME GRASS COMMUNITY, South Richibucto Beach, N.B. August.

The glaucous leaves of the flowering sea lyme grass are distinctive in comparison to the other marsh species. At this site, the Sea Lavender community occupies the shore position. Eelgrass debris mark two recent water lines. The wrack zone between the Sea Lavender and Sea Lyme Grass communities identifies the limit of higher high water.

Both communities are restricted to the low dune found on the lagoon shore, and neither occur over large areas or with high density (52 and 58 percent). Rather, the Lyme Grass community is distributed as a series of localized stands. The lyme grass always grows up to 1 m in height but its density varies greatly. Eelgrass is often rafted around grass stalks, having been carried in by high waves. Very little marram or lyme grass remains are visible on the surface, but can be uncovered at varying depths in the mobile sand.

Although the Sea Lyme Grass community was recorded only at Buctouche, its presence at South Beach and Rustico Island was noted. Its position and habitat never deviated from that described above.

3.2.3 The Typical Marsh Profile: A Discussion

The preceding community descriptions illustrate the variability of species, communities and their environments within the southern Gulf. While it is recognized that not all communities are ubiquitous, some degree of similarity between individual marshes is exhibited by many of the vegetation units. Based on this knowledge, the typical salt marsh profile for the southern Gulf of St. Lawrence can be derived.

The community hierarchy is illustrated in Figure 3.21. At the second level of division, three major groups can be identified. The fourth class contains but a single species, and can essentially be ignored for the purposes of this discussion. The differential species for the other three classes are as follows: *Spartina alterniflora* and *Salicornia europaea; Spartina patens* and *Glaux maritima;* and *Juncus balticus Solidago sempervirens*, other grasses, *Festuca rubra* and *Ammophila*

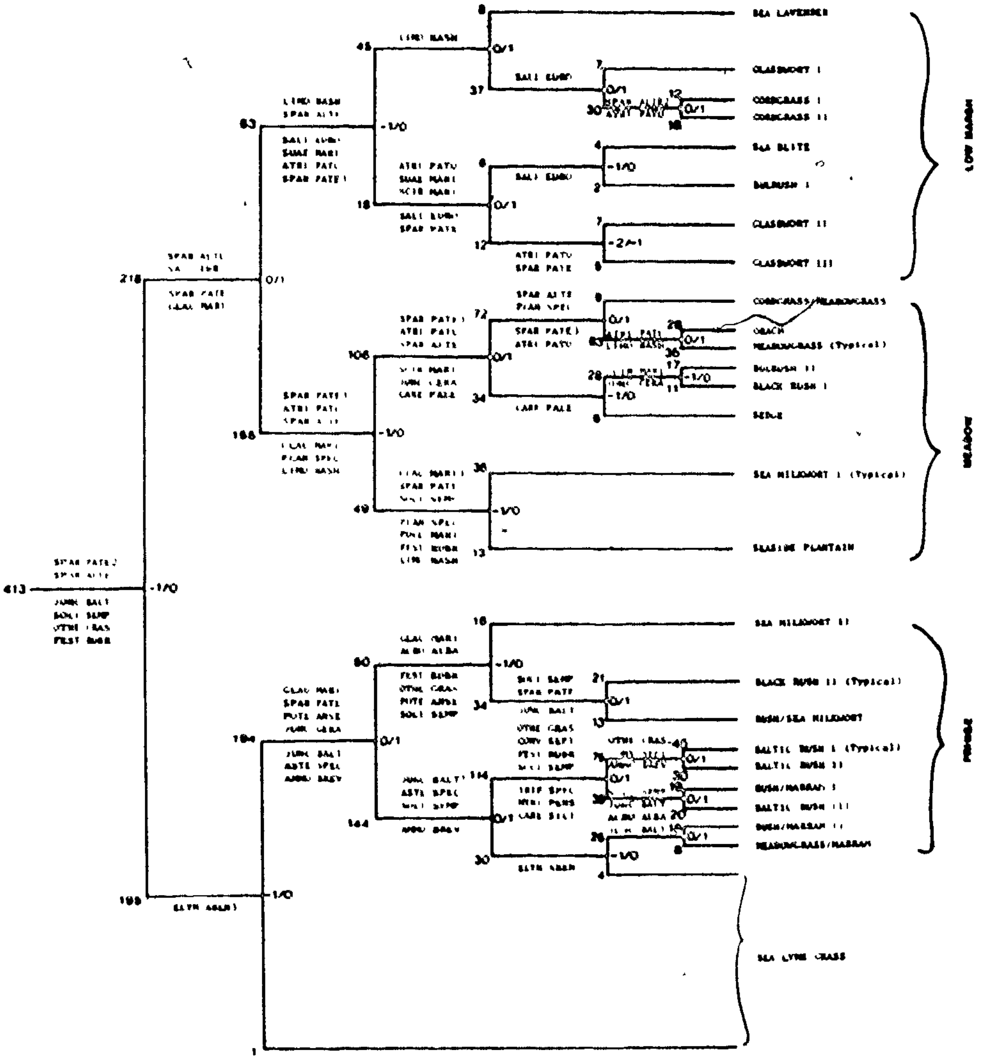


Figure 3.21: TWINSPAN Hierarchy for the marsh communities identified in the combined analysis. The three major groups identified at Level 2 roughly correspond to the three marsh zones as identified in the literature.

breviligulata. It is readily apparent that these zones correspond closely to those described in the literature. However, the level of detail provided here has not been previously described. Further, it might be assumed that the tidal levels associated with these three zones are the same as previously defined. This assumption can be tested by considering the distribution and composition of plant communities. For the purpose of clarity and further duscussion, these three zones shall be herein identified as the low marsh, meadow and fringe, respectively. No widely accepted, consistent terminology presently exists in the literature. The term 'marsh', shall refer to the entire vegetated intertidal zone. A fourth zone, not strictly part of the marsh, but frequently within its limits, is the dunelet, or low sand ridge situated on the lagoon shore. Its vegetation is unique and is represented by the fourth second level branch of the classification hierarchy.

The twenty-six communities described can be assigned to particular marsh zones, based on the hierarchial arrangement of the classification. The respective groupings are illustrated in Table 3.2. It should be noted that with few exceptions the communities derived from each of the three zones have been previously identified and associated (in the community descriptions) with each zone. The major exception, the Black Rush II (typical) community, is presented here as being similar to the Baltic Rush or fringe zone, whereas the occurrence of meadowgrass suggests otherwise. However, it is apparent from the composition of the community outlined in Table 3.2, that it has affinities to both the Meadowgrass and Baltic Rush communities. Its position at the boundary between the meadow and fringe reflects the vegetation.

Of the twenty-six communities, ten can be identified as typical of the three study areas, according to the near ubiquitous distribution and species similarity (composition). Salt pan and pond communities are defined largely by the Brackley data set. However, a 'typical' form is immediately apparent and will be considered an integral part of the marsh, within the low marsh zone. A more detailed discussion of salt pans and ponds follows in Section 3.4. Transition communities have been eliminated from the idealized profile model, with the exception of the Rush/ Marram community.

Figure 3.22 illustrates the four major marsh zones, the ten typical communities within them and the dominant species and frequency of each for the communities. Not all communities indicated will necessarily be found along any given profile. Rather, this is an idealized representation of the communities most likely to be observed and their profile position relative to each other and the tide levels. In some instances where more than one community requires a similar set of habitat conditions, these communities may all appear in close proximity or there may be a reduced number of communities recorded. The exact nature of the response ultimately depends upon the combination of environmental factors (e.g., substrate texture, exposure). These parameters were not sampled sufficiently in the present study to yield any definite conclusions regarding detailed community/habitat relationships. For example, the Sea Lavender and Cordgrass communities appear to be somewhat interchangeable. One or the other is usually present, although both may be recorded where the low marsh zone covers a wide area. A Glasswort community is characteristic of almost all salt pans. While the Bulrush community is occassionally observed in this habitat, its occurrence is insufficient to

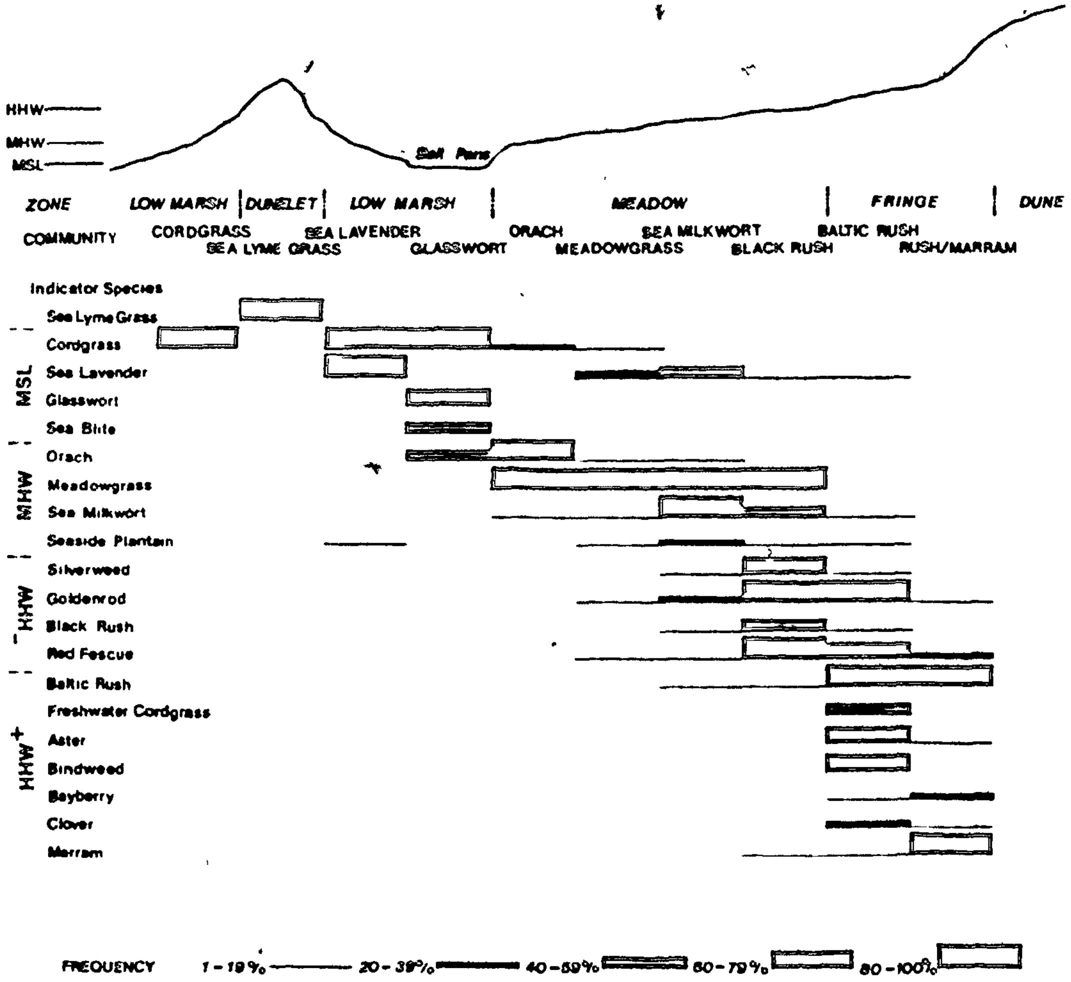


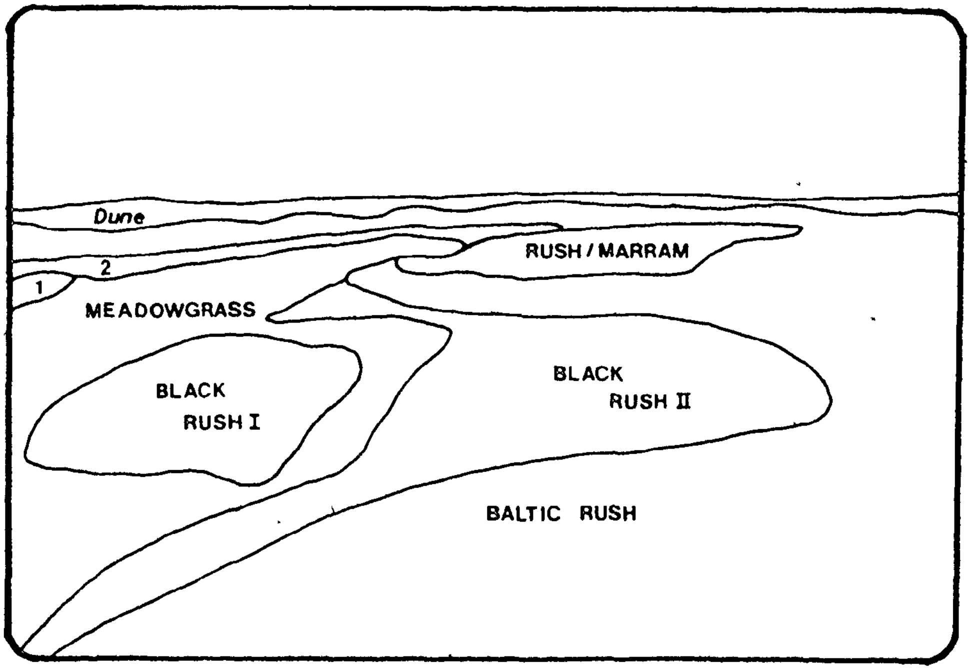
Figure 3.22: Schematic representation of a typical marsh profile for marshes within the southern Gulf of St. Lawrence study area. Communities and indicator species identified from TWINSPAN analysis. Species' heights relative to sea level were identified from a variety of independent sources. Frequency (percent) values were obtained from the Braun-Blanquet tables constructed from the collected data.

warrant its classification as a typical feature. The dunelet is frequently but not consistently observed at all marsh sites. Where it is recorded, the vegetation is typically Sea Lyme Grass. Within the meadow, the Meadowgrass community and either the Sea Milkwort or Black Rush communities, or both, are almost always recorded. While the Orach community is typical of salt marshes in this area, its distribution is generally more dispersed, forming small patches across the marsh surface. The fringe zone varies in width from less than a meter to many tens of meters and is rarely absent from a given transect.

Within each of the typical communities differential species are described, some of which have already been identified as tidal indicators. This information, from a variety of independent sources, will serve as a check on the tide levels indicated for each marsh zone (low marsh, meadow or fringe). The dunelet and its vegetation are not directly influenced by the tide and will not be considered in the discussion relating tide levels to communities. From the figure, it can be seen that the three dominant species (cordgrass, meadowgrass and baltic rush) have clearly defined limits, corresponding to the zones identified both by floristic analysis and in the literature. Specifically, the low marsh occurs above and below mean sea level, the meadow around mean high water and the fringe above the highest tides. Within each zone, communities are arranged in response to discrete tidal levels. In particular, the Black Rush community with its differential species, goldenrod, red fescue and silverweed, is found just below the level of the highest tides. Similarly, the differentials of the Rush/Marram community, marram and bayberry (typical dune species) intolerant of wetting by salt water, are seen only at the highest level.

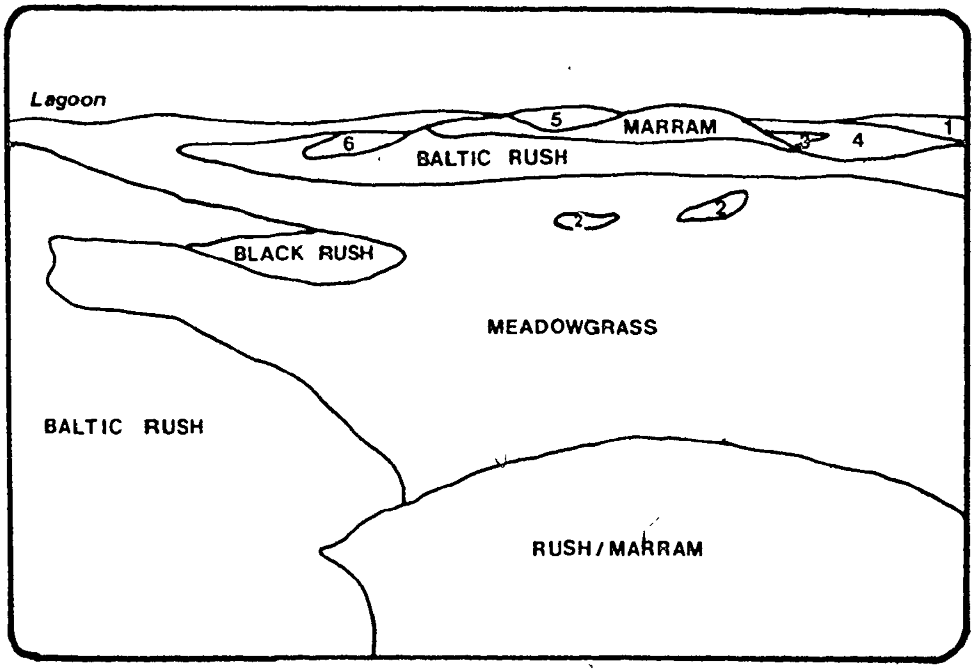
While the relationship between the typical communities and tide levels has been established it is still necessary to define the applicability of the typical profile to areas within the southern Gulf, not directly surveyed. Two independent checks can be employed to serve this purpose. From photographs, enlarged to ease visual interpretation, communities can be identified between the surveyed profiles (Figures 3.23 and 3.24). Between transects 1A and 1B at Buctouche, the Meadowgrass, Black Rush, Baltic Rush and Rush/Marram communities are evidenced. In addition, there appears to be two expressions of the Black Rush community, only one of which is dominated by black rush (Black Rush II). The other Rush community is identified on the basis of the component species (seaside goldenrod, silverweed and freshwater cordgrass) and its position on the profile (stands within the upper meadow). Figure 3.24, from South Richibucto Beach, illustrates similar meadow and fringe communities. However, fescue appears to be more prevalent in these Black Rush, Baltic Rush and Rush/Marram communities. An examination of the community ordinations for each marsh (Appendices B1.1 and B1.3) indicates similar fescue occurrence, at least at the surveyed sites. The apparent difference may be attributed to seasonal changes. The mature and flowering grass is more obvious in the late summer, when this photograph was taken.

A comparison of the 'typical' communities may also be made with the results of Thannheiser's (1981) study. Table 3.3 lists the marsh associations and their geographical limits as defined by Thannheiser (1981). Corresponding communities, identified by this study, are indicated as are those additional to Thannheiser's survey. Of the ten communities designated



1. BLACK RUSH I 2. BLACK RUSH II

Figure 3.23: A view of the marsh communities between transects 1A and 1B at Buctouche, N.B. Two Black Rush communities can be identified by their component species.



1. MEADOWGRASS
2. BLACK RUSH
3. BALTIC RUSH
4. RUSH/MARRAM
5. Bayberry
6. Scotch Lovage

FIGURE 3.24: A view of the marsh communities between transects 1A and 1B at South Richibucto Beach, N.B. In addition to the typical marsh communities, two dune communities dominated by bayberry and scotch lovage, are recorded.

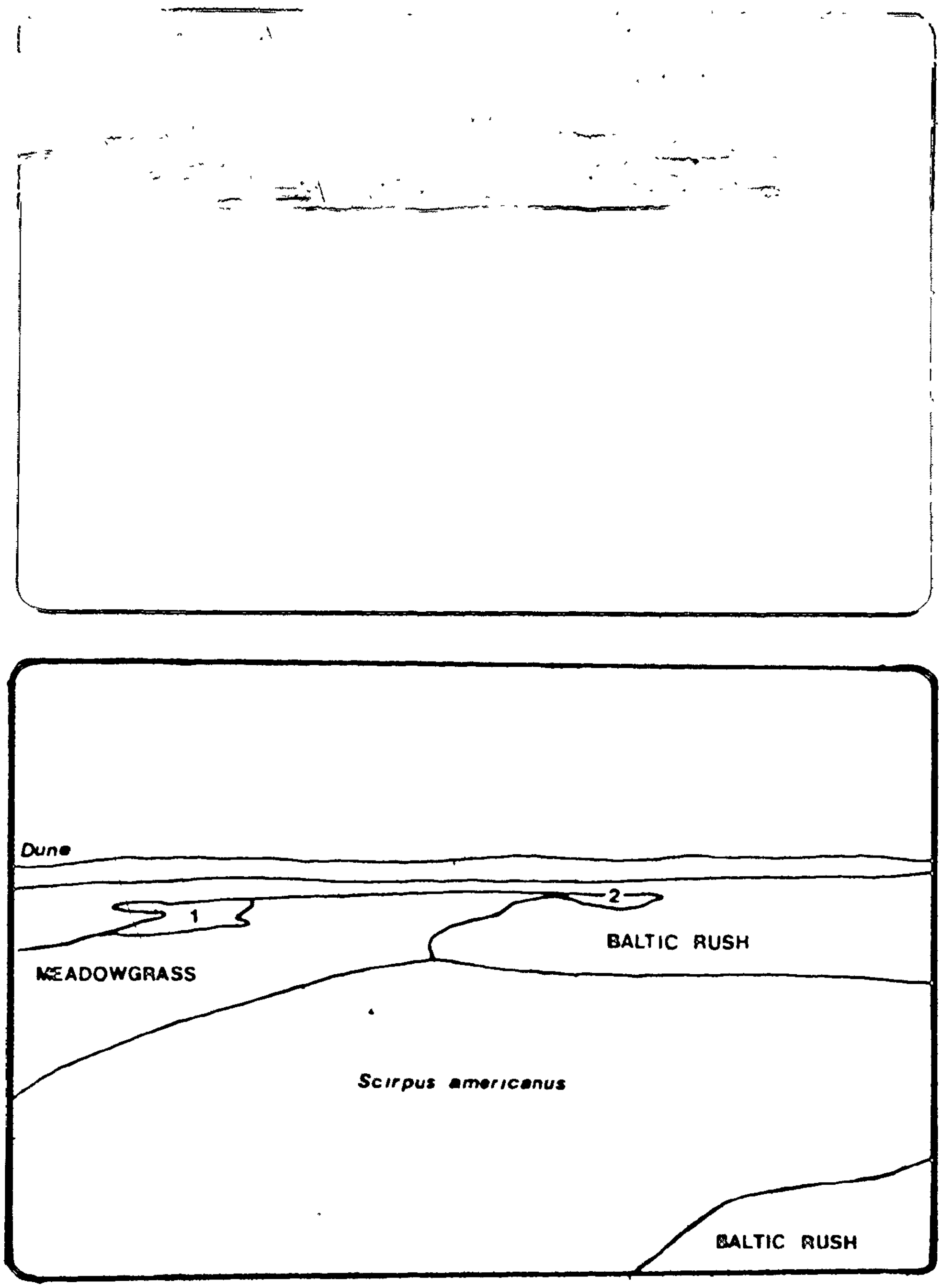
TABLE 3.3 : DISTRIBUTION OF SALT MARSH ASSOCIATIONS AND COMMUNITIES IN EASTERN CANADA. THE ASSOCIATIONS INDICATED (▶) CORRESPOND TO THOSE IDENTIFIED AND DISCUSSED WITHIN THIS STUDY UNDER THE COMMUNITY NAMES GIVEN AT LEFT. OTHERS (▷) WERE IDENTIFIED IN THE FIELD. THE EXTENDED RANGE AND COMMUNITY LIST IDENTIFIED BY THIS STUDY IS ALSO SHOWN (-----). (AFTER THANNHEISER 1981).

		S.W. New Brunswick	E. New Brunswick	Prince Edward Island	Nova Scotia	Magdalen Islands	Gaspe Pen.	Newfound-land	South Labrador
	Festuco-Caricetum glareosae							———	
	Puccinellietum coarctatae							———	
	Plantagini-Caricetum subspathaceae							———	
	Puccinellietum pauperculae							———	———
	Spergularietum canadensis							———	———
	Ranunculetum cymbalariae						———	———	
	Triglochinetum gaspensis						———	———	———
	Caricetum salinae						———		
	Scirpetum rufi					———	———	———	
	Distichlidetum spicatae				———				
	Eleocharitetum halophilae				———	———	———	———	
	Caricetum mackenziei				———	———		———	———
	Eleocharitetum parvulae				———	———	———	———	———
	▷ Zosteretum marinae		-----	———	———	———	———	———	
	▷ Ruppietum maritimae		———	———	———	———	———	———	
GLASSWORT	▶ *Salicornia europaea* - Ges.		———	———	———	———	———	———	
	▷ Limonietum nashii		———	———	———				
	Puccinellietum americanae		———	———	———	———			
	Puccinellietum ambiguae	———			———	———	———	———	
MEADOWGRASS	▶ Spartinetum patentis	———	———	———	———	———	———		
~~ORACH~~	▶ Typishe subassoziation								
	▷ Scirpetum americani	———	-----	———	———	———	———	———	
CORDGRASS	▶ Spartinetum alterniflorae	———	———	———	———	———	———	———	
BLACK RUSH	▶ Juncetum gerardii	———	———	———	———	———	———	———	
SEASIDE PLANTAIN	▶ *Plantago maritima* - Ges.	———	———	———	———	———	———	———	———
SEA MILKWORT	▶ Ausbildung mit *Glaux maritima*								
SEDGE	▶ Caricetum paleaceae	———	———	———	———	———	———	———	———
SEA LAVENDER			-----	-----					
SALT MARSH BULRUSH			-----	-----					
BALTIC RUSH			-----	-----					

as typical of the southern Gulf, six directly correspond to associations, sub-associations or communities previously defined.

Of the remaining associations identified by Thannheiser (1981) but not considered here as typical communities, four have, in fact been either identified or described. The Caricetum Paleaceae corresponds to the Sedge community identified only at Brackley, transect 2B. Thannheiser's (1981) *Plantago maritima* - Gesellschaft is similar to the Seaside Plantain community, identified separately but here considered a variant of the Sea Milkwort community. Within the Meadowgrass community, a variation defined by sea lavender and meadowgrass was noted although not classified as a separate community. This appears to be very similar to the Limonietum nashii identified by Thannheiser (1981). The aquatic association dominated by *Zostera marina* (Zosteretum marinae) is, in fact, a community characteristic of the southern Gulf of St. Lawrence, although it is not so considered here, owing to its subtidal habitat. Similarly a *Ruppia maritima* dominated community was identified in several salt ponds at Brackley, although these sites were not sampled. While a community dominated by *Scirpus americanus* was not identified in this analysis, visual inspection of colour photographs reveal its presence at Buctouche, near transect 1B (Figure 3.25). That Thannheiser (1981) does not recognize this association in eastern New Brunswick, although it has been observed, suggests that the distribution of individual stands is limited, but is more ubiquitous than previously described. A similar reasoning may be put forth to explain the distribution of other communities identified only locally, such as the Bulrush and Sedge communities.

Two communities not defined by Thannheiser, but designated here as characteristic of eastern marshes are the Sea Lavender and Baltic



1. *Scirpus americanus* 2. Bayberry and marram

Figure 3.25: A community dominated by *Scirpus americanus* was identified from this photograph near Buctouche 1B. This community was not sampled and therefore, not included in the community analysis.

Rush. While the former is recorded covering large areas only at South Richibucto Beach, the latter is common to all of the study areas. According to the literature, the Baltic Rush community has also been identified throughout the southern Gulf and New England.

Although included as part of the typical marsh profile, the Sea Lyme Grass and Rush/Marram communities are not true marsh communities. Thannheiser (1981) does not define either within the salt marsh context, however, the former is considered part of the coastal dune sequence. Sea lyme grass has been identified as a key species in the initiation of dune-building processes (Thannheiser 1978). This statement is fully supported by the results of this study. Sea lyme grass was never seen within dune or sand flat areas; its occurrence was restricted to small stands on the dunelet at the lagoon shore. The Rush/Marram community represents the upper limit of the salt marsh. While tidal waters rarely, if ever, penetrate into the marsh sufficiently to directly flood this community, water table fluctuations, controlled by the tidal regime are a major influence in the upper fringe communities (Ranwell 1972).

In comparison with Thannheiser (1981), only one association, the Puccinellietum americanae, or its equivalent, was not recorded in the present study. Throughout the study area, all *Puccinellia* species were recorded less frequently than indicated by the literature. The reason for this is not immediately apparent.

Further investigation regarding the distribution of communities is required for evaluating the typical marsh profile derived here. This will be attempted in Chapter 4, using air photo interpretation techniques to extend the surveyed data and classification over a wider area and back through time.

3.3. RELATION TO THE TIDE

The relationship of certain marsh zones, plant communities and their component species to different tidal levels has been established (Section 3.2). As a check on the reliability of such interpretations, tidal measurements can be compared directly with community distributions. In the following discussion, all heights are given relative to mean sea level.

Variations in community heights have been observed between the Atlantic and Pacific coasts of North America (Reimold 1977). Two factors, tidal regime and substrate composition, have been identified as the mechanisms controlling differences in marsh boundary placement (Gross 1972). Atlantic coastal marshes are subject to a semi-diurnal tidal regime, whereas the Pacific coast and the Gulf of St. Lawrence (Godin 1980) are diurnal and mixed tides. It has been suggested that this difference accounts for much of the community height variation (Frey & Basan 1978).

Substrate composition is a more significant factor on a local scale (Frey and Basan 1978). Low marsh species favour the wetter conditions associated with a low profile position or muddy substrates. Meadow plants prefer drier substrates, also characteristic of rapidly draining sands. Locally, marsh communities may trade their normal profile position, indicative of inundation frequency, for more preferable substrate conditions. Where substrate composition shows little variation, such as within the predominantly sandy study area, tidal effects alone can be inferred as the major control and may be assessed accordingly.

3.3.1 Tidal Observations

In order to compare community position in eastern New Brunswick and northern Prince Edward Island, tidal differences need to be considered. Table 3.4 illustrates the tide levels relative to chart datum and mean sea level for the tidal gauges nearest to the study areas. While it is apparent that heights are similar at all three stations, the diurnal nature of the tide at Crossman Point needs to be noted. The frequency of inundation at any given height will be less under this circumstance than at sites controlled by the mixed, mainly diurnal, tides at Rustico. The actual length of time a specific height is flooded depends upon the shape of the tidal curve. This will be further discussed elsewhere.

Between the tide gauge and the marsh itself, the tide will be changed in terms of amplitude and phase. In this area, tide gauges are located in the inlets. Thus, as the tide propagates through the inlets and lagoons towards the marsh, the times of high and low water become progressively later. The actual lag time is a function of distance from the gauge, tidal range and length of time over which the rise and fall occurs (Greenwood & Davidson-Arnott 1977). At high tide the lag effect is minimized; at low tide it is maximized. Because the phase speed or celerity increases with increasing depth, these tendencies are accentuated under spring (large) tide conditions. Within a 2 km segment of the Kouchibouguac system, phase lags of one and a half hours and four to five hours were recorded for high and low water respectively (Greenwood & Davidson-Arnott 1977). Marked differences in tidal height are observed at sites away from the gauge, especially where coastline or channel conditions vary. Along the lagoon side of each barrier or bar segment, from

TABLE 3.4 : TIDAL RANGE AND WATER LEVELS FOR TIDE GAUGE AND CORRESPONDING REFERENCE PORT, NEAREST TO EACH STUDY AREA. HEIGHTS (METRES) ARE EXPRESSED RELATIVE TO BOTH CHART DATUM AND MEAN SEA LEVEL.

	Mean Sea Level (MSL)	Mean High Water (MHW)	Higher High Water (HHW)	Range (Large Tide)
SHEDIAC BAY, N.B.	1.0	1.4	1.5	1.6
	0	0.4	0.5	
Crossman Point	0.76	1.16	1.50	1.16
	0	0.4	0.74	
RUSTICO, P.E.I.	0.54	0.9	1.2	1.1
	0	0.36	0.66	
Richibucto Bar	0.55	0.99	1.29	1.07
	0	0.44	0.74	
Brackley*	0.27	0.45	0.60	
	0	0.18	0.33	0.50

* Derived from Rustico curve with 0.5 range ratio.

the inlet or baymouth to the attached end, progressive changes in tide levels can be expected, the result of shallow water effects. As the tide is propagated along and through the constricted channel, energy is lost partly due to friction with the bottom. This is most noticeable where the channel has been vegetated with eelgrass (*Zostera marina*). In a landward direction, the following trends can be identified:

1) tidal range will decrease;
2) the decrease will be disproportionate around mean sea level as frictional effects and, hence, loss of energy will be more pronounced at lower water levels; and
3) the resultant mean sea level may show a slight increase in height, relative to a common datum.

Within each of the three marshes, similar height ranges for each community are expected. However, along each barrier, trends mimicking those described above for tidal height variations should be observed. Specifically:

1) community sequences will be more compacted (as the tidal range is less);
2) species normally found above mean sea level will be recorded at lower elevations, and those below mean sea level will be observed at higher elevations (relative to a common datum); and
3) species or communities usually found at mean sea level will be recorded at higher elevations.

Ranwell et al. (1964) reported variations of this sort within the *Spartina angelica* community in the Dovey estuary.

Tables were constructed to compare community heights at each transect (Appendix B4). Between marshes, heights of similar communities showed little agreement. However, within each system, the recorded heights for many communities did overlap between transects. Trends of decreasing community heights and overall range were noted, but were inconsistent and highly erratic. Had the original transects been selected to represent similar community structures, more clearly defined trends would be expected.

The internal similarity at each marsh suggests the lag and height differences within each barrier are less than those between the marsh and nearest tidal guage. All observations are dependent upon the calculation of tide height from the surveyed water level. Where a significant phase lag occurs and has not been accounted for, all tide levels, relative to mean sea, will be incorrect. Within each barrier, similar lag conditions will influence all water level measures in the same manner.

An estimation of tidal conditions at Brackley, better than those predicted from the Rustico curve, is available. A 2.5 hour lag was observed during the spring flood period at transect 2B. Under ebb conditions a similar lag of 2 hours was recorded, along with a reduction in tidal range by one half (McCann 1978). The corresponding tide levels calculated with the .5 range ratio are given in Table 3.4. The lack of replicate communities at Rustico/Brackley sites prevented comparisons; however, the range ratio correction will be considered further and applied in association with the exposure curve analysis.

3.3.2 Exposure Curves

An alternate approach to direct height comparison of species or communities, is the calculation of emergence (percent) limits through the construction of exposure curves. Based on tidal predictions, the percentage exposure for all intertidal levels can be determined by summing exposure times for unit increments. These results are expressed as a percentage of the total time.

Exposure curves have been constructed for Rustico/Brackley, Buctouche and South Richibucto Beach using hourly tidal predictions for each .005 m increment (W.P. Budgell, pers. comm.). Both the predicted and observed tide levels for July, 1978, are shown for Brackley (Figure 3.26). The latter indicates water levels higher than predicted, reaching a maximum of 0.04 m between exposures of 60 and 70 percent. This could be attributed to normal storm and/or wind activity for July; no abnormal weather activity is indicated for the month (Environment Canada 1978). The observed values will be used for all subsequent analyses. The exposure curve for South Richibucto Beach is very similar to Brackley and will not be considered separately. The curve produced for Buctouche (Crossman Point) is shown in Figure 3.27, calculated using range ratios of both 1.0 and 0.5. This latter value is the range ratio between Brackley and the Rustico gauge, and is considered here for comparison only. At this time, there is no evidence to support the validity of this approximation. No correction for phase lag or range is considered further. The Crossman Point curve is nearly linear between the end points. In comparison the Brackley curve, corrected for the 0.5 range ratio (Figure 3.26), is distinctly steeper, attributed to its smaller tidal range. In comparison to Buctouche, the Brackley curve indicates drier, more exposed conditions at heights greater than -0.5 m to mean sea level. At lower elevations, conditions will be more flooded. The implication is that species characteristically found at the higher elevations, may be recorded at lower than normal heights. Similarly, low marsh species may be seen at higher elevations when compared to Buctouche.

Both community and species height limits can be plotted onto the exposure curve, to identify the corresponding exposure limits. Data of this type can be compared directly for different marshes under a variety of tidal regimes. Under similar conditions, height data are not directly comparable.

Major plant communities for Brackley (Transect 2B) have been plotted in Figure 3.28. Upper and lower limits for each community are defined by profile data and displayed with the mean height intersecting the exposure curve. Further, tidal heights, (mean sea level, mean high and higher high water) are superimposed. In comparison with these tide levels, the following community/height relationships are evident. The mean elevation of the Cordgrass, Meadowgrass and Baltic Rush communities correspond to within .005 m of the calculated mean sea, mean high, higher high water levels respectively. While this agreement is better than anticipated given the number of unknowns and uncertainties, it is consistent with the relationships identified from the literature.

Further testing of this approach is required to firmly establish these and other tide level/community relationships. The results, so far, are based upon observations made over only part of one tidal cycle, and are specific to the Brackley 2B site. Without range ratio measures for South Richibucto Beach and Buctouche, similar analyses are futile.

A comparison of individual species found along the profile is given in Table 3.5. The limits defined by the communities are, in most cases, more compact than those of the species. The spatial dispersion of the species is also reflected in community composition.

When compared to other data sets (Thomas 1969; Johnson & York 1915) similar exposure values for many species are evident. The greatest discrepancy is noted in the lower limits of the annual species, often but

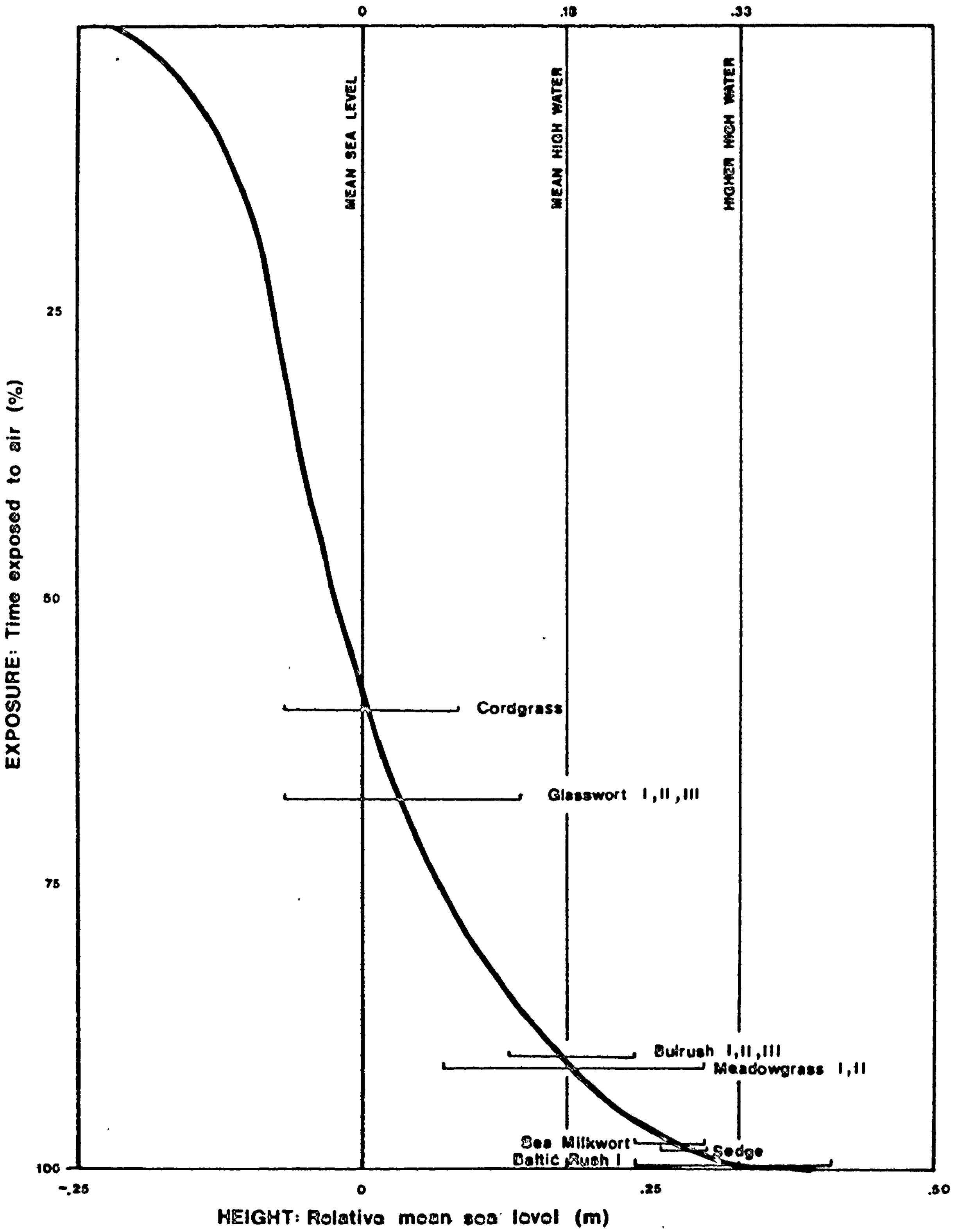


Figure 3.28: Height ranges of major plant communities from the Br~~ackley~~ Marsh 2B transect plotted against the exposure curve for July 1978. MSL, MHW and HHW are shown at the appropriate heights.

TABLE 3.5 : A COMPARISON OF PERCENTAGE EXPOSURE LIMITS FOR COMMUNITIES AND SPECIES RECORDED AT BRACKLEY MARSH (TRANSECT 2B), P.E.I., BIDEFORD RIVER, P.E.I. AND COLD SPRING HARBOR, MAINE.

	COMMUNITY Species	BRACKLEY MARSH, P.E.I.				BIDEFORD RIVER, P.E.I.[1]		COLD SPRING HARBOR, ME.[2]	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
LOW MARSH	CORDGRASS	28.9	77.6						
	Cordgrass			28.9	95.7	18.5	88.0	32.6	78.1
	GLASSWORT I, II, III	28.9	85.8						
	Glasswort			28.9	92.9	93.5	97.0	70.3	74.1
	Sea Blite			39.1	85.8	84.3	97.0	78.1	95.9
	Orach			74.5	95.7	95.0	99.0	72.5	98.8
MEADOW	MEADOWGRASS I,II	74.5	98.7						
	Meadowgrass			74.5	100.0	88.0	99.2	78.1	97.7
	Seaside Plantain			80.5	98.7	86.0	96.2	-	-
	Sea Lavender			85.8	98.7	79.8	98.2	-	-
	BULRUSH I, II, III	84.8	96.1						
	Salt Marsh Bulrush			84.8	96.1	-	-	-	-
	SEA MILKWORT	96.1	98.7						
	Sea Milkwort			96.0	100.0	86.0	96.2	-	-
	Three Square Rush			96.0	98.7	63.0	93.3	74.1	100.0
	Black Rush			96.1	98.4	-	-	-	-
	SEDGE	97.2	98.7						
	Sedge			96.8	100.0	-	-	-	-
FRINGE	BALTIC RUSH	96.1	100+						
	Baltic Rush			96.8	100+	98.2	100.0	-	-
	Red Fescue			96.1	100+	-	-	-	-
	Seaside Goldenrod			80.0	100+	97.0	100.0	98.9	100.0

[1] Thomas 1969

[2] Johnson & York 1917, in Thomas 1969

not always associated with salt pans. Under normal conditions, specific boundaries of these species are likely to vary from year to year. Thomas (1969) attributed the higher position of meadowgrass at Bideford River to the harsh winter climate. In particular, ice scour of the exposed vegetative parts limits the lower boundary. The Brackley data do not follow this trend. More transects, accompanied by good tidal data, are required to derive precise limits for comparison within and between marshes.

3.4 SALT PANS AND PONDS

3.4.1 Formation, Morphology and Classification

Salt pans and ponds are a distinctive feature found on the surface of most salt marshes. The circular to linear denuded, and sometimes waterfilled, depressions represent a unique habitat. As such, they are colonized by highly specialized communities, tolerant of the extreme conditions found here. After a flood tide, water remains within the pan for some time, draining slowly through the surrounding vegetal mat (Chapman 1974). During summer periods when evaporation is intense, this water and eventually the substrate can become highly saline. Precipitation periodically flushes the pan with freshwater, a short-term condition which remains only until the next high tide.

It is only the edges of salt pans that are normally colonized. Here the water level fluctuates regularly and conditions may duplicate those of the marsh creek environment. Similar species often occupy both the creek bank and pan habitats, frequently displaying a distinctive zonation reflecting moisture, salinity and substrate variations over a very narrow area. Occasionally pans remain waterfilled between high tides.

This is especially common within the meadow where the thick root and litter mat precludes adequate drainage. These ponds are often colonized by the same species as the salt pans, with additional species, tolerant of waterlogged conditions, within the pond.

Many hypotheses have been advanced to explain the formation of salt pans and ponds. This has contributed to a confusing and sometimes inconsistent nomenclature for these features. Table 3.6 illustrates an attempt to provide, for them, a systematic and comprehensive morphogenetic classification. Pertinent characteristics and attributes have also been summarized. This classification consists of two major groups; primary and secondary forms. All primary pans are those whose formation is contemporaneous with the development of the marsh. They are found within the low marsh and meadow zones and may be either permanent or short-term marsh features. Secondary forms are those created by the destruction or removal of established vegetation. This is controlled by a number of natural and man-induced processes. Two of the forms, residual and erosional/depositional have elements of both primary and secondary processes. However, since in both cases is the initial process, they will be grouped with other primary forms.

It is recognized that the above nomenclature conflicts with the classification originally proposed by Yapp and Johns (1917) which is currently in common use. Their terms, primary and secondary refer to the two marsh levels, similar to the upper and lower or high and low marsh levels defined elsewhere (Chapman 1974). Pans created by similar mechanisms are identified by the marsh level (either primary or secondary) with which they are associated. As this terminology has not been widely

TABLE 3.6 : SUMMARY OF SALT PAN TYPES AND CHARACTERISTICS

	Position			Shape			Persistence		
	Low Marsh	Meadow	Fringe	Circular	Linear	Irregular	Temporary	Permanent	Variable
PRIMARY									
Depression--Simple	x	x		x					x
-Compound	x	x		x		x			x
Channel	x	x			x			x	
Depositional/Erosional	x	x				x	x		
Residual	x	x		x		x	x		
SECONDARY									
Rotten Spot-Depression		x		x		x			x
-Cowlick		x	x	x		x			x
-Trash	x	x	x			x			x
Ice Scour	x	x			x	x			x
Vehicle Track	x	x	x		x			x	

applied to North American marshes, its use in this context could be confusing. The definitions of primary and secondary here are offered as an alternative nomenclature.

Primary depression pans are those created as a result of irregular colonization across the intertidal zone. Differential deposition of marsh sediments reinforces the boundaries of the bare areas. During periods of high water, small eddies form within the shallow depressions on the flood. This produces the characteristic, circular shape (Yapp & Johns 1917). Where two or more simple pans coalesce, compound forms result. Depression pans are most common within the marsh but can exist as remnants well into the meadow.

Channel pans are those created by blocked drainage channels within the meadow. This is frequently accomplished by undercutting and subsequent slumping of the creek sides (Redfield 1972).

At the seaward marsh edge, a low cliff sometimes develops, primarily where the substrate is sandy. As the area below the step is colonized (Yapp & Johns' 1917 secondary marsh) erosion and subsequent deposition of wave-washed turf materials from the cliff edge, impound tidal waters. These irregularly-shaped erosional/depositional pans correspond to some of the secondary pans described by Yapp and Johns (1917).

Residual pans are those which have been partially colonized, followed by renewed pan development (Chapman 1974). These salt pans are most common where vegetation includes species which propagate vegetatively, predominantly grass, rush and sedge species. The distribution of annuals, such as glasswort and seablite, varies from year to year. It is unlikely that these species will be involved in pan subdivision, although they may colonize locally.

Chapman (1974) offers three possible mechanisms for the creation of rotten spot pans. First, it is suggested that minor depressions in the marsh surface retain water and through excess salinity or substrate waterlogging, kill the existing vegetation. Alternatively, densely matted patches of marsh grasses, create cowlicks, which eventually kill and retard the growth of the underlying vegetation. This effectively causes a depression in the marsh surface, forming an embryo pan. Cowlick pans are most common within the typical meadowgrass association, although the black rush community may also become similarly matted.

Trash pans were originally described by Warming (1904, in Yapp & Johns 1917) as those created by formation of 'weak spots' within the marsh vegetation, beneath eelgrass or algal litter. Yapp and Johns (1917) considered this method of minor importance in the Dovey Estuary. However, Redfield (1972) recognizes their occurrence in New England, north of Virginia. Litter material is thought to remain on the marsh surface after snowmelt, or to be washed in by high water. In the latter case, Miller and Egler (1950) claim tidal litter on Connecticut marshes disintegrates before degradation of the undergrowth occurs. However, Ranwell (1964) and Packham and Liddle (1970), both working in Britain, have found evidence that the litter deposited early in the season remains for sufficient time to cause destruction of the marsh vegetation.

Pans created by ice scour have been documented in northeastern North America (Gauthier 1978; Redfield 1972). Dionne (1968) also reports scour depressions up to 50 cm deep, on the low marsh surface in the St. Lawrence estuary. While these pans are most evident on the sparsely vegetated low marsh surface, material from the lower meadow boundary may be eroded and deposited onto the low marsh in much the same manner as the wave eroded erosional/depositional form. This process has been observed in sub-Arctic marshes (W. Glooschenko, pers. comm.). In Prince Edward Island, Thomas (1969) suggested that the lower boundary of the meadowgrass, is controlled by the winter ice limit. Meadowgrass is not usually found within the zone of ice scour, where its exposed vegetal matter would be or had been damaged.

The final type of salt pan is anthropogenic in origin and not previously documented. Vehicles driven across the soft marsh surface can create deep linear channels, which may persist for years. These pans are, for the most part, restricted to the meadow and fringe where a deep vegetal layer provides a firm surface upon which to drive.

It is apparant that salt pans and ponds may have a complex history. More than one of the above mentioned mechanisms may influence the formation of any given pan and it is often difficult to identify the precise sequency of events. Ultimate pan shape and position within the marsh may offer clues, although the position changes with the development of the marsh itself. Some of the pan types are temporary in nature, eventually becoming colonized. Many others persist for long periods depending upon depth relative to the marsh surface, drainage conditions and potential colonizing species. Through time, environmental conditions within the marsh are apt to change and may alter pan occurrence.

In a study of salt pans on the north Norfolk coast, Pethick (1974), found pan density to be positively correlated with marsh height and negatively, with distance from the sea. In light of this, the original explanation of pan formation as simple depression types does not appear to be exclusive. While causal factors cannot be ascribed to the relationships derived, the rafting of litter material by high water, is a plausable explanation.

3.4.2 Brackley Marsh: A Case Study

A major occurrence of salt pans and ponds was recorded at Brackley Beach, 2B. In all, eight different types of salt pans were identified, which display five different salt pan communities already discussed in Section 3.2. At that time, it was recognized that the pan communities were arranged in sequence along the profile, implying a relationship to distance from salt water and height, relative to mean sea level. While the different salt pan types could be identified from field notes, distribution was more easily interpreted from large scale aerial photographs.

The eight pan types and their relevant characteristics can be summarized as follows:

(i) Depression Pans: Simple: Simple pans are small scale features and cannot generally be identified on aerial photographs. However, within the low marsh, well defined barren near circular depressions, bounded by dense cordgrass and occasionally glasswort were recorded (Figure 3.29).

Compound: Coalescing pans with poorly defined boundaries cover much of the low marsh. This form grades with the simple and ice scour pans. Unless obviously produced by ice scour, it was difficult to determine the reason for the lack of distinct boundaries.

(ii) Erosional/Depositional Pans: Near the upper limit of the low marsh, distinct clumps of meadowgrass impound water in an irregular fashion. At higher elevations adjacent to this, similar irregularly shaped and water filled, steep-sided pans were identified within the meadow. These are of an erosional nature. While wave attack definitely contributes to this, ice scour may be another agent. There is some evidence to suggest these pans may be relict vehcile tracks.

Figure 3.29: Simple depression pan colonized at the margins by glasswort and cordgrass.

Figure 3.30: Rotten spots develop within the upper meadow, eventually killing the underlying vegetation.

(iii) Rotten Spot Pans: Depression: Seen frequently within the upper meadow, but covering a very small area, these pans are very deep (15 - 25 cm) and nearly as wide. Uncolonized, the pan bottom is sandy and water-filled at the highest tides. There is no apparant causative mechanism.

Cowlick: Cowlick pans are identified by the presence of deep (8 cm) dead meadowgrass mats covering the irregular pan bottom. There were no distinct depressions in the marsh surface associated with these. However, at high tide they were considerably wetter than the surrounding meadow (Figure 3.30).

Trash: At Brackley, trash pans, as such, were not identified. However, when eelgrass and algal mats were removed from the marsh surface, the underlying vegetation had succumbed and a depression had been initiated (Figure 3.31). This was most commonly seen near the shore and in the vicinity of the marsh, where algal mats are readily rafted onto the surrounding vegetation at high tide.

(iv) Ice Scour Pans: Within the low marsh, and especially near the upper boundary, cordegrass stubble surrounded by irregularily-shaped deeper depressions are indicative of recent ice action (Figure 3.32). During winter months, the marsh is almost entirely covered by sheet ice, which is subject to daily tidal fluctuations (S.B. McCann, pers. comm.).

(v) Vehicle Track: Much of the meadow is characterized by vehicle tracks. The resultant pans are uniquely linear deep and generally water filled even at lower water levels (Figures 3.12, 3.33 and 3.34). Based on evidence from the aerial photographs, many of these track pans have remained for years.

The distribution of each pan type is shown in Figure 3.35, as well as the associated plant community. The correspondence between the two is clearly illustrated. While the Bulrush communities prefer the wetter, more blackish pans or ponds within the meadow, the Glasswort communities, composed of annuals plus the two *Spartina* species, dominate the low marsh. Drainage is better (more rapid) and, while standing water is less likely to be a common occurrence, high substrate salinities are

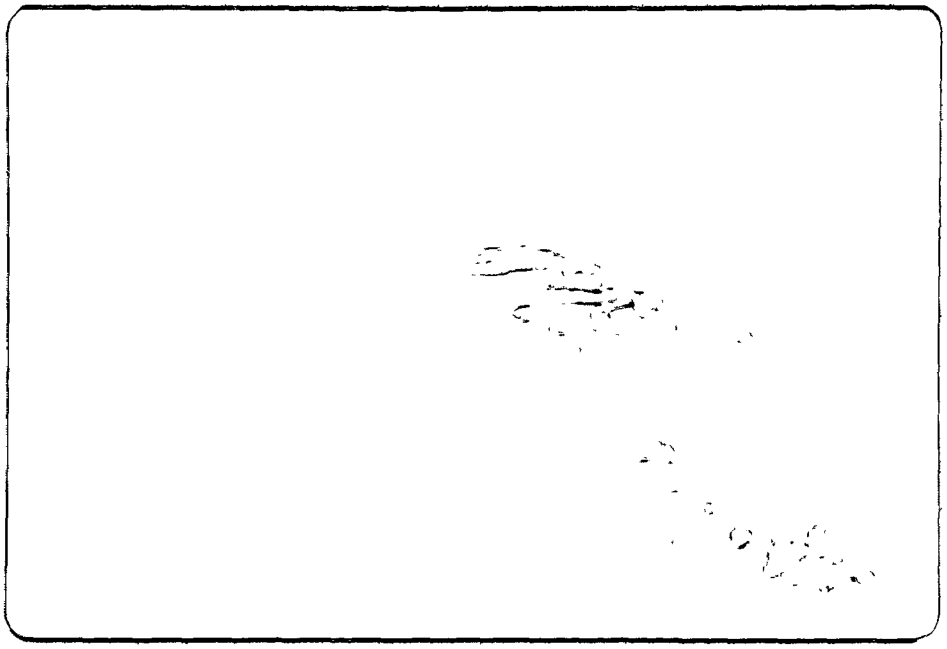


Figure 3.31: The eelgrass and algal mats deposited near the lagoon shore and around salt pans may remain long enough to kill the underlying vegetation. This infrared photograph clearly shows the dead meadowgrass and cordgrass where the litter had been.

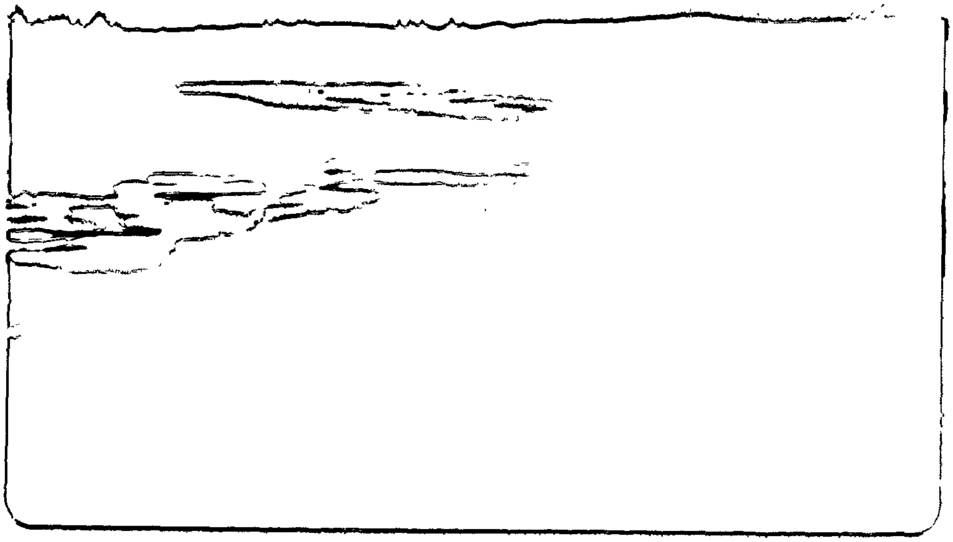


Figure 3.32: Ice scour denudes the surface leaving many irregularly shaped depressions across the marsh surface. Cordgrass stubble can be seen in the recently scoured surface.

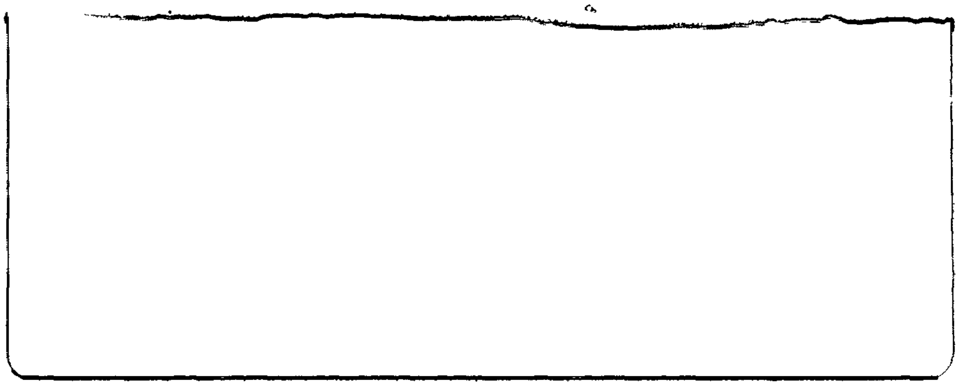


Figure 3.33: Vehicle tracks are deeply incised where the meadowgrass is dense and the litter mat is deep. The irregular pattern in the meadow, observed here, is typical of early spring.

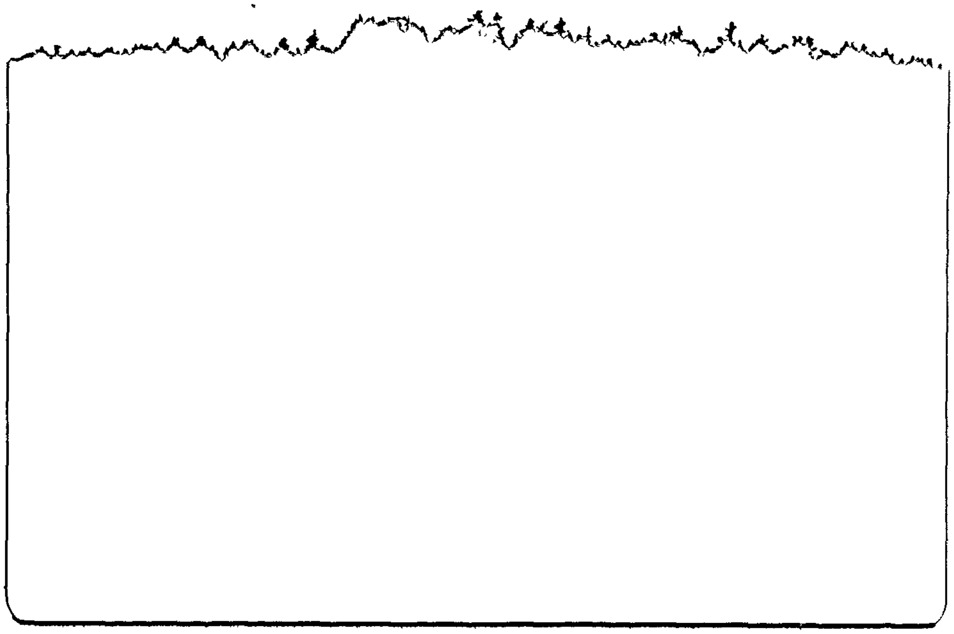
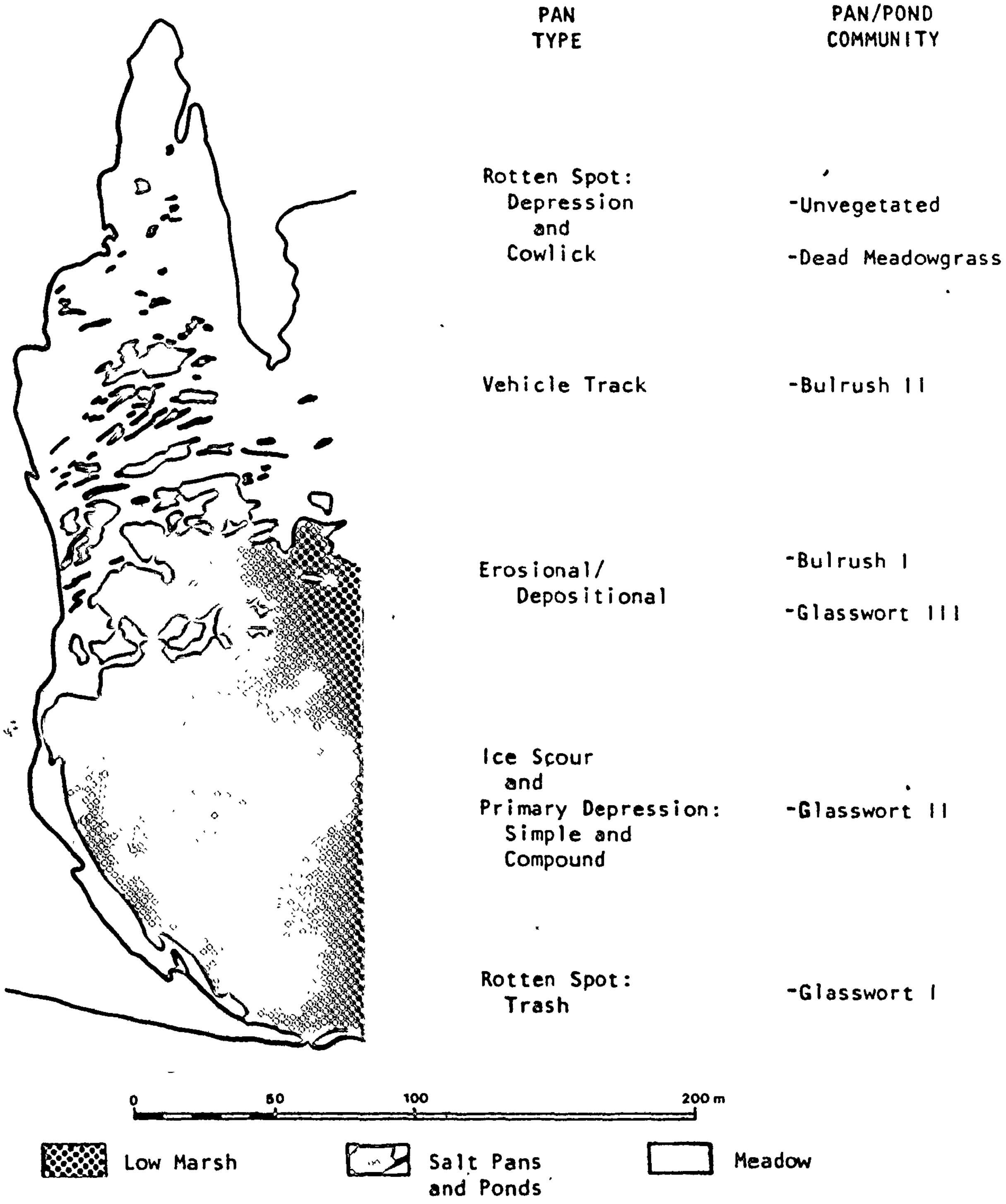


Figure 3.34: Within the upper meadow, shallow water-filled tracks are visible at high tide. In comparison to Figure 3.33, the meadowgrass here is sparse and less vigorous.



PAN TYPE	PAN/POND COMMUNITY
Rotten Spot: Depression and Cowlick	-Unvegetated -Dead Meadowgrass
Vehicle Track	-Bulrush II
Erosional/ Depositional	-Bulrush I -Glasswort III
Ice Scour and Primary Depression: Simple and Compound	-Glasswort II
Rotten Spot: Trash	-Glasswort I

Figure 3.35: Distribution of salt pan and pond types and their corresponding communities at Brackley Marsh, transect 2B.

probably frequent, especially in the summer. Glasswort and sea blite are tolerant of these conditions. However, ice scour alters the habitat each year and species distribution will change accordingly (Redfield 1972). In this respect, the ice scour pans should be considered a temporary and variable feature. Glasswort communities (III), where meadowgrass is a component, may represent the upper limit of ice action (Thomas 1969). Vegetal mats, exposed during the winter months are vulnerable to erosion by ice and unlikely to remain in a vigorous condition over the long term. Perhaps it is ice scour and wave/water erosion combined, that produce the hummocky depositional forms identified at Brackley Beach.

Major species, bulrush, meadowgrass and cordgrass and the litter mats were easily identified directly on the aerial photograph. Taken at high water, the colour infrared image also permitted rapid pan delineation as all were moist, if not water-filled. This verifies the interpretation made above. Specific image characteristics and temporal information will be further discussed in Chapter 4.

While good correlation between pans and their communities was found for Brackley, similar relationships need to be defined elsewhere before generalizations can be made. Pan communities at Buctouche and South Beach are similar to one another and do not show nearly as much variation as those at Brackley. Different pan types, such as channel pans and waterfilled primary depression pans, compound forms (Figure 3.36), have been identified at Buctouche. However, at this time there is insufficient data to further identify the relationship between pan origin and community.

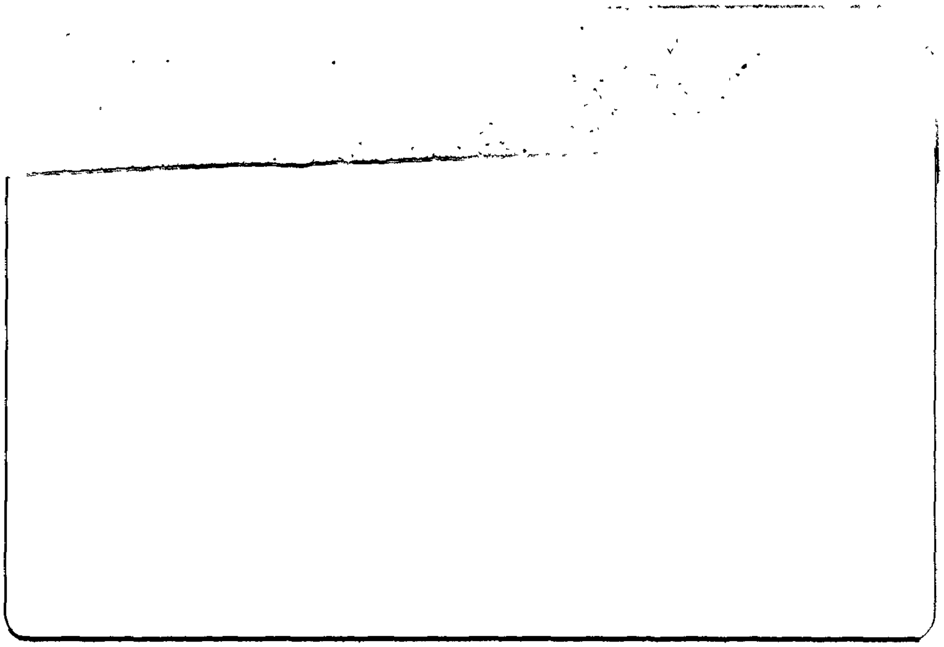


Figure 3.36: Large areas of coalescing pans, unseen at Brackley, are common to both Buctouche and South Richibucto Beach.

3.5 DISCUSSION

The emphasis of Chapter 3 is the identification and description of salt marsh communities and their habitats. The communities derived in this analysis show good correspondence to those described elsewhere in the literature. However, the communities derived in this study are defined more precisely and with greater detail, particularly in terms of species composition, cover (percent) and distribution. Information of this nature was previously lacking for the study area and surrounding region.

The idealized profile showing the relationship between salt marsh communities and tide height is presented as a summary of the community analysis conducted in Section 3.2.2. A classification, describing four major marsh zones and the communities which comprise them, is proposed. This classification forms the basis for all further discussion regarding community and aerial photo analyses. Frequency of occurrence of each species within each community has been calculated from the results of the community analysis and generalized for the 'typical' profile. More specific data relating to individual communities at each marsh has been tabulated and is presented elsewhere (Appendix B3).

While the idealized profile was constructed in an attempt to represent the typical marsh communities within the southern Gulf of St. Lawrence, it appears that the profile is best representative of eastern New Brunswick and the north shore of Prince Edward Island. The recent literature (Thannheiser 1981) indicates more variability in community composition within the salt marsh environment than previously recognized. However, most of the differences in marsh communities are recorded at sites other than New Brunswick and Prince Edward Island (e.g., les Iles de la Madeleine).

The relationship between marsh communities and tide levels, initially tested in connection with the typical profile, is subsequently defined by tidal heights obtained from observed tidal data. In both cases, the Cordgrass community is an indicator of mean sea level, the Meadowgrass community relates to mean high water, and the Baltic Rush community is usually at or above higher high water levels. Although this relationship had been defined in correspondence with either specific marsh communities or tidal data.

Salt pans and ponds were described in detail and a relationship between pan community and pan genesis was identified. Although not previously described, the relationship is implicit. The mode of formation of salt pans is in many cases related to the distance from the shore, as is the zonation of marsh, including pan, species.

The community descriptions and idealized profile presented here will provide the basis for the aerial photo interpretation in the next chapter. The relationships identified between communities and their habitats will enhance the interpretation of environmental conditions from aerial photographs.

CHAPTER 4

AERIAL PHOTO ANALYSIS

The vegetation communities, derived in the preceding chapter, define species composition and position along an idealized profile. In reality, the arrangement of such communities is neither so simply nor so easily described. In order to interpret and understand the ecological implications and significance of the different marsh communities, spatial and temporal information relating to distribution, aerial coverage, and changes through time is required. Aerial photography provides a complimentary data source in this respect. With the great variability in aerial photo quality, scale, season and film type, a method to assess the accuracy and repeatability of subsequent interpretations is required. Once reliability levels have been established, data extrapolation through space and time can be accomplished. The aerial analysis presented in this chapter can be described by three separate but progressive steps as follows:

1) The development of a community description outlining features of zones, communities and individual species and their photo characteristics on different film/scale combinations through the seasons. This will be derived from profile data and community classifications previously described.
2) An extension of the techniques developed above to areas, not directly surveyed. This will assess the applicability/validity of the approach and test the typical marsh profile derived in Chapter 3.
3) Further extrapolation of these data through time using sequential aerial photos, to develop an historical record of marsh growth and response.

Prior to these analyses, a review of the literature relating aerial photo interpretation to coastal/vegetation studies is undertaken.

4.1 LITERATURE REVIEW

4.1.1 Introduction

The applicability of remote sensing techniques, both aerial and orbital, to landscape analysis has been well documented (Reeves 1975). However, for the purpose of this review only aerial photographic technqiues applied to coastal studies will be considered.

The use of remotely sensed data offers a number of advantages over conventional field or ground surveys. These include increased accessibility over large or otherwise inaccessible areas and flexibility in terms of data acquisition, timing and method of analysis (Steiner et al. 1972; Thaman 1972). In addition, a permanent record and mapping base is provided. Perhaps the most obvious benefit is that of the aerial perspective. Although initially difficult to interpret, the vertical synoptic view permits identification and assessment of environmental relationships in a spatial context.

The quality and quantity of information that can be extracted from air photos is a function of film type, scale, season and the abilities of the interpreter. Although it is unrealistic in practice to identify each factor separately, a review of the literature is best approached in this manner. The relative merits of different film types, photo scales and seasonal imagery will be discussed individually with reference to coastal and wetland studies.

4.1.2 Film Type

The four major film types in current use are black and white (B&W), colour, black and white infrared (B&WIR) and colour infrared (CIR).

For a complete discussion of processing and film properties the reader is referred to the Manual of Remote Sensing (Reeves 1975). Since each film type has a unique set of characteristics, film evaluation must be considered with respect to specific purposes.

Black and White: B&W film is the most commonly used, being both inexpensive and relatively simple to interpret for major features. Although B&W photos contain most of the information found on other film types (Randall & Marlar 1978), interpretation can be severely limited when distinguishing between similar shades of grey. Variations in texture, contrast and tone across the image further complicate interpretation. For example, shadows and sunglare on bare, wet tidal flats are confusing and can obscure detail unless photos are acquired under diffuse light conditions (Cameron 1950). Investigations into the use of narrow, multiband photography have shown potential for specific applications, such as sediment distribution (Pestrong 1969). This data source, however, is not widely used, probably due to the need for special interpretation equipment. For general detailed work, B&W photos are often combined with other imagery to increase reliability (Chime et al. 1978; Cowardin & Myers 1974).

Colour: It is the 'natural colour' capabilities of colour film that identify it as the single most useful film for general coastal interpretation (Pestrong 1969). Mixed results as to its usefulness for vegetation identification and mapping have been reported by a number of authors. Hubbard and Grimes (1972b) summarize the application of colour film as necessary only where colour variations are important. At other times the unnecessary detail tends to be confusing. Wetland species having unique colours (e.g., dark olive green *Juncus* spp.) (Reimold et al.1973) or nonspecific plant groupings are readily identified (Grimes & Hubbard 1971). Anderson (1971) found the green tones blended together on medium and high altitude photos, effectively reducing the number of individual species identified. This was confirmed by Thompson et al.(1973) and attributed to haze sensitivity.

Wheeler (in Eitel 1972) reports colour as the preferable sensor for species identification in the Maryland wetlands mapping program. Brown (1977, 1978) concluded that for complete species identification in New York and New Jersey, colour alone was insufficient and required combination with CIR data. However, Olson (1964) identified no significant difference between large and medium scale B&W, colour and CIR photos for marine marsh vegetation, with the single exception of pickleweed which could only be identified on colour. In the southeastern U.S., Seher and Tueller (1973) reported no difference in interpretations with either large-scale colour or CIR. It is probably differences in environment that lead to varying conclusions about species identification.

Of the four film types, colour is capable of good water penetration, an important consideration for nearshore studies (Theurer 1959). Subsurface features (bars, channels) can be identified (Swanson 1964) and when combined with suspended particles, wave and current patterns can be deduced (Berryhill 1969). Submerged vegetation, sometimes indicative of variable offshore salinity (e.g., *Thalassia* species) (Schneider 1968) and/or wave energy conditions can also be detected (Eitel 1972). Where aquatic vegetation dominates or for specific floating species studies, colour film is optimal (Kolipinski & Higer 1969; Van der Valk & Davis 1979).

Infrared: On black and white - and colour - infrared photographs (B&WIR and CIR, respectively) infrared (IR) radiation is absorbed by water and reflected by vegetation creating distinctive photo signatures for these surfaces. On B&WIR, water is black while vegetation has very light tones. On the CIR, clear water is dark blue and healthy vegetation images in colours from pink to red. The high contrast between water and vegetation and wet/dry interfaces aids the delineation of the water line. If vegetation data are not required, B&WIR is optimal for water boundary and drainage pattern identification (Cowardin & Myers 1974; Jones 1958; O'Hargan 1973; Reimold & Linthurst 1975). U.S. state programmes feature B&WIR imagery timed with maximum and minimum tides, for water level data (Cole 1978; Garvin & Wheeler 1973). This is especially effective where heavily silted water is indistinguishable from bare mud flats on B&W films (Swanson 1960). In other areas, mean water line can be identified on colour and B&W film by the break in slope between the foreshore and backshore (McBeth 1956) or flotam-jetsam lines on sandy beaches (Latham 1973). Near surface water can reduce the infrared reflectance from vegetated surfaces (Wallentinus & Jonson 1972). Therefore, where tidal boundaries are obscurred the water line can be identified especially on CIR, by moisture variations and plant response to these conditions (Hull et al. 1973 ; Pestrong 1969). Sparse vegetation on the intertidal flat can also be easily recognized with CIR photos (Medley & Luternauer 1976). Confusion with wet sediments exists on B&W photos (Cameron 1965c).

As little as three inches of clear standing water is required to produce a black tone on B&WIR film (Jones 1958). CIR has slightly better penetration ability as the film also records in the green and red parts of the spectrum. Keller (1975), for example, identified bottom features through 25 feet of clear coastal water. Aquatic plants can be identified but only if found in sufficient quantities near the surface (Pestrong 1969). Anderson (1971) described a technique for processing CIR at a higher step to maximize water penetration and aquatic species identification. Since this process renders the rest of the film useless, CIR should not be regarded as having good water penetrating capabilities. Infared imagery is highly sensitive to changes in vegetal reflectance and capable of detecting subtle changes in condition or composition (Carter & Anderson 1972; Wallentinus & Jonson 1972). Variations within a monospecific stand can be attributed to changes in folliage area, plant density, leaf and stem orientation, age, and edaphic stress conditions (water, salinity) (Carter & Anderson 1972; Colwell 1974; Gausman et al. 1973; Gates 1970; Reeves 1975; Shima et al. 1976) Differences in plant vigor due to moisture variations within a wetland environment can be correlated to productivity and biomass data (Gallagher 1974). High and low vigor zones for *Spartina alterniflora*, the marsh dominant in the southeastern U.S. can be delineated on CIR (Anderson 1970; Reimold et al. 1973). With marginal success, Anderson (1969) has extended this further in an attempt to directly correlate vegetation with salinity, pH, pollution, temperature and soil/rock type.

Without a doubt, CIR provides maximum information regarding community composition, much of which cannot be determined from other film types (Anderson 1969). Mixed communities, not always discernable on B&W photos by height and textural differences, can be identified on CIR (Grimes & Hubbard 1971). Boundaries between communities are easily delineated, except where quantitative variations occur within qualitatively similar communities (Shima et al. 1976). However, since species are not readily recognizable on the false colour image, CIR photography is often combined with true colour or B&W photos of a larger scale, for maximum interpretation (Eitel 1972). Anderson and Wobber (1973) used large scale B&W photos to check interpretation of 1:12,000 CIR. In this respect it is important to note that infrared films have superior haze penetration abilities, producing correspondingly better quality photos from greater altitudes (Thompson et al. 1975). In a comparison of colour and CIR photos at 1:52,000, Howland (1980) noted the better resolving capability of the infrared film. A minimum ground area of 20 m diameter could be identified with the CIR, whereas areas less than 22 m could not be discriminated on the colour photos.

A summary and evaluation of information extracted from different film types is presented in Table 4.1. This review is based on information cited in the literature.

4.1.3 Scale

Variations in vegetation are continuous and the degree of detail observed on aerial photographs increases with scale (Hubbard & Grimes 1972b). This emphasizes the need to combine a suitable mapping/vegetation classification or hierarchy with an appropriate interpretation and/or map scale. As a result, small scale photography (with scales less than 1:50,000) has not been widely used for wetland mapping except where major boundaries are its only information required (Anderson 1972). Most wetland inventories and mapping projects have been conducted at scales less

TABLE 4.1: A SUMMARY OF COASTAL FEATURES ON DIFFERENT FILM TYPES, AS INTERPRETED FROM AERIAL PHOTOGRAPHS.

COASTAL FEATURE	FILM TYPE B&W	FILM TYPE B&WIR	FILM TYPE COLOUR	FILM TYPE CIR	PHOTO SIGNATURE	INTERPRETATION
Vegetation	X	X	XX	XXX	CIR: shades of red and magenta: highly reflected COLOUR: shades of green and brown	Unique response for each species, vigor and growing condition.
Submerged vegetation	X		XXX	*XX	CIR: dark irregular patches in the offshore COLOUR: visible on the bottom through water	Can overexpose CIR one step for better rendition but this deletes all other information.
Salinity	X	X	XX	XXX		Based on species identification.
Channels (unvegetated flats)	XX		XXX	XX	COLOUR & CIR: deeper channels	Relict channels (mud filled) detected where overlying sands.
Drainage (vegetated flats)	X	XX	X	XXX	CIR: dark blue/black tone contrasts against red vegetation	Often only detected by vegetation species and/or vigor.
Shoreline Delineation	XX	XXX	XX	XX	B&WIR: dark tone of water contrasts against highly reflected vegetation	Standing water can be detected through vegetation canopy.
Moisture (unvegetated flats)	X	XXX	X	XX	B&WIR: moist areas are dark	Fine material holds moisture longer than coarse; can be confusing.
Mudflats		XX	XX	XX	All Films: identified by smooth texture and position	'Between photo' tonal variations caused by sun glare.

X fair; XX good; XXX excellent; *may be adequate if target near to surface than 1:24,000, often using CIR and B&W films (Carter 1977). Olson (1964) found that between scales of 1:20,000 and 1:12,000 there was a 10% increase in the accuracy of species identification. Similarly, between 1:12,000 and 1:5,000 there was a 5% increase. The recommendation was made that 1:12,000 photos be used for non-quantitative wetland evaluations or mapping purposes. Individual species identification was best accomplished at larger scales (1:15,000), one or two hours after high tide. Grimes and Hubbard (1971) reported similar results interpreting from colour photos at 1:12,500 and B&W at 1:7,500. At 1:2,500, features 23 cm in diameter could be correctly identified on B&W photos (Hubbard & Grimes 1972b). Thompson (1972) argued that large scale photos contained too much confusing detail for all but species specific studies and suggested the use of medium scale imagery for most wetland studies. In a later paper, Thompson et al. (1973) evaluated each film type at different scales, identifying changes in photo characteristics. At scales greater than 1:12,000, textural indicators on B&W films began to lose definition, increasing interpretation difficulties. Colour films exhibited blending of subtle shades at 1:24,000, a problem which severely limited interpretation from 1:40,000 scale photos. Haze also reduced the clarity of colour and B&W photographs at scales greater than 1:10,000. In general, tones and textures on CIR film remained consistent throughout the test range.

One area in which small scale photos are of value is in shoreline and wetland monitoring (Anderson 1972). Dolan and Vincent (1973) also identified and measured crescentic shoreline features (e.g., sand waves) at scales of 1:60,000 and 1:120,000, a task not easily completed at larger scales. For detailed analysis scales of 1:10,000 to 1:60,000 were suggested.

4.1.4 Seasonality

Equally important as film type and scale is the selection of the time frame for photography. Many authors (Anderson et al. 1975a; Carter et al. 1979; Carter & Stewart 1975; Cowardin & Myers 1974; Gammon et al. 1977; Thompson et al. 1973) have recommended the use of seasonal imagery for accurate species identification. At least two dates are required, the first being a 'leaves off' period in order to identify water level and sub-shrub strata vegetation. This is especially important where vegetation grades into swamp species and standing water can be obscured by the canopy (MacConnell & Garvin 1956). Tonal and textural differences are at a maximim during flowering or when vegetation is mature (Brown 1977; McEwen 1976; Reimold & Linthurst 1975; Seher & Tueller 1973). The second date of photography should be timed to coincide with the period during which the maximum number of species are in bloom.

Single image date interpretations tend to be less reliable and detailed (Eitel 1972; Enslin & Sullivan 1974; Seher & Tueller 1973). For the reasons stated above, late summer photography is generally preferred, although the actual date varies locally and yearly. Late summer photos are best for observation of floating leaved species which tend to develop late (Anderson 1972) while early summer imagery is best for spring flowering dune and beach plants (Hubbard & Grimes 1972a).

October has been identified as the best time for species discrimination with colour and height differences at a maximum on B&W film in southern England (Hubbard & Grimes 1972a). With reduced cover in February, pedologic and topographic variations are clearly visible. For similar reasons, September was determined to be optimum for upper marsh boundary and drainage pattern delineation on CIR in Chesapeake Bay (Anderson et al. 1975b).

Climatic variations at the local level can also create varying dates of maturity. Brown (1977) found that cooler waters had reduced biological activity further into the season than in warmer waters. Vegetation associated with fresh and brackish marshes matured earlier than similar saline marshes due to the lack of mixing with cool ocean water.

Optimal timing can also vary with film type. Gallagher and Reimold (1974) found that fresher marsh zones were identified more easily on colour film during the winter when leaf canopies are removed. In the same area, CIR was the optimum film for summer.

Thompson (1972) planned a four flight coverage throughout the growing season of a Georgian *Spartina alterniflora* marsh with CIR. Early June photos depicted the extent of spring growth, mid-July photos were taken just prior to flowering which occurred in mid-August. During the following February, vegetation was photographed at its most dormant stage. In a later study, a comparison of the interpretation of colour, CIR, B&W and B&WIR films during the four seasons yielded much information (Thompson et al. 1973). Summer photography was best for all species and all films although B&W films showed little change between seasons. Textural variations on B&W provide most of the significant information and this type of photography should be flown with this in mind (Grimes & Hubbard 1971). Although October photography produce duller tones and less distinct textural changes on CIR, three types of *S. alterniflora* could still be identified (Holman 1974). Robust forms (greater than 150 cm) imaged pink to grey and short plants (less than 100 cm) were medium blue owing to the low density and wet soil background. Medium height S. *alterniflora* appeared blue or green, the green due to the growth of epiphytic algae on the stems.

4.1.5 Interpreter Experience

While image film response to scale and seasonal variations can be predicted from film characteristics, it is not possible to define interpreter experience in a similar manner, as interpretation is a highly subjective task. Olson (1964) attempted to relate experience to ability in marsh interpretations with subjects of varying degrees of skill in air photo interpretation (API) and marsh ecology. He found that interpreters with a greater knowledge of marsh ecology used more deductive reasoning (interpretation) when making decisions, while those with less ecology background relied upon the identification of photographic images (photo-reading).

To simplify interpretation Grimes and Hubbard (1971) identified five criteria required for accurate wetland analysis. They are:

1) a knowledge of species zonation in coastal marshes;
2) known phenological differences between species of marsh plants;
3) familiarity with the study case;
4) tonal/textural differences on air photos characteristic of individual species; and
5) good quality photos at adequate scale.

To this Garvin and Wheeler (1971, 1973) added the following interpretive aids:

1) period of inundation;
2) proximity to the water's edge or upland boundary;
3) general vegetal patterns;
4) salinity range;
5) season;

6) common associations; and
7) species reactions to disruptions of the natural system.

With these factors in mind, typical wetland and coastal studies can be described and evaluated.

4.1.6 Static vs. Sequential Studies

Past remote sensing studies may be categorized as one of two types. Those using single photo coverage can be analyzed with respect to static ground conditions and are most often used for mapping purposes. With sequential photos, landscape changes can be identified and causative processes inferred (Howarth & Lucas 1980). In practical terms, the latter study type is really an extension of the former. Since they formed the basis of the preceding discussion, static applications will not be considered in detail.

The practical application of static analysis is map production. However, qualitative descriptions often in the form of photo-keys are presented. Although photo-keys tend to be site specific, generalizations may be drawn especially for morphological or process-related features (Dietz 1947; Lucke 1934; McBeth 1956; Paul 1974; Russell 1967; Shepard 1950; Smith 1960; Sonu 1964; Welsted 1974, 1979). Such is not the case for plant community keys which are variable in composition and quality (Carter et al. 1979; Cowardin & Myers 1974; Enslin & Sullivan 1974; Howland 1980; Reimold et al. 1973; Seher & Tueller 1973; Thompson et al. 1973; Wallentinus & Jonson 1972).

Sequential photos provide the mapping base for studies to illustrate coastal erosion (Horikawa & Sunamura 1967; Stafford & Langfelder

1971), deposition (Benton et al. 1978; El-Ashray & Wanless 1965; Moffitt 1969) and storm damage (Howard 1939; Steers 1953; Waugh 1962). Bryant and McCann (1972) illustrated the change in the Kouchibouguac barrier system, New Brunswick, over 35 years using a series of four maps. Similarly Cameron (1965a,b,c) demonstrated photo capabilities elsewhere in the Maritimes. Historical changes in intertidal morphology have been identified by Medley and Luternauer (1976) in the Fraser River Delta. Man-induced variations in drainage patterns have also been mapped from sequential photos (Herron 1972; Watts et al. 1973). Application of sequential photos includes the estimation of sediment budgets where changes in shorelines can be mapped and quantified (Armon & McCann 1977).

Long term coastal vegetation studies are not well discussed in the literature being limited by the lack of good quality imagery. Hubbard (1965) interpreted terrestrial photos taken in 1919 and 1924 comparing them to present conditions in the Blakeney Marsh. Short term variations have been identified where significant accelerated change has occurred due to natural or man-induced influences (Dirschl & Coupland 1972; Merilainen & Toivonen 1979; Vander Valk & Davis 1979).

4.2 PHOTO COMMUNITY DESCRIPTIONS

4.2.1 Introduction

In the marsh environment, the vegetation represents a continuum from the hydric marsh edge to the xeric dune communities. Unlike surveyed profile data, where apparent community limits were established visually and arbitrarily, the aerial photograph records this continual change. However, it is difficult to describe and compare information in this format. (It is comparable to describing and analyzing the raw data for 467 1 m^2 quadrats individually).

For the purposes of analysis and description, photo communities, defined as "the smallest assemblage of plant species discernible on stereo pairs of aerial photographs at a specified scale" (Howard 1970), can be identified. Within this definition as stated by Howard, stands or plant communities (the smallest recognizable group of plants growing together) can be identified at scales greater than 1:5,000. Groups identified from photographs at scales between 1:10,000 and 1:5,840 are equated with associations. Although the hierarchy of associations and communities has not been precisely outlined for these vegetation groups, it will be shown that areal coverage of individual stands, is a more important consideration. In the coastal plain marshes of Virginia monospecific communities greater than 1 acre in size have been identified on small and medium scale photographs (Penny & Gordon 1975). It is unlikely that similar monospecific Glasswort communities, for example, in this environment will be identified at even large scales.

The composition of the photo community will vary with scale; larger scales defining more specific plant groups while photo communities on small scale photographs are more likely to be a combination of several smaller vegetation units.

Similarly, some community classifications (such as TWINSPAN) based on floristics also produce hierarchial groupings, each division defining successively more discrete units. However, there is no reason to assume that the photo community and the floristic community will be the same. Only where the differential species are highly visible or possess a unique photo characteristic will the two groups be similar. Based on a comparison of the typical marsh communities and those identified on aerial photographs, the applicability of aerial analysis to marsh studies can be determined.

In this investigation, photo community descriptions are derived by comparing aerial photography with the surveyed profile data identifying typical marsh communities. As recent photography did not include all possible combinations of film type, scale and season, it was necessary to use some photography from earlier dates in that part of the analysis. Working in sequence, backwards through time, the typical marsh communities could be delineated with little difficulty. Little change at most profile sites was noted, and any variation in image characteristics could be attributed to the differences in film type, scale or season. Sites where obvious alterations in the marsh vegetation were noted (e.g., Brackley marsh, P.E.I.), were not included in this part of the analysis.

Direct comparisons of film type and image product, scale and season were made where possible. Film types used in the analysis were black and white, colour and colour infrared. All were in 23 by 23 cm format and were viewed as both prints and transparencies. Scales of photography ranged from 1:3,000 to 1:30,000. For this study, large scale was taken to be greater than 1:10,000, while small scale was less than 1:20,000. To aid the comparison of photography from different seasons, three periods were identified based on the timing of significant floristic variations for the majority of marsh species. The seasons and months were: spring, May and June; summer, July and August; and fall, September to November.

To aid interpretation, the summary tables (Appendix B3) showing species frequency and cover by community were used extensively. As not all communities encountered were incorporated into the typical marsh profile model, the original surveyed data were required to identify the less frequent communities and stands (e.g., stands of freshwater cordgrass). In the following discussion, indicator species or features for photo interpretation are identified where possible.

4.2.2 The Dunelet

The dunelet is rarely identified on aerial photographs. Where relief is significant the dunelet may be detected through stereoscopic viewing. Elsewhere, bare sand or wrack zones often indicate the presence of Sea Lyme Grass or Marram/Meadowgrass communities. In general practice, the dunelet can only be delineated on large scale photography owing to its narrow width. High water levels may obscure much of this zone making it difficult to identify on medium and small scale photographs.

4.2.2.1 Sea Lyme Grass

Sea Lyme Grass is the typical community although Meadowgrass/ Marram may also be found. However, neither is directly visible except on large scale imagery owing to their low density of occurrence. Summer photography is optimal to prevent confusion with other denuded shore areas that by summer have been vegetated. However, maximum discrimination occurs in the fall. During this period, marram and sea lyme grass can be seen as a faint pink stippled pattern on large scale CIR photographs. At other times of the year, presence of a dunelet community can only be inferred.

4.2.3 The Low Marsh

Characterized by the Cordgrass and Sea Lavender communities, the low marsh is easily recognized by its position on the marsh shore. Even on small scale photography, where individual communities can be neither delineated nor often separated, the low marsh can be identified by areas of wrack, exposed sand or mud and by its general wet (or flooded) appearance. Unbleached eelgrass debris demarcate the most recent high tide within this zone.

Within the outer marsh boundaries, low areas are inhabited by one of these communities (usually Cordgrass) and occasionally Glasswort. This latter community is never visible from the aerial perspective and its presence can only be inferred.

4.2.3.1 Cordgrass

The Cordgrass community may be identified by its unique position on the marsh. It is the only community regularly flooded at high tide. During low water periods, cordgrass is usually the only vegetation that may be observed on the exposed flats.

Cordgrass, frequently buried or otherwise removed during the winter season, begins growth early in the spring. However, it is rarely sufficiently dense or tall to be observed on spring photography. On all medium and large scale photographs, a stippled pattern and eelgrass mats indicate the presence of cordgrass. Confusion with damp exposed mud and sand flats is a problem where the density of the vegetation is insufficient to accurately delineate the boundaries of the Cordgrass community.

During the mid-summer season, cordgrass is best identified on colour or CIR films. B&W films of all scales lack the tonal differences required to separate all but very dense cordgrass from the background. On small and medium scale colour photographs, sparse cordgrass is often lost against the dark-coloured mud background. Where density of growth is greater, a dark green, coarse textured surface indicates the presence of cordgrass. During high water periods, CIR film records the partially submerged cordgrass, while both B&W and colour films cannot. A medium pink colour is registered for cordgrass with some minor variations. In Georgia four forms of *Spartina alterniflora* can be identified on photos by height and IR reflectance (Reimold et al. 1973). On CIR they image as:

a) bright red, tall robust plants;
b) light red, medium height robust plants;
c) blue-red, medium height, medium density plants; and
d) blue, short or medium height, low density plants.

Each of these classes has been correlated to biomass data and a specific subhabitat. The more vigorous form had the highest dry weight and was always found in streambank positions with frequent flooding and good drainage. Low density 'blue' plants were limited to inner marsh areas where short term waterlogging of soils and less frequent flooding conditions prevailed. Similar results were observed, however, only two growth forms of cordgrass (related to density) were delineated. At Brackley, the denser cordgrass was observed in the more sheltered locations; the shorter and more sparse vegetation within the open pan area where ice scour effects had been recorded. In this latter habitat, the marsh/mud surface is highly exposed (approximately 47 percent, Appendix B3.2) causing reduced IR reflectance. In addition, within this part of the marsh, owing to the nature of sedimentation, a veneer of mud (<1 mm) is likely to be deposited over the entire plant surface. Green and red reflectances are increased, hence, exposure of the yellow and red emulsions are reduced. A corresponding decrease in IR reflectance increases the density of the cyan layer and the film colour changes from red or pink to blue (Carter & Anderson 1972). While such extremes in colour variations were not observed from the air, ground level CIR photographs do illustrate this (Figure 4.1). The coarse texture of the Cordgrass community is also immediately obvious compared to the neighbouring Meadowgrass.

Fall photography, especially large scale, reveals the cordgrass distribution by its very rough texture. CIR images are dominated by shades of beige and green rather than pinks. Distinction between cordgrass and meadowgrass is easily made especially around salt pans and ponds and at the low marsh/meadow boundary.

Throughout the study area, cordgrass never forms a dense continuous zone within the marsh. Its occurrence on the shore is patchy, discontinuous and only locally dense.

4.2.3.2 Sea Lavender

The distinctive morphology of sea lavender makes for easy identification of this community. However the morphology of the plant and its low density of growth limit its visibility on all but large scale photographs.

During the summer the broad basal leaves appear as small, dark irregular patches between and within the Cordgrass and Meadowgrass communities. When in flower (August) the lavender blooms produce a circular

Figure 4.1: The colour and textural differences between the meadowgrass and cordgrass make identification and delineation of these communities easy on CIR film. This photograph was taken near low tide. The wet substrate is clearly visible between and through the cordgrass.

'fluffy' texture throughout the low marsh zone (Hubbard & Grimes 1972a). This can be observed on low level B&W, colour and CIR photographs (Figures 4.2, 4.3 and 4.4).

The best expression of this community is seen at South Richibucto Beach where it occupies a wide nearly continuous zone at the marsh edge, unlike the Cordgrass community which it appears to replace.

4.2.3.3 Glasswort

The Glasswort community cannot be identified directly on aerial photographs. The only constant species of sufficient size to be seen on a photograph is cordgrass. However, cordgrass is not unique to the Glasswort community. When found in a salt pan/pond habitat cordgrass presence may be used to infer the Glasswort community.

Salt pans are most easily identified in spring or fall, when the surrounding vegetation is not fully developed. CIR photographs provide maximum discrimination between tall, dense cordgrass surrounding the pan and the shorter Cordgrass or Meadowgrass community within which the pan may be situated. In the spring, cordgrass is rarely sufficiently developed to identify and in summer it is often hidden under the Meadowgrass. Fall photography is optimal with the larger scales more easily interpreted.

The salt pans themselves are often outlined by a highly visible bleached eelgrass or algal litter mat. Elsewhere a distinct change in elevation may be noted. The appearance of the pan changes through the tidal cycle. Although this does not create problems for the interpretation of CIR or colour photographs, B&W images may be confusing. At low

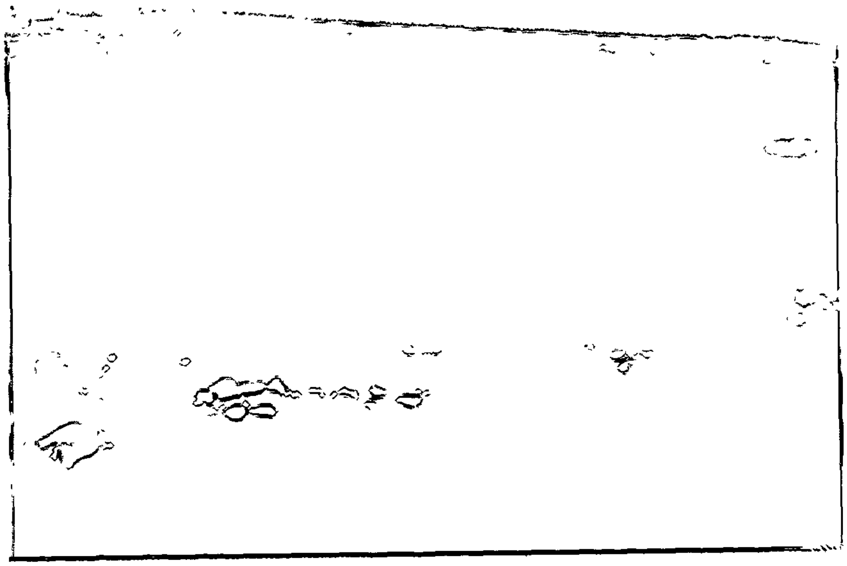
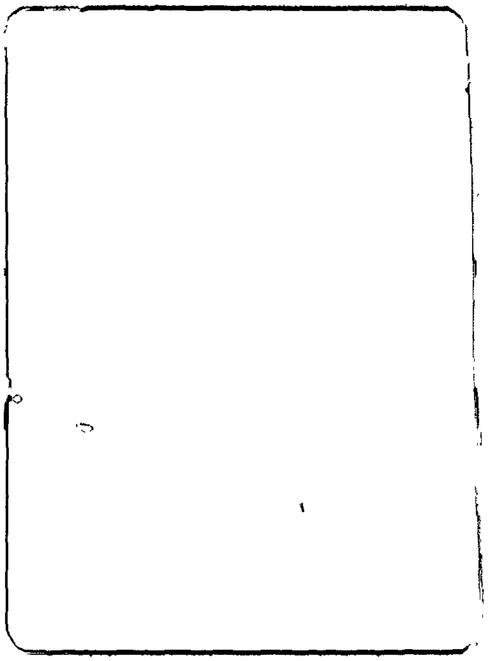


Figure 4.2: The Sea Lavender community at the shore is easy to recognize by the 'fluffy' texture of the flowers. Further inland, the Meadowgrass community is interspersed with cordgrass tufts.



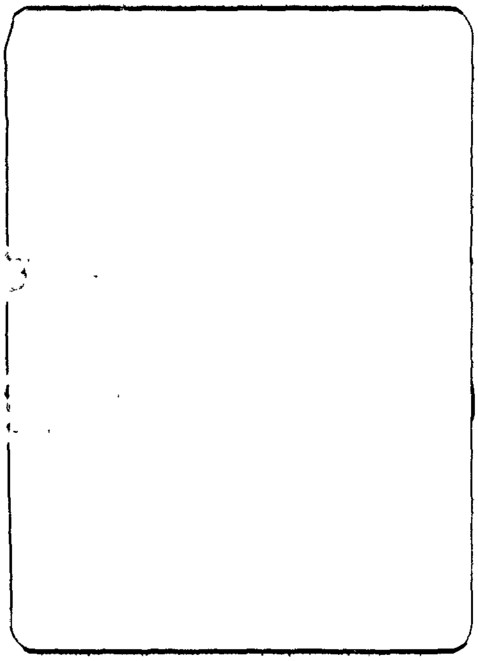


Figure 4.3 (left) The same communities (as Figure 4.2) are much easier to delineate on colour film.

Figure 4.4 (right) The CIR photograph provides the best discrimination between the Sea Lavender and meadowgrass.

Figures 4.2, 4.3 & 4.4 were taken from an altitude of approximately 70m.

tide, the dry bottom pans have a light tone. When wet or flooded the appearance is very dark. Reflection from the sun may change the appearance of the bare substrate between successive photographs, especially in predominantly muddy areas. Inspection of two or more B&W images may be required to detect all of the salt pans. This problem was encountered on the older photographs, where tones and textures were already indistinct and pan boundaries blended with the surrounding vegetation.

4.2.4 The Meadow

The meadow, dominated by meadowgrass constitutes a major portion of the regularly flooded marsh surface. Situated between two very distinctive zones, the coarse textured low marsh and the dark coloured *Juncus* fringe, the meadow is readily recognized throughout the year. Individual communities within the marsh are frequently masked by the dense meadowgrass and may only be observed during specific seasons. All four of the typical meadow communities are rarely observed along any one transect although they are frequently found in close proximity. Individual stand size is small, creating an overall patchy appearance. Detection and delineation of these communities is difficult at best and scale is a major factor when assessing the interpretability of these units.

4.2.4.1 Meadowgrass

Throughout the growing season, meadowgrass, within both the Meadowgrass (typical) community and the others (Orach, Sea Milkwort and Black Rush) undergoes continual change. These changes as recorded on film, alter the appearance of any community containing meadowgrass and an understanding of the seasonal variations is necessary to ensure accurate interpretation.

Early in the season the litter mat, remaining from the previous year's growth, is highly visible producing a characteristic rough texture on all film types. On colour and CIR photographs, this registers as a straw-coloured image; B&W photos show this as a medium grey. Slender green shoots growing up through the mat are not seen from the air until late spring. Wetter areas, including those closer to the shore and subject to more frequent inundation, appear to begin growing before the higher and drier sites. Large scale colour and CIR photography are the optimal photographic systems at this time; however, consideration must be given to the great variation in texture, colour and the initiation of growth between years. This is dependent on local climates.

In the spring, both the Cordgrass/Meadowgrass transition zone. and sites where these two communities are highly intermixed, are easily identified by the textural and tonal differences previously discussed. Figure 4.5 illustrates the variability in an area characterized by a hummocky topography. In the early summer, the Meadowgrass community takes on a smooth even texture and tone as the dense meadowgrass fills in (see also Figures 4.2, 4.3 and 4.4). By mid-summer (early August) the weak stems have bent under their weight producing a 'cowlick' pattern and rough surface texture. This characteristic response has been observed throughout New England where meadowgrass is a marsh dominant (Brown 1977). The time of maximum cowlick formation is variable, from mid-July to mid-August. Photographs taken at the same date on subsequent years, show markedly different patterns in the Meadowgrass community. This is especially noticeable on B&W photographs. The bright green or medium pink

Figure 4.5: The hummocky topography seen here is reflected in the vegetation. Cordgrass occupies the lowest sites with meadowgrass at slightly higher elevations. In the spring, it is the lower, wetter meadowgrass that first appear green.

tones on colour and CIR photos, respectively, are not easily confused with other communities in the summer. The Cordgrass/Meadowgrass transition zones are readily identified on all but B&W images. Owing to the narrow area covered or highly interspersed nature of this community, it is rarely of sufficient size to be precisely delineated, even at large scales (see also Figures 4.1, 4.2, 4.3 & 4.4).

Flowering seed heads were not identified on any of the aerial photographs examined, although ground level photographs illustrated their distinctive texture. Elsewhere, the coarse texture produced by scattered patches of flowering meadowgrass has been described (Brown 1977).

Fall photographs are generally highly variable in time and texture across the marsh surface. B&W photographs, even at large scales, tend to be confusing and delineation of individual meadow communities is difficult. The Meadowgrass community cannot be consistently identified. As the density of cowlicks increases (especially in the upper regions) and deterioration of the meadowgrass progresses, the Meadowgrass community and, in fact, the entire meadow zone appears covered with irregular to circular patches of varying tones and textures. Despite the textural variations inherent in fall photography, the single best image for meadowgrass interpretation is the large scale CIR. In this photograph, texture is not the prime indicator; rather, the straw-coloured grass and litter mat is a more important criterion. Even the smallest Meadowgrass can be identified by this characteristic.

4.2.4.2 Orach

The Orach community is not directly observed on standard format aerial photographs. Its distribution is usually very patchy and the single distinguishing species, orach, is often obscured by the dense meadowgrass. However, eelgrass mats, frequently associated with orach near the meadow/low marsh boundary, are readily identified on all film types, at all scales and throughout the year. During the mid-summer season, a high density of bleached eelgrass mats were recorded in shallow depressions on the low meadow. This corresponds to the typical Orach community site and its presence may be inferred in these locations.

Well into the upper meadow, often within the Sea Milkwort community, a deep but discontinuous line of rafted eelgrass is usually seen. Comparison between successive years indicates the highest level of eelgrass litter remains reasonably constant from year to year. This would appear to correspond to the highest annual storm level. By early spring this eelgrass debris is already bleached, probably having been deposited during the winter months when storm activity is at a maximum. According tp field data Orach is occasionally, but not consistently, reported within this zone. Its presence may be inferred at these sites.

4.2.4.3 Sea Milkwort

Based on the composition of the Sea Milkwort community, identification is difficult even under optimal conditions. Where either differential sea milkwort or seaside plantain constitutes monospecific stands, separation of this community from the others is possible. Elsewhere, however, meadowgrass effectively masks from aerial view any evidence of the presence of the differential species. At the upper meadow boundary, where meadowgrass density is reduced, identification is less difficult but the lower Sea Milkwort community limit remains obscurred. Occasionally, a slight but distinct rise in elevation denotes the lower Sea Milkwort boundary.

In the early and late seasons, when the meadowgrass is matted down, the understory species can grow through the grass stalks. From the air, the resultant pattern appears to be composed of a number of circular and sometimes intersecting, patches of variable size and tone/colour. At the same time, however, the entire meadow has a similar appearance and delineation of separate communities is difficult. In comparison to the Meadowgrass community, the Sea Milkwort shows less actual surface roughness when viewed stereoscopically. The overall effect is a smoother but still highly variable appearance.

Timing of photography to specifically delineate the Sea Milkwort community is critical with late summer being the optimal period. This is before the entire meadow takes on the characteristic fall patchiness, but after the understory species (sea milkwort, seaside plantain) are visible through the meadowgrass. Individual patches cannot be specifically identified even on large scale photography taken only months after the survey.

The Sea Milkwort community is recorded as a discontinuous band of variable width within the upper meadow. It is most frequently observed in the meadow slack between two dune ridges nearly perpendicular to the foredune crest. Elsewhere, and especially where the meadow is wide, Sea Milkwort occupies small stands scattered throughout the middle and upper regions. In both sites, this community is frequently confused with the Black Rush.

4.2.4.4 Black Rush

Black Rush is a very distinctive species, easily recognized on most aerial photographs regardless of scale, film or season. However, as a component of the Black Rush community with an average frequency of occurrence of less than 60 percent, it is not a particularly consistent indicator for aerial interpretation. Where the occurrence and/or density of black rush is substantially less than the maximum, identification must be based on a combination of the other differentiating species, including red fescue, silverweed, seaside goldenrod, sea milkwort and other grasses. In this circumstance, it is difficult to consistently separate the Black Rush from the Sea Milkwort community.

The Black Rush community is easily confused with other meadow communities during spring and fall. This is attributed to the similarity in tonal and textural variations created by the appearance of understory vegetation and cowlick formation.

During the summer season, black rush can be identified by its characteristic colour (reddish-brown) and coarse texture. This is especially easy to identify on colour photographs, even small scale. The lower boundary of the community is generally irregularly scalloped with many smaller stands scattered within the Meadowgrass or Sea Milkwort communities. These are rarely of sufficient size to delineate, even on large scale photographs.

Associated species, such as red fescue, may ease identification of the Black Rush community,especially during their flowering period. Although this stage was not specifically recognized in any of the images analyzed, the dramatic effect is illustrated in Figure 4.6. By late

Figure 4.6: The Black Rush community may be identified by the presence of red fescue. In late summer it is highly visible, as shown here. Between stands of fescue, black rush characterized by its bright green colour, occupies slightly lower areas. From this photograph, it is obvious that the Black Rush community as defined in this study has at least two very different expressions.

summer, red fescue has flowered and die-back has occurred producing stands (sometimes very dense) having a distinctive colour and texture.

4.2.5 The Fringe

The fringe zone is rarely confused with other marsh communities regardless of film type, scale or season of photography. Its dune slack/ margin habitat and characteristic vegetation, baltic rush, are unique. However, it is usually difficult to separate the two fringe communities, Baltic Rush and Rush/Marram. More obvious here than elsewhere in the marsh sequence, the two communities represent a continuum in the vegetation, the major difference between them being the density of baltic rush. Separation of the two fringe communities is difficult based on baltic rush density values. It has been shown that baltic rush density is consistently underestimated by on ground measures when compared to aerial inspection (Seher & Tueller 1973). The two communities will be discussed together.

4.2.5.1 Baltic Rush and Rush/Marram

Summer is the best season for delineation of these communities when the entire fringe zone acquires a black to dark olive green cast, depending upon baltic rush density and the number and kind of associated species. On B&W films, the Baltic Rush commuity produces the darkest tone of all marsh communities. The characteristic tone and stippled texture, coupled with topography yields near certain identification of the Baltic Rush community. However, precise delineation of the upper boundary is difficult at most times.

The texture of the fringe zone is coarse, as baltic rush remains upright throughout the year and generally topography is hummocky. Within the upper Baltic Rush community, species composition increases owing to the fresher nature of the environment. While this may increase the IR reflectance (because of the denser cover and multiple leaf layers) (Anderson et al. 1975a), the patchy distribution is visible and can be confusing.

Bayberry, a component of both communities, has a distinctive photographic character. When viewed from the aerial perspective, the individual and intersecting shrubs appear as a black, dark green or deep red circles on B&W, colour, and CIR films, respectively. This is especially noticeable on summer imagery. Delineation of the shrubs is simplified by stereo viewing. Examination of the aerial photographs at survey locations has revealed an otherwise unrecognized feature regarding bayberry distribution. The bayberry shrubs form a near-continuous belt around the Baltic Rush community. This also coincides with the break in slope around the low dunes. Despite this, the inability to otherwise reliably identify the Rush/Marram community limits the utilization of this feature as a photo indicator at other sites.

In summer the Rush/Marram community has a stippled texture, varying between grey and green on colour photographs and shades of medium to dark grey on B&W. Low nearly circular dunes, often found within the upper meadow, are emphasized by the combination of communities, especially on B&W photographs. The dark Baltic Rush community outlines the topographic high and grades into the light grey Rush/Marram community on the dune crest. The infrared reflectance of baltic rush is quite distinctive relative to the marram (and all other species) in mid-season (Figure

4.7). While a distinct boundary is often difficult to determine, one can be identified subjectively. The IR characteristics of the two species enable optimal delineation of the boundary on fall CIR photography. In October, marram registers as a pale pink against the faintly blue sand and contrasting sharply with the brown-green baltic rush.

On spring and all but CIR fall photography, the fringe communities appear similar. Although highly variable, texture is generally coarse and the colour or tone, dark.

4.2.6 Evaluation

The preceding descriptions illustrate the correlations between photo communities and the typical marsh communities. Not all communities could be identified equally well, but most could be delineated under optimal photographic conditions. Communities that could not be consistently identified were of three types based on plant size, plant density and community or stand size. The first group including the Glasswort, Orach and, to a lesser extent, Sea Milkwort communities are all defined by inconspicuous differential species. In all cases, the distinguishing species are low growing, scattered and generally hidden beneath taller plants (e.g., meadowgrass). While baltic rush, a very distinctive species, can usually be seen, the Baltic Rush community cannot be reliably separated from the Rush/Marram under most circumstances. The subtle changes in plant density of the dominant species could not be recognized in this (or the Meadowgrass) community. The dunelet zone was easily identified by its topography and profile position; however the typical Sea Lyme Grass community rarely extends over a large enough area to be seen on aerial photo-

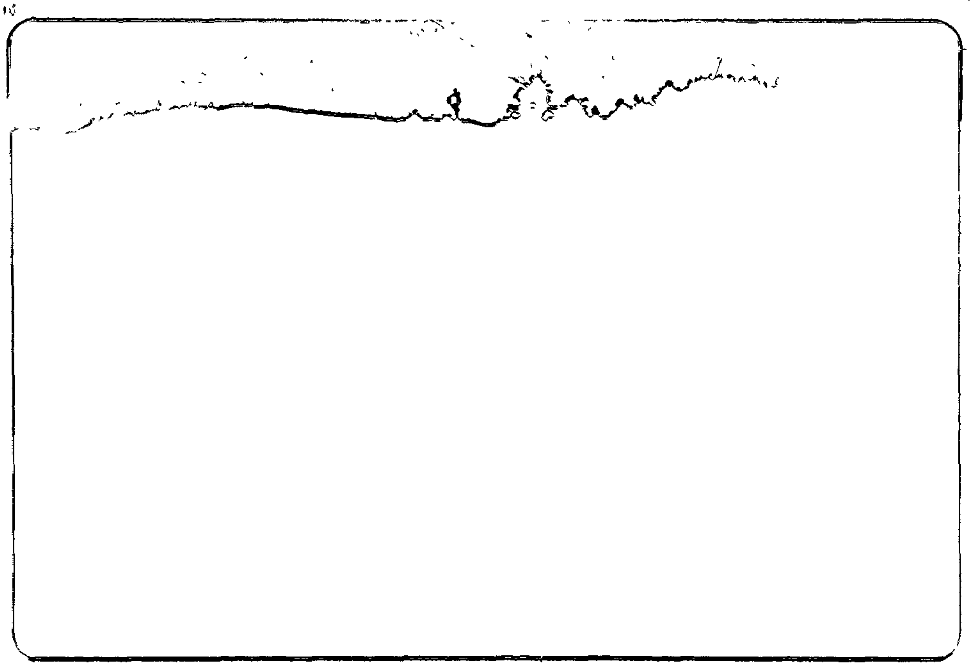


Figure 4.7: Four distinctive zones can be easily identified in this photograph. In the foreground, the meadow contains pans and ponds colonized by salt marsh bulrush. Marram is found on the dunes with baltic rush at the upper marsh border. The infrared reflectance for each of these dominant species is unique.

graphs.

The communities most easily recognized and delineated were those forming, nearly continuous zones, approximately parallel to each other. These include the Cordgrass, Sea Lavender, Meadowgrass and Black Rush communities. The communities not consistently identified are characteristically found in patches or stands of limited areal extent. Larger scale photographs (>1:3,000) should increase the interpretation of these communities. Even where the differential species are obscurred by taller vegetation, other accompanying features, such as salt pans or cordgrass and eelgrass mats for the Glasswort and Orach communities respectively, are more likely to be identified and used to infer community occurrence. Examination of large scale (c. 1:2,000) B&W, colour and CIR photographs taken by 35 mm camera from fixed-wing aircraft at the time of surveying indicates (Frontispiece, Figures 4.8 and 4.9) indicates all communities may be more easily identified at these larger scales.

To complete the description and evaluation of photo communities, twenty-nine sets of aerial photographs were interpreted. The aquisition data for these photographs are summarized in Table 4.2. All but six sets of photographs are B&W and most of these are medium scale, summer and spring images. With a biased data set such as this, it is difficult to derive comparable conclusions regarding the ease of interpretation from different photo scale/film/season combinations. There are, for example, no fall colour images, of any scale, to compare to summer and spring colour or fall B&W and CIR images. All colour and CIR photography was of limited areal coverage and comparable photographs at each of the three study areas were not generally available. This sporadic coverage, however,

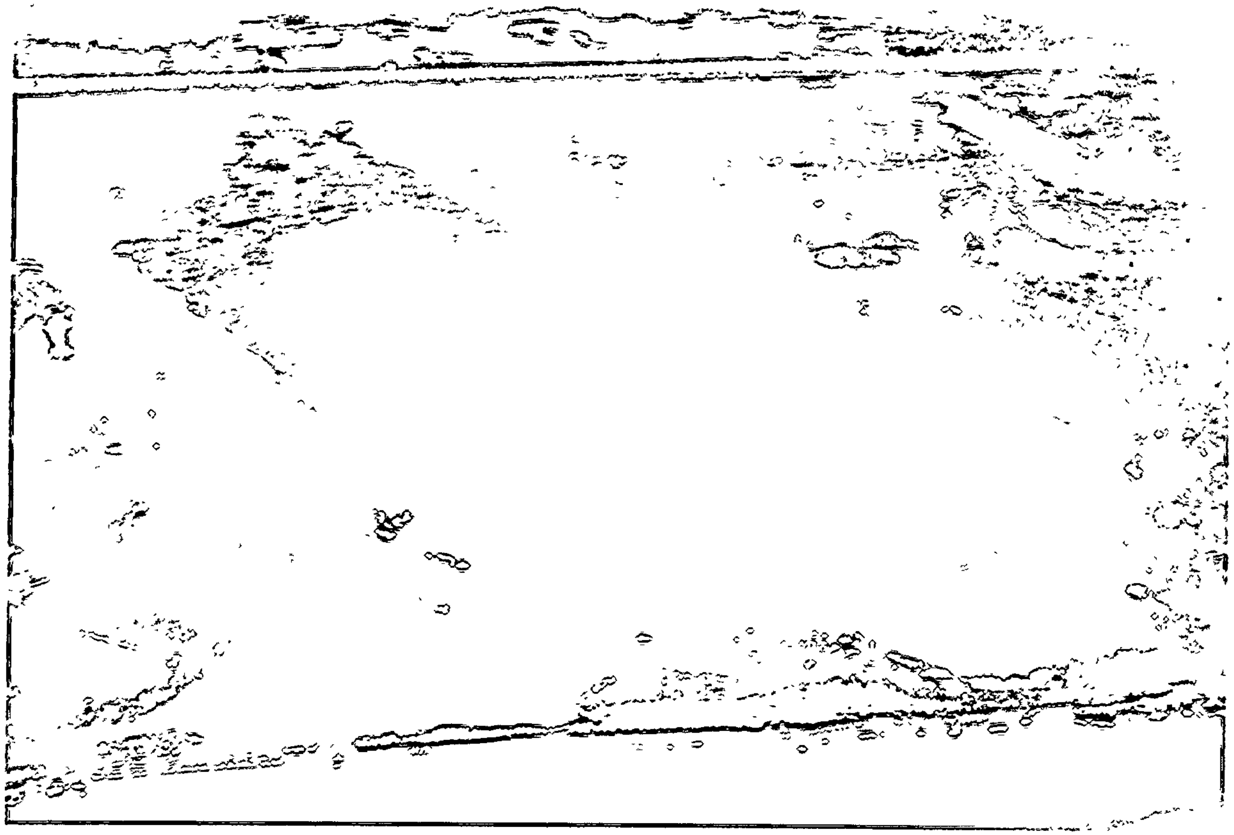


Figure 4.8: A black-and-white aerial photograph of Brackley Marsh at mid tide. While all individual communities cannot be identified, the most zones are recognizable.

TABLE 4.2: SUMMARY OF AERIAL PHOTOGRAPHS ANALYZED TO DERIVE PHOTO COMMUNITY DESCRIPTIONS AND EVALUATIONS.

	BLACK AND WHITE			COLOUR			COLOUR INFRARED		
	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
Spring (May-June)	1	8	-	1	-	-	-	-	1
Summer (July-August)	2	8	1	-	1	1	-	1	-
Fall (September-November)	1	2	-	-	-	-	1	-	-

is typical for most non-urban areas of the country. In most cases, both print and transparency products for colour and CIR films were examined.

It is important to consider the actual film type/scale/season combinations and numbers of each sampled when evaluating community identification from aerial photographs. A sample of three photographs used in this analysis, is shown in Figures 4.10, 4.11 and 4.12.

An evaluation of the typical marsh, communities and zones interpreted from aerial photographs is summarized in Table 4.3. This evaluation is based on the analysis of medium scale photographs, except where indicated. Large scale photos were included when comparable medium scale (CIR and colour) images were not available. In both cases, it would appear that the larger scale photos do not necessarily provide more information but do increase reliability of identification and accuracy of boundary placement. The number of samples of available small scale images was insufficient to draw reliable conclusions. However, there was considerable loss of information on the small scale photos compared to the medium scale images. Small scale B&W and colour photographs exhibited significant deterioration of clarity by haze interference. This problem was less sever on all CIR images, both prints and transparencies. In addition, image quality of all colour photography was far superior in the transparency form compared to prints.

<u>Film Type:</u> The major differences in accuracy and ease of community identification are based upon film type and season of photography. In the case of film type, it is the spectral characteristics of individual species (or groups of species) and their resultant photo response that causes interpretation differences. For example, baltic rush exhibits a

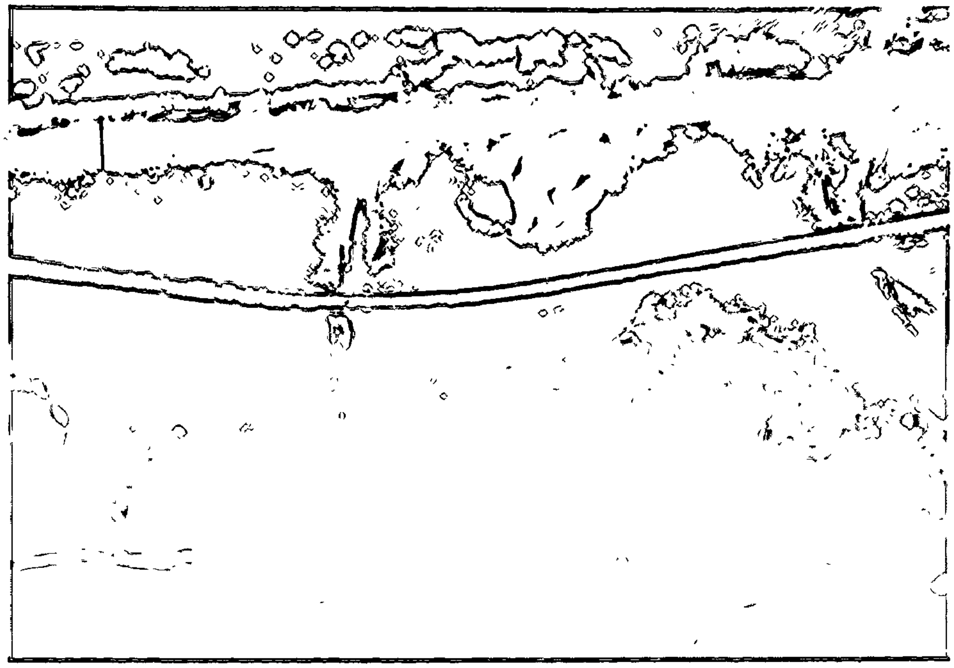


Figure 4.10: A summer black-and-white photograph. The original scale was 1:10,000. The Brackley 2B transect is shown.

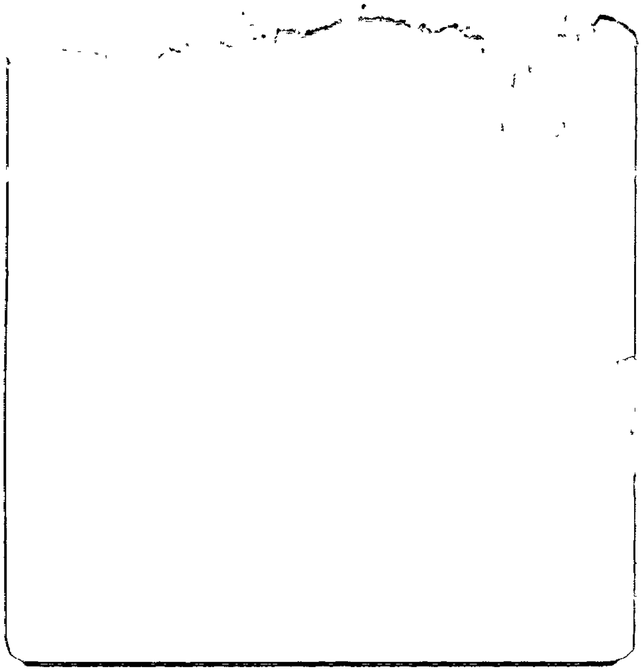


Figure 4.11: (left) Summer colour photograph of the same area. The original scale was also 1:10,000. The addition of colour simplifies community interpretation especially within the meadow.

Figure 4.12: (right) Separation of communities is optimal on this fall CIR image (original scale-1:3000). However, identification of individual communities (or species) is difficult without the true colour photo.

TABLE 4.3: EVLAUATION OF ZONE/COMMUNITY IDENTIFICATION FROM AERIAL PHOTOGRAPHS BASED ON FILM TYPE AND SEASONAL VARIATIONS.

	BLACK AND WHITE			COLOUR			COLOUR INFRARED		
	Spring	Summer	Fall	Spring*	Summer	Fall	Spring	Summer	Fall*
DUNELET	○	○	○	○	○	NOT AVAILABLE	○	○	◐
Sea Lyme Grass		○			○		○	○	◐
LOW MARSH	○	◎	○	○	◎		○	◎	◎
Cordgrass	○	◐	○	○	◐		○	◎	◎
Sea Lavender		◐	○		○			◐	○
Glasswort	x	x	x	x	x		x	○	◎
MEADOW	◐	◎	○	◎	◎		◎	◎	◎
Meadowgrass	○	◎	◎	◐	◎		◐	◎	◎
Orach	x	x	x	x	x		x	x	x
Sea Milkwort		○			◐			◐	○
Black Rush	○	◐	○	◐	◎		○	◐	◐
FRINGE	◐	◎	◐	◐	◎		◐	◎	◎
Baltic Rush	○	◐	○	◐	◎		○	◎	◎
Rush/Marram		○		○	◐		○	◐	◎

◎ optimal
◐ good
○ poor
x by inference
* evaluation based on large-scale imagery

unique dark tone on B&W and colour photos, and has a distinctive IR reflectance. It is easily recognized on all film types. Each species or community produces a characteristic photo tone or texture at different stages of growth. Maximum photo variation will not occur at the same time for all species. Some species are more readily recognized in spring, others in the fall. The optimal combination of film and season should enable the delination of a maximum number of communities with the greatest reliability. This combination can be derived from the preceding analyses.

In general, B&W photographs were the least reliable for delineation of community boundaries and community identification. Shades of grey tended to blend with one another, producing indistinct patterns (Figure 4.10). Water was easily confused with damp sand and submerged vegetation (e.g., cordgrass) was rarely visible.

While colour photographs contain essentially the same information as the B&W images, identification of communities was simplified. Comparison of natural plant colours through the seasons with photo colours increased the accuracy of boundary delineation and identification of all communities, especially where plant colours are distinctive (e.g. black rush) (Figure 4.11).

CIR imagery provided maximum discrimination of all communities owing to the unique IR reflectance characteristics of the different vegetation species. However, without adequate ground information, species (community) identification is difficult. (IR reflectance characteristics are not typically known for each species). Large scale CIR photographs actually provided more detail than required, based on the typical marsh communities (Figure 4.12). Individual species within the meadow zone could be seen but not specifically identified. This created some problem in delineation of the meadow communities. While medium scale photographs did not exhibit these characteristics, comparable seasonal information was not available to precisely define their cause (either seasonal or photographic).

Season: The time of photography appears to be more important in the identification and delineation of communities than either film type or scale, although they all must be considered simultaneously. Spring photography is generally unreliable for the identification of individual communities. However, the major zones could usually be recognized on all film types (Figure 4.13). Most marsh vegetation in the southern Gulf of St. Lawrence is not sufficiently developed to be accurately identified at this time of year. In addition, year to year variations in the onset of spring growth have been shown to create significant differences in photo characteristics on photographs from successive years.

By summer and throughout that season, most communities take on a uniform characteristic tone and/or texture. 'Peak-of-green' conditions are usually recommended for maximum discrimination (Reimold & Linthurst 1975). The results presented here do not conflict with this statement. The *Juncus* species flower early in the season and inflorescence is required for optimal identification. However, *Spartina* species bloom later in summer and do not flower simultaneously. Although flowering stands were not recognized on photos in this analysis, the pattern of bloom would tend to confuse interpretations, especially on B&W photos.

Fall photographs appeared to exhibit maximum variation in

Figure 4.13: An early spring photograph (May 1978) shows little evidence of vegetation growth. Major zones can be identified although communities cannot.

tonal/textural contrast. However, in the case of the meadow communities, variations often obscured relevant community information. Where communities and approximate boundaries had been previously established, fall photography enabled precise delineation of some boundaries. This was more evident on CIR photos than B&W and was best for the fringe, Black Rush, Cordgrass and Glasswort (based on cordgrass presence) communities. Similar conclusions are predicted for fall colour photography although discrimination is not likely to be as distinct.

The optimal single photographic coverage for the identification and delineation of marsh communities is summer colour photography. Large scale photographs are superior to medium scale and will show greater accuracy in boundary placement. However, medium scale photos appear to be sufficient for the identification of most typical marsh communities. Where more than one set of photographs is available (or can be acquired), summer colour in combination with fall CIR is optimal. All communities identified as typical to these salt marshes should be easily delineated.

4.3 SPATIAL EXTRAPOLATION

4.3.1 Introduction

It has been demonstrated that most of the plant communities can be identified from aerial photographs using their tonal and textural photo characteristics. The variability in tone and texture along the transect as outlined on the aerial photograph, corresponds to the community distribution as indicated from survey notes. However, considerable variation in photo pattern is observed between transects. This is also recorded in the differences in communities between each transect.

In order to describe and understand the development and ecology of the marsh system, community distribution needs to be considered. To extend the application of the photo community descriptions, three examples will be examined. This will be accomplished in the following manner:

1) Interpretation of marsh communities extending several hundred meters either side of a known transect will be completed on a single B&W image viewed in stereo. The profile and community data will be used to establish the initial photo communities.
2) Interpretation will be carried out in a second area, without benefit of community or profile information. The completed interpretation will then be compared to these data.
3) A detailed map will be produced using the optimal image combination. This will cover areas not specifically included in the intitial ground survey.

All discussions can be related to the typical marsh profile.

4.3.2 Interpretation About A Single Profile

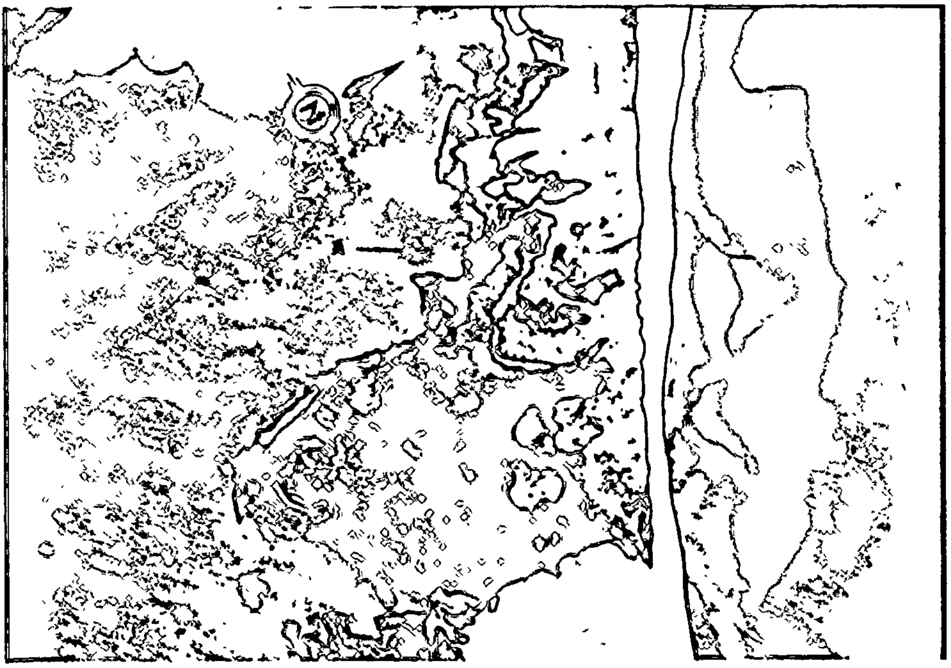
In order to test the reliability of the photo community descriptions as defined in Section 4.2, communities along a single profile were delineated and then extended on either side of that profile to cover a distance of approximately 800 m. Changes in community composition, appearance and distribution were also noted.

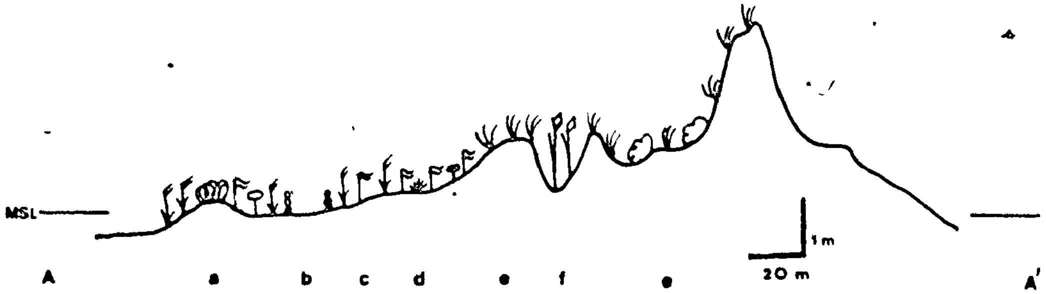
The 2A transect of South Richibucto Beach was selected for this interpretation as it has a varied community composition. Although none of the rush communities were identified along this profile, the other communities are well represented. Of the ten typical marsh communities, five are recorded at transect 2A. Specifically, these are Cordgrass, Sea Lavender, Glasswort, Meadowgrass and Sea Milkwort. Photo interpretation was completed using a medium scale (1:10,250) summer B&W stereopair.

According to Table 4.3 all of these communities, with the exception of the Sea Milkwort and Glasswort should be easily identified and delineated. The latter community can be inferred by the presence of salt pans. The dune communities are unspecified and contain marram, bayberry and freshwater cordgrass.

The relationships between the photo communities, floristic communities and the surveyed profile are shown in Figure 4.14. Individual communities could not always be separated. At the lagoon shore, group a, consisting of the Cordgrass and Sea Lavender communities separated by a wrack zone, can be identified. At the transect location, these two communities could not be distinguished because of the narrow zone width. However, further along the barrier towards the southeast, a wider band of Sea Lavender could be separated from the Cordgrass. Elsewhere (towards the northwest) both low marsh communities form a discontinuous border at the marsh edge. Although a low marsh community is not always visible, it is unlikely that a meadow community is directly exposed to tidal influence. More likely, the size of the low marsh community is below the level of resolution of the B&W photography.

Presence of the Glasswort community can be inferred throughout the photo area by the occurrence of salt pans (b) although none of the component species can be seen. Throughout much of the area, salt pans are sparse and usually found in the lower meadow. Where the barrier widens, many small pans can be identified. This figure (Figure 4.14) does not show the outline of all salt pans and creeks. Others can be identified by the bleached eelgrass and algal mats at the pan margins. The stereo image was required to accurately delineate all salt pans, ponds and creeks.





	ZONE	COMMUNITY	Indicator Species
a	*LOW MARSH*	CORDGRASS	Cordgrass
			Wrack
		SEA LAVENDER	Sea Lavender
b	*Salt Pan*	GLASSWORT	*Inferred*
c	*MEADOW*	MEADOWGRASS	Meadowgrass
d		SEA MILKWORT	Sea Milkwort
			Plantain
e	*DUNE*	Unspecified	Marram
			Bayberry
f			Freshwater Cordgrass

Figure 4.14: Interpretation of marsh communities about a known transect (South Richibucto Beach 2A). Most communities present could be identified on this summer medium scale photograph.

Two meadow communities can be separated. The Meadowgrass community (c) exhibits great variability along and adjacent to the profile. This may be attributed to the hummocky marsh surface. Small pockets of cordgrass are frequently mixed with the Meadowgrass, as illustrated in the profile diagram (Figure 4.14).

The Sea Milkwort community (d) forms a discontinuous zone at the upper edge of the meadow. Without the surveyed profile data identification of this unit would have been restricted to 'an upper meadow community', probably Sea Milkwort, Black Rush or perhaps, Baltic Rush The photo characteristics of the Sea Milkwort community are indistinct.

The dune communities (e) show great variability in tone and texture. Within this zone, a monospecific stand of freshwater cordgrass was identified along the profile (f). Several other similar communities were delineated in nearby slacks. Without profile data this community would not have been identified.

Throughout this study area, interpretation of the marsh communities was accomplished with little difficulty. Identification was aided by the description of the typical marsh profile and communities follow the sequence given in Figure 3.22 with little deviation. Occasionally low dunes were seen out-of-sequence, within the upper meadow. These,however, were easily identified. Sparse communities not included in the photo community or marsh analyses required profile data for their identification.

4.3.3 Interpretation Between Two Profiles

Interpretation of marsh communities in the vicinity of two known profiles was accomplished using a B&W stereopair at a scale of

1:10,000. The photographs were early May images, less than the ideal combination for maximum community delineation. However, most major zones were easily identified and delineated over a 1200 m long area. Individual communities could not be identified. These results agree with those predicted in Table 4.3.

When the interpreted image was compared to the surveyed profile and community analysis, good correlation was observed (Figure 4.15). The low marsh and dunelet zones (a) could not be separated. Neither of the dominant species are sufficiently developed to permit identification. While it is shown as a discontinuous border, unseen Cordgrass likely extends along most of the lagoon shoreline.

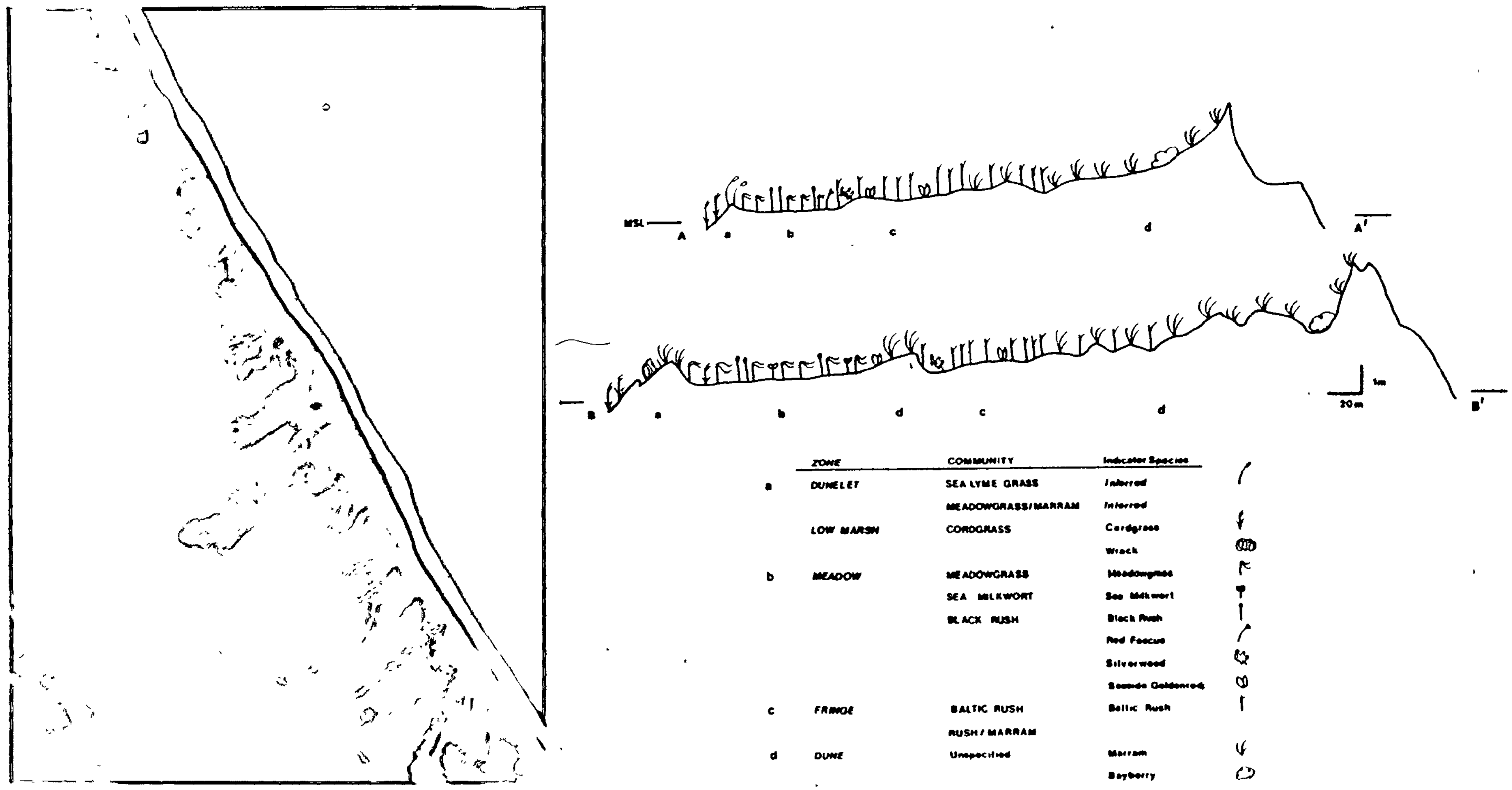
The three meadow communities (b) can be neither separated nor identified. Placement of the upper meadow boundary is sometimes difficult, the patchy appearance of fringe communities mixing with the meadow.

The fringe communities (c) cannot be separated either. However, identification of both communities is enhanced by their dune slack position. Variations in relief are accentuated by the surrounding unvegetated and sparsely vegetated terrain (d).

Only one area, south of B-B^1, could not be identified. It is most likely another expression of one of the meadow communities. Other anomalous communities are probably obscured by the lack of detail evident in the early spring photography.

4.3.4 Spatial Extrapolation: A Case Study

In addition to describing the distribution and variability of communities between surveyed profiles, the two previous examples also



B.

Figure 15. Int tation of marsh communities between two known profiles. Alt dunelet communities could be inferred by the change in raphy, meadow communities could not be separated on thi imagery.

illustrate the level of detail available from a single (stereopair) B&W aerial photograph. This is the usual type of photography available for interpretive mapping purposes. The following example is an extension of the previous analysis. Four separate sets of photography were examined in order to make the final interpretation. Specifically, the data included medium scale, B&W, colour summer and large scale CIR fall photography (Figures 4.10, 4.11 and 4.12). Medium scale CIR summer imagery was also used. According to Table 4.3, this combination should provide optimal conditions for the delineation of all communities. The data were also supplemented by low level non-vertical photographs taken from fixed-wing aircraft (Frontispiece, Figures 4.8 and 4.9).

The Brackley marsh site, covering more than 2 km linear distance, was chosen on the basis of good quality photography being available. In addition, the marsh at Brackley is wider than most others and hence, individual zones should be correspondingly wider. This interpretation of Brackley also provides the basis for the multi-temporal analysis discussed in Section 4.4.

Standard aerial photo interpretation procedures were followed to produce the map (Figure 4.16). The scale, 1:10,000, was selected as being the optimal scale for representing the interpreted data. Most of the photographs were at or near this scale.

Nine communities could be delineated. At the lagoon shore, a discontinuous dunelet is indicated. Although interpretation of the large scale photography indicates its distribution is much greater, the narrow zone is less than the minimum mapping size and therefore, not shown.

At Brackley, the low marsh consists of two communities, Glasswort

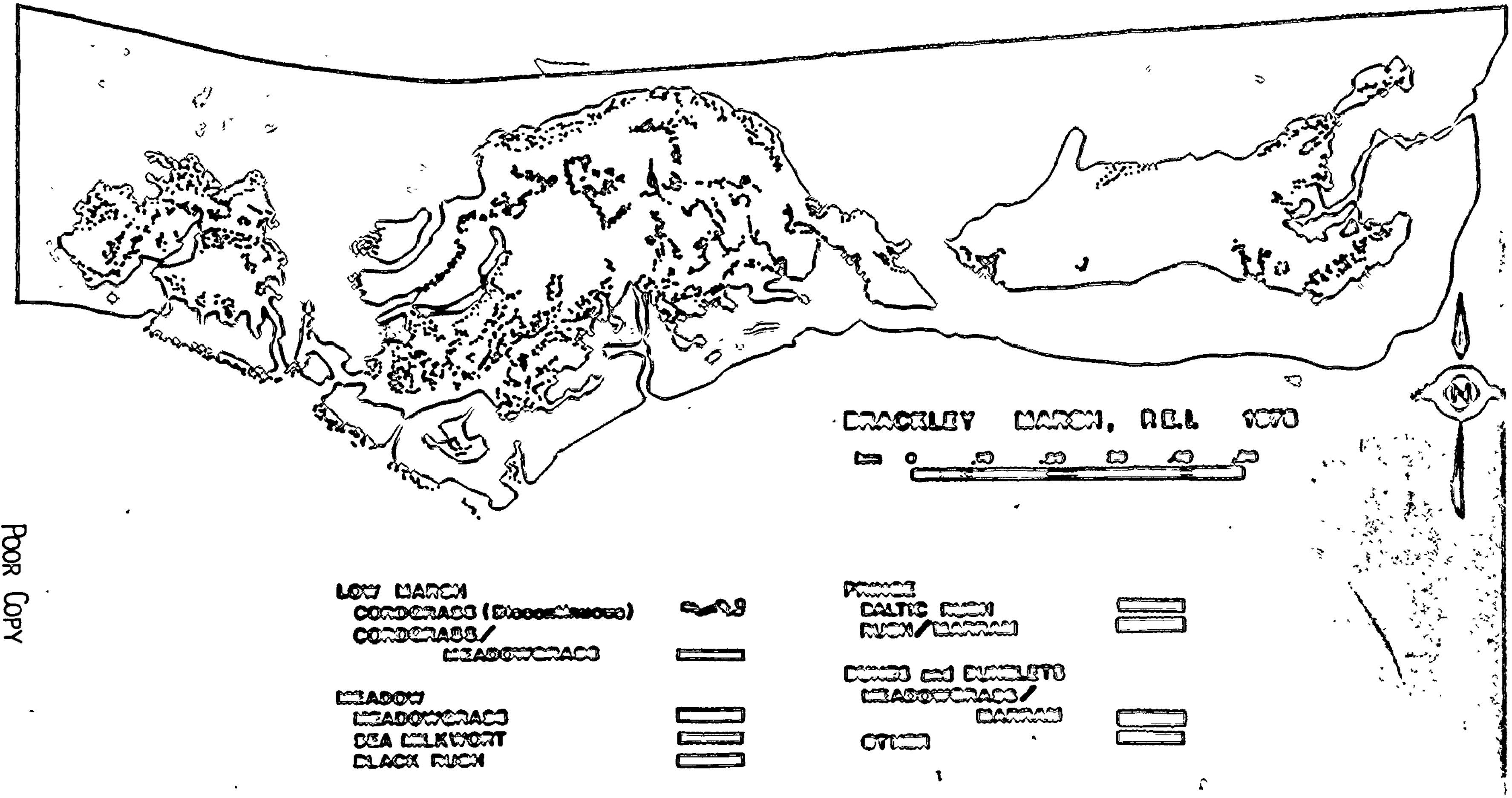


Figure 4.16: Interpretation of Brackley Marsh, P.E.I.; Marsh communities were identified from large- and medium-scale, multitemporal, black and white, colour and CIR photographs.

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and Cordgrass, although only the latter is indicated on the map. The two communities are highly mixed and without ground data there is no accurate way to separate them. From the community descriptions (Section 3.2.2) it is known that the Glasswort community associated with sheltered (but not salt pan) sites is characterized by low vigor cordgrass. Had vertical aerial CIR photographs taken at the time of survey, been available for the marsh, delineation of the two communities might have been possible based on cordgrass vigor. The two vigor types could not be distinguished on late season CIR photography and the oblique aerial photographs are not adequate for mapping purposes. However, as glasswort is an annual species its distribution may change yearly. Without further data regarding the factors controlling glasswort distribution, it is better to group the Glasswort and Cordgrass communities together for this analysis.

Cordgrass is recorded as a nearly continuous border around the marsh. Seen unfrequently in pure stands directly exposed to the bay, it is more often found in the lee of low dunelet or beach on the lagoon shore. At these sites, Meadowgrass and Cordgrass are well mixed, creating a hummocky surface (Figure 4.5). These two communities cannot be delineated individually at this scale.

The meadow communities, Meadowgrass and Black Rush,are easily identified using the combination of films. A third community,the Sea Milkwort, could not be precisely identified on any of the imagery, or from the field notes. Initially identified and delineated as part of the meadow, further field checking was required to identify its specific composition. The community appears to be a variant of the Sea Milkwort unit previously described. Sea milkwort and seaside plantain are its sole constitutents. Early in the season, the plantain appears to be the dominant (Figure 4.17). By mid-season, the sea milkwort is fully developed and the characteristic bright green colour is seen (Figure 4.18). This community has a wide distribution at Brackley, although it was neither recorded nor seen elsewhere. This variation of the Sea Milkwort community is probably indicative of regularly flooded but waterlogged conditions. Its role in the successional sequence will be further discussed in Section 4.4.

The fringe communities, Baltic Rush and Rush/Marram were separated where possible. The variability of baltic rush density within the Rush community complicated this analysis. However, a correlation between areas of high density and topographic lows was noted.

Within the marsh, minor dune formations containing marram and bayberry were recorded. Their occurrence and distribution is related to the historical sequence of marsh developed. This is considered in Section 4.4.

4.3.5 Evaluation

With optimal photography, interpretation of the typical marsh communities can be extended into otherwise unknown areas with confidence. Although anomalous communities cannot be specifically identified, they can be delineated and assigned to the appropriate marsh zone based on topography and position. From this limited survey, the distribution of marsh communities closely follows the pattern defined by the typical profile model. However, it is apparent that not all communities have been incorporated into the typical marsh profile model.

Figure 4.17: This Sea Milkwort community is seen only at Brackley. In the early spring (June) seaside plantain dominates the waterlogged substrates. Its companion species, sea milkwort is abundant, widely distributed but covers very little area.

Figure 4.18: By mid summer the two species combined produce a dense, bright green cover. Remant dunes on the marsh are easily identified by the grass fringe.

4.4 TEMPORAL EXTRAPOLATION: BRACKLEY MARSH, P.E.I.

Aerial photographs for Brackley Marsh, dated from 1935 to 1978 were examined to determine changes in shoreline and vegetation communities. Although these two features are studied separately, there is a definite relationship between them which will be considered in detail. Based on the identification of these changes, the development of the Brackley barrier system may be deduced. In 1956 a road was constructed across a series of washovers along a 2 km section of the Brackley system. Photographs from before and after this will be studied to determine the effect, if any, on the natural barrier formation processes.

4.4.1 Aerial Photo Interpretation

Six sets of aerial photographs dated between 1935 and 1978, determine the sequence of marsh development at Brackley Marsh, P.E.I. This was accomplished through the delineation and assessment of shoreline and community changes. The photographs used in the interpretation are the best available (on the basis of film, scale and season) for the six dates chosen to represent the marsh history. With the exception of the most recent, all photography was large and medium scale B&W acquired during late summer and fall. The dates and scale of the photographs examined are given in Table 4.4. While community boundaries for 1978 were delineated using the CIR transparencies exclusively, the final interpretation was checked against the map produced from a number of photographs, as described in Section 4.3.4. The variability in the level of detail seen in both maps (Figures 4.16 and 4.22).reflects the scales of the original data and the final map product. Much of the detail, visible on the 1:3000 images

TABLE 4.4. LIST OF AERIAL PHOTOGRAPHS EXAMINED FOR THE TEMPORAL STUDY OF BRACKLEY MARSH, P.E.I.

DATE	SCALE	FILM TYPE
1935 August	1:15,200	B&W
1953 September	1: 7,200	B&W
1956 September	1: 7,600	B&W
1958 July	1:15,840	B&W
1960 November	1: 6,000	B&W
1978 October	1: 3,000	CIR Transparency

was lost in the production of the small scale maps (Figure 4.21).

Image quality of the photographs decreased with both age and scale. Although six separate sets of images were examined, only four were used in the final analysis. Two sets, from 1956 and 1958, were excluded because of their poor quality. A steropair of the 1956 photography was unavailable. The position of the marsh on the single photo available was at the edge where distortion and fading are at a maximum. The medium scale photo from 1958 was generally unclear and hence used only for comparison. Between 1956 and 1958, little significant change was identified on the photos that could not also be observed between 1953 and 1960.

According to Table 4.3, interpretations made from the majority of these photographs would be less than optimal. At best, delineation of the major zones could be expected; it is unlikely that communities would be identified separately. The results of this analysis indicate interpretation is better than anticipated. The increase in photo scale, from the medium scale used in the evaluation to the large scale examined in the interpretation, appears to have improved the delineation of zones and communities. In addition, the morphology of the Brackley marsh simplified the separation of low marsh from meadow communities. A distinct cliff on the inner meadow, lower boundary, was visible on all stereo images. This feature is unlikely to be found within a low marsh community.

The meadow, fringe and dune zones could be reliably identified on all images. However, delineation of the low marsh was difficult on all but the CIR imagery. Behind the lagoon beach ridge, cordgrass is interspersed with the meadowgrass (Figure 4.6) and designated accordingly , as a mixed community. Only the largest scale (and CIR) imagery provided sufficient detail to separate the two species although, due to mapping scale constraints, even these had to be grouped. Within the open area in the central portion of the marsh, vehicle tracks were used as indicators of the dense cordgrass stands. Without adequate vegetal cover, it is unlikely that vehicles could have traversed the soft, wet marsh surface without considerable difficulty. Elsewhere, Cordgrass could rarely be delineated, although its sparse and scattered presence, based on present day patterns of distribution, could be inferred.

Once communities and zones had been delineated on the aerial photographs, all images were redrawn to the same scale (1:3,000) using a Zoom Transfer Scope. Proper registration of each photograph required the identification of a set of control points. Very few features suitable for use as control were available for all four photographs. Individual bayberry shrubs identified throughout the photographic record were used as control points within the dunes and dune slacks. It was noted that although the position of the plant did not vary, its shape and size was subject to change over the 43 year period. In the later photography, the newly constructed road and duck blinds, disguised as dunelets, could be used for control. Elsewhere a series of artificial control points was constructed from known points across the marsh surface.

Once the sequence of photographs was properly registered, a comparison of the shoreline and community changes could be undertaken.

4.4.2 Changes in Shoreline and Mean High Water

Within the barrier environment a number of features may be examined from which changes in shoreline may be assessed. The seaward edge of a barrier may be represented by the eroded base of the fore dune. On the lagoon shore, the narrow beach ridge defines the outer marsh boundary. A third 'shoreline' has been identified for the Brackley marsh. Within the marsh a low cliff separates the dense meadow from the sparsely vegetated low marsh creating a distinct inner marsh shoreline. This may be related to specific tide levels. In addition, washover channels and the associated sand flats illustrate the dynamic nature of the barrier environment. Based on an examination of these features, the development of the Brackley barrier and marsh can be determined.

In 1935 there were three active washovers along the Brackley barrier segment. There is evidence that all three were active at this time, although the westernmost washover (closest to the 2B transect) was undergoing a state of decline. By 1953 the narrow washover channel did not appear to be in use (McCann 1978).

Shortly, thereafter, the newly constructed road effectively sealed off all three washovers, although wind blown sand continued to regularly bury the road for several years (M. Simmons, pers. comm.). At the present time, the washovers are completely closed and a low dune dune scarp has formed across the former washover channels.

Both the gulf and bay sides of the barrier show evidence of recession (Figure 4.19). Between 1935 and 1960 average rates of retreat for the dunes and lagoon ridges were 1.03 and 0.92 meters per year, respectively (McCann 1978). This amounted to averages of approximately 26 and 23 meters over the 25 years. While the amount of recession identified here is only approximately one half that, the pattern of retreat remains

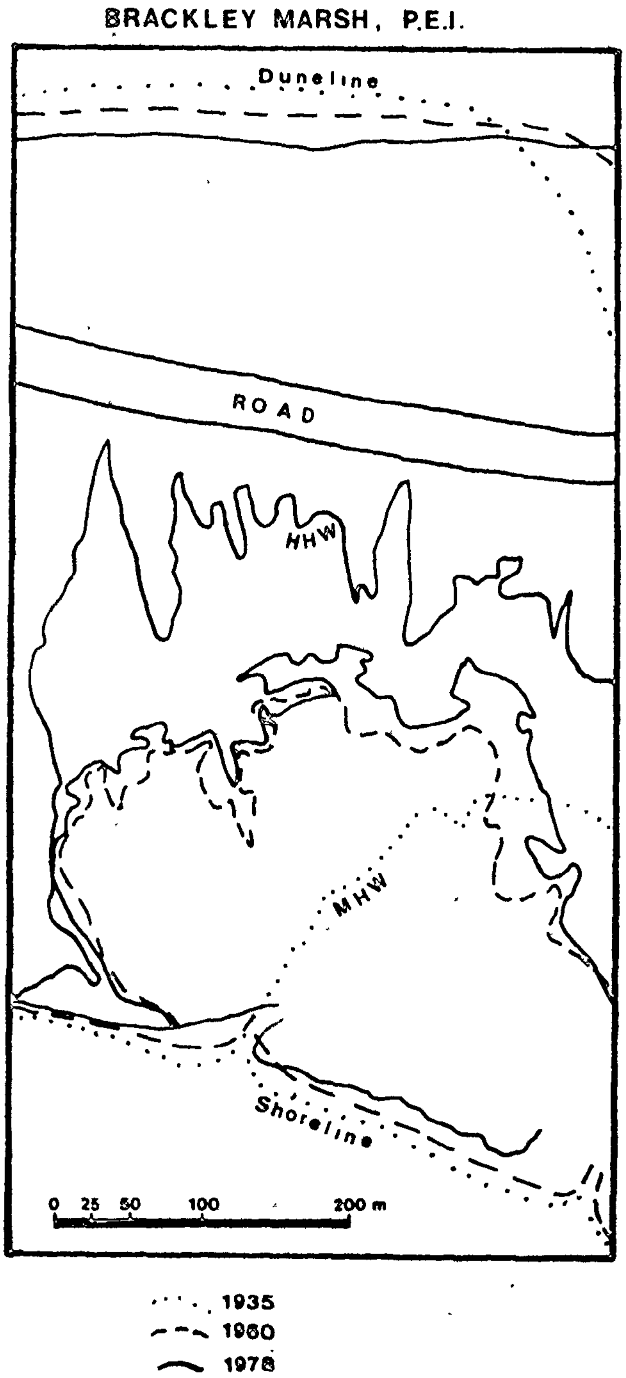

Figure 4.19: Changes in shoreline and mean high water (MHW) limit between 1935 and 1978, as interpreted from aerial photographs.

similar. On the bayshore, erosion is greatest in the vicinity of tidal creeks and least along the headland shore. Erosion of the fore dune is relatively consistent except near the washover where fences had been constructed to promote accumulation of sand and growth of vegetation.

The difference in erosion rates between this and the previous study (McCann 1978) may be attributed to the method of calculation. In the latter study, measurements were taken directly off the photographs, whereas here a comparative method was used with the Zoom Transfer Scope to rescale the photographs. Both procedures allow for error in the selection and alignment of control points and delineation of the required boundaries.

Given the nature of the barrier, erosion is not unexpected along both shorelines. The transgressive character of the barrier is maintained by deposition of sand by wind and water over the dunes and through washovers. McCann (1978) cites early (c. 1775) nautical surveys depicting Brackley as an offshore island, as evidence of the long history of landward movement.

The inner marsh shoreline, directly exposed to tidal action, is visible on all photographs and represents the lower meadow boundary. A narrow fringe of cordgrass is only occasionally visible, although its presence may be inferred throughout the photographic record. As previously determined, the limit of mean high water (MHW) is located within the meadow zone (Sections 3.4 and 3.5). Specifically, the height (above MSL) of the Meadowgrass community at Brackley is centered around MHW. While individual meadow communities, such as the Meadowgrass, cannot be precisely delineated, placement of the MHW line is, at best, approximate, and may be ascertained to be located within the lower meadow regions.

In the past, air photo interpretation has been used to establish tide levels (Carter 1977). An abrupt change in topography (Hull et al. 1973) or zone of wrack, either cordgrass or eelgrass (Guss 1972) have been used to delineate MHW. In New Jersey, MHW has been identified as the boundary between high and low vigor forms of cordgrass (Anderson & Wobber 1973; Wobber & Anderson 1972). Brown (1977) supported these findings with similar results in New York. Further north, the traditional MHW line has been defined as the boundary between cordgrass and meadowgrass (Redfield 1972).

It is suggested here that this boundary, between the Meadowgrass and Cordgrass communities be identified as representative of MHW for the Brackley study area. It is understood that while this is a slight underestimation of this tide level (Figure 3.28), it is the best available using aerial photo interpretation.

The changes between 1935 and 1978 in MHW, as indicated by the position of the lower Meadowgrass limit, are shown in Figure 4.19. The upper limit of present day (1978) salt water influence (HHW) is identified by the Baltic Rush community (Section 3.4) and is shown for reference. From the aerial photo record, the major trend can be identified. There has been considerable erosion of the meadow or inner marsh shoreline. From all photographs this can be identified as a low eroding cliff, evidenced by the numerous, irregularly shaped hummocks in front of the boundary (Hubbard & Grimes 1971). Water and ice are the eroding agents. Most of the erosion occurred between 1935 and 1953, before the road was built, although it is still continuing at the present.

This erosion can be interpreted in two manners. Firstly, penetration of tidal waters into the marsh will be increased. The reduced (or removed) vegetal cover, provides access for surface waters into the previously drier areas. Secondly, assuming that the marsh profile (from the gulf to lagoon shores) is not perfectly flat, but rather slopes gently southwards as does the present day surface and that the meadowgrass limit is a consistent record of MHW through time, this pattern is evidence of a rising water level relative to the land. Tide records from Charlottetown indicate a rate of submergence of 26 cm/100 years. If similar rates exist at Brackley, this is equivalent to 11 cm over the 43 year study period. It has been shown that a variation in height relative to sea level of this magnitude (or even less) is sufficient to change community composition (Figure 3.28). While it is not suggested that the Brackley barrier is experiencing subsidence at this rate, it is a possible explanation for the change in apparent MHW. This may also be affected by erosion of the newly exposed flats within the dynamic barrier environment.

It is expected that this trend towards a 'wetter' marsh over the period of study will be reflected in the vegetation. This will be considered in the next section.

4.4.3 Changes in Vegetation

Changes in vegetation follow a systematic arrangement defined by successional trends. In the barrier environment, this trend is from hydric to xeric (or mesic) conditions, except where the sequence is interupted by other forces (e.g., mowing of meadowgrass). Figures 4.20 and 4.21 illustrate two proposed succession patterns for marshes within the Maritime provinces. They both follow from an initial unvegetated flat to the

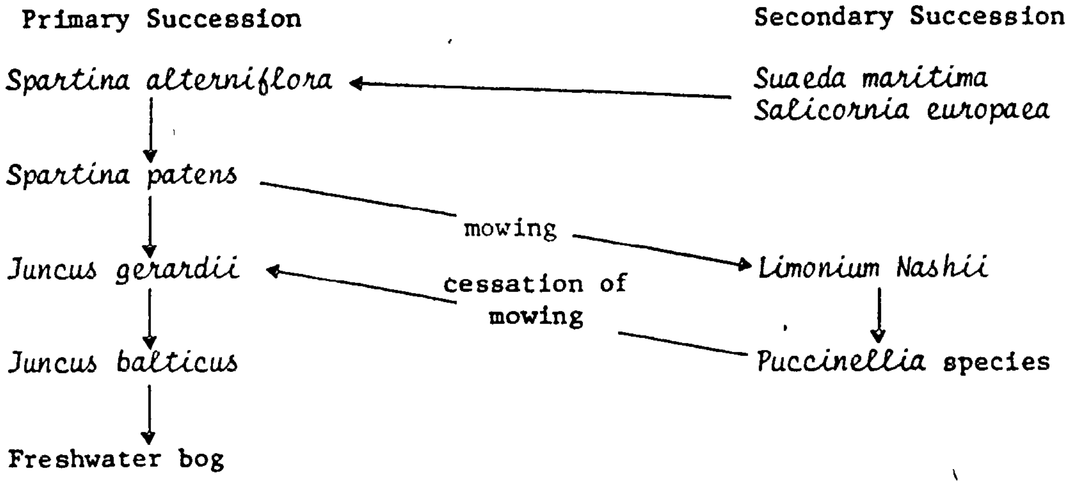

Figure 4.20: Succession patterns for salt marshes in eastern Canada (Chapman 1974).

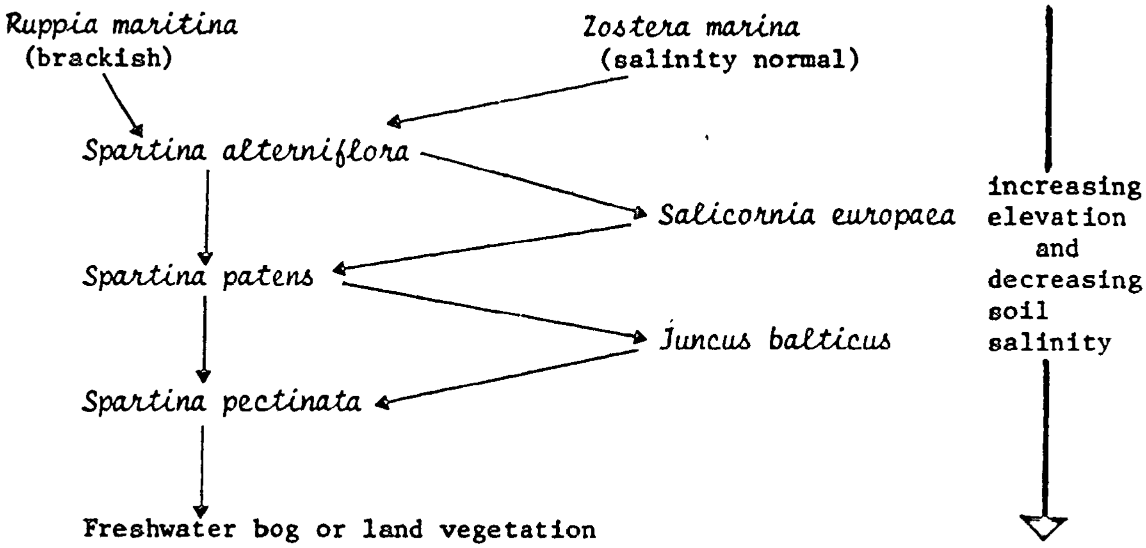

Figure 4.21: Succession of shore zone flora, Bideford, P.E.I. (Thomas 1969).

final freshwater dominated condition. Within the vicinity of the sand flats associated with the washovers, a similar pattern of vegetation succession is anticipated. Elsewhere the reverse trend is likely to be seen. It has already been demonstrated that the marsh is degrading and gradually becoming wetter. Figure 4.22 illustrates the changes in vegetation from 1935 until 1978.

The low marsh near the lagoon ridge maintains a similar appearance from 1935 until 1978, as does the low dunelet although this is not shown. There is evidence of minor accretion along the inner margin of the lagoon ridge. Within the open low marsh, only dense stands of Cordgrass are delineated. All photographs showed evidence of sparse cordgrass scattered throughout what is identified here as unvegetated flat. The position of the dense cordgrass varies from year to year, sometimes increasing in area and at other times showing signs of die-back. Redfield (1972) has estimated a five year time-frame for the establishment of dense cordgrass from bare substrate. It is possible that unobserved trends in the pattern of cordgrass distribution are subject to reversal more frequently than the photography records.

The position of the meadow remains constant from 1953 until the present. Separate communities can be identified only on the most recent imagery and reflect data quality, not necessarily the occurrence of a 'new' community.

Baltic Rush is seen to colonize the dune ridges, unvegetated in 1935. Through time the fringe zone decreases in area and by 1978 a Black Rush community inhabits what had formerly been occupied by the fringe communities. It is unlikely that the Black and Baltic Rush communities

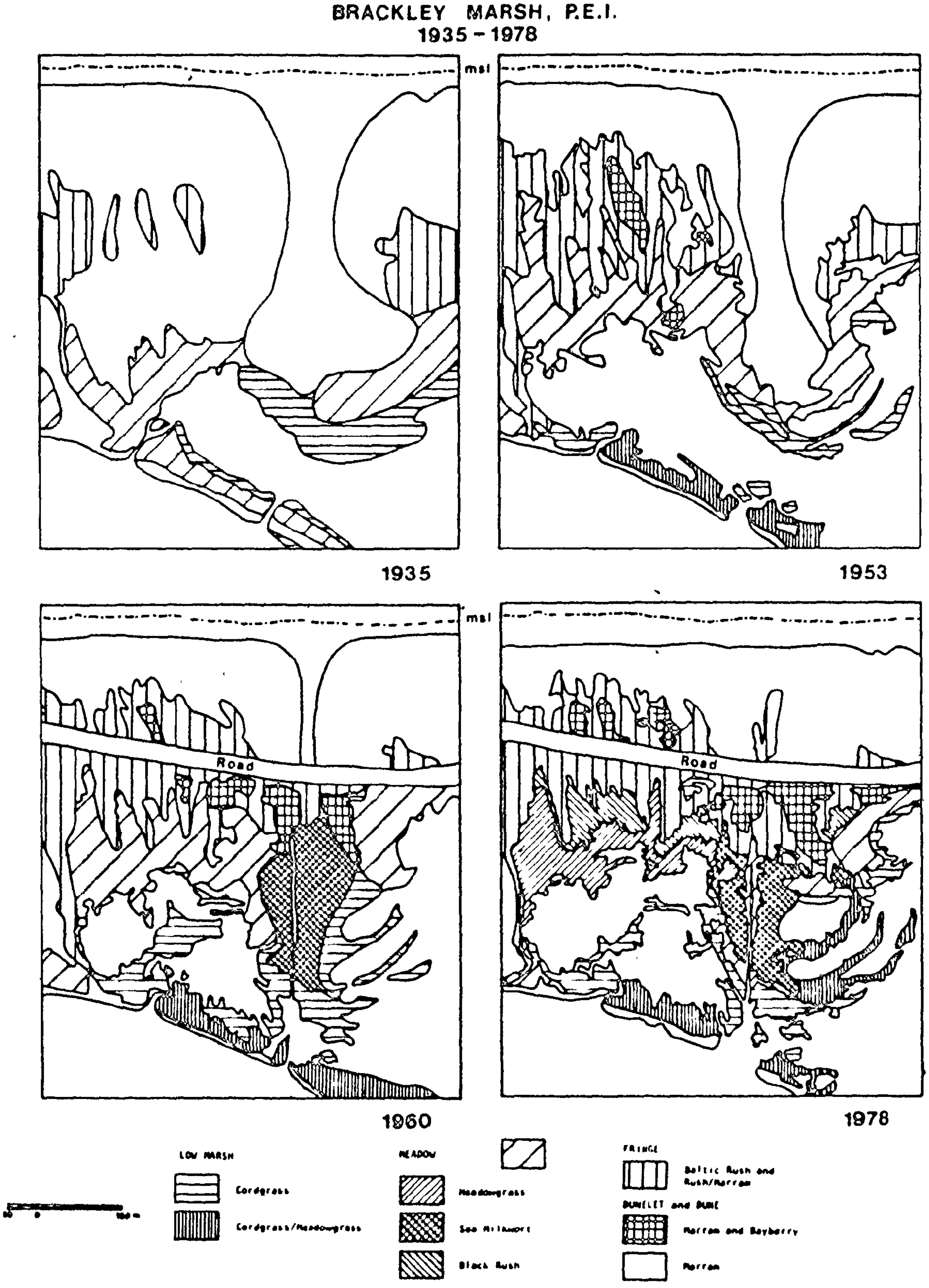

Figure 4.22: Changes in the vegetation for four dates between 1935 and 1978, as interpreted from aerial photographs.

had been misidentified (Section 4.2).

The community changes stated above are consistent with those anticipated. They reflect a marsh system gradually being subjected to higher water levels.

The washover and sand flats unvegetated in 1935 had been partially colonized by meadowgrass by 1953. The central portion of the washover was not vegetated until 1960, and then only sparsely. Precise identification of this community is difficult as it does not exactly match any known photo community (Section 4.2). However, it is similar to the Sea Milkwort community identified in 1973 at the same location (Section 4.3). This entire zone is characterized by waterlogged soils. Through time as the trend towards a 'wetter' marsh continues, this community could be replaced by either Cordgrass or Glasswort. As this successional pattern has not yet been defined elsewhere, a time-frame for this change cannot be deduced. However, any change could be rapid, as the main component species, Sea Milkwort, is an annual and its distribution may vary yearly.

4.4.4 Interpretation

The interpretation of temporal photography for Brackley Marsh over the period 1935 to 1978, has revealed several trends. Firstly, the marsh is becoming wetter, as evidenced by the changes in vegetation. The most obvious changes include the Black Rush replacing the Baltic Rush community and the sparsely vegetated to unvegetated low marsh occupying what had formerly been the meadow. These changes correspond to those defined by successional models. While the colonization of the sand flats by the Sea Milkwort community has not been previously described in terms of succession, its occurrence indicates waterlogged soil conditions. This concurs with the observed trend.

The second trend is the shoreline recession along both the lagoon and gulf coasts. Stanley and Simmons (1976) have predicted continuation of this trend such that the dunes will be completely removed within 75 years. At this time the highway will be exposed to direct wave attack. Thirdly, mean high water level, as identified by the vegetation, has similarly encroached upon former upper marsh areas.

Each of the three trends indicates a relative increase in water level. But the trends themselves are not necessarily independent. Each can be explained in terms of response to coastal submergence. However, the effects of coastal processes, specifically erosion by ice scour and wave action, are superimposed upon this. At this time, it is not possible to separate the two sets of factors.

A comparison of the photographs from before and after 1956 reveals that most of the change in marsh vegetation and the MHW line occurred prior to road construction. Significant variation in the rate of shoreline recession was not observed between the two time periods.

There is, however, evidence to indicate major changes in the dunes, their vegetation and morphology, that are a direct result of road construction. At the entrance of the former washover, a new dune ridge has been created with the aid of sandfencing. Existing dunes appear to have increased in height. At the same time, slacks and blowouts have enlarged and become vegetated. A freshwater bog has been observed in the slacks north of the road where only sand had been visible on pre-1956 photography. The pedestrian traffic across the dunes, increased due to increased accessibility made possible by the road, has resulted in dune degradation. The fragile marram grass, tolerant of continual deposition by sand, is susceptible to destruction by breakage as it is stepped upon (Stuckey 1975a).

Within the salt marsh, the increased accessibility is evidenced by the number of vehicle tracks across the meadow. While the meadow species themselves are not particularly sensitive to trampling, the vehicle tracks may be quite deeply incised through the litter mat and into the marsh substrate (Figures 3.33 and 3.34). This weakens the structure of the marsh, making it vulnerable to erosion by water and ice. The position of the lower meadow boundary (MHW line) reflects this process.

The susceptibility of *Juncus* species to destruction was also noted in field. A distinct path following the transect 2B line, is clearly visible on low level aerial photographs (Frontispiece, Figures 4.8 and 4.9). The path is still visible on the CIR images several months later (Figure 4.12).

In conclusion, the road construction appears to have had only limited effect on the marsh itself. The major trends, the result of apparent subsidence, had already been established prior to 1956. It is suggested that the road construction may have altered the rate of the otherwise naturally occurring change. Although the westernmost washover was closing, the result of natural processes, it is unlikely that the resultant dune growth and colonization of the sand flats would have been as rapid without the sandfencing and road, respectively. In the latter case, the road prevented continued sediment supply to the sand flats.

However, without more frequent photo coverage, especially prior to 1956, precise determination of the rates and nature of change is not possible.

4.5 DISCUSSION

Chapter 4 is concerned with the identification, description and application of photo communities in the salt marsh environment. An evaluation of aerial photo interpretation using various film, scale and season combinations was carried out. The optimal combination for the identification and delineation of marsh communities was determined to be colour summer and CIR fall imagery, both of at least medium scale. With this combination all of the communities defined as typical marsh communities in Chapter 3 could be identified. In most cases, the photo communities showed good correspondence with the floristic communities defined in Chapter 3.

The only benefits derived from the interpretation of large scale photographs are:

1) the delineation of those communities which typically cover a small area (e.g., Sea Lyme Grass); and
2) an increase in interpretation reliability and accuracy in boundary placement.

In general, most typical salt marsh communities can be identified on medium and large-scale photography with equal ease. An image scale of 1:10,000 appears to be optimal for the delineation of marsh communities within this environment.

Information regarding seasonal changes in the marsh vegetation is critical for accurate interpretation at any scale. Seasonal variations within zones may mask community boundaries. This was especially noted in the meadow zone, where the Meadowgrass, Sea Milkwort and Black Rush communities all exhibit similar photo characteristics in the late summer and fall. Possible differences in the year-to-year timing of specific phenological events (e.g., flowering) also need to be recognized.

In spite of the many variables and variations encountered in the aerial analyses, it was shown that provided sufficient background information is known, photo communities (and the identification, thereof) are consistent through space and time. This background information includes all of factors listed by Grimes and Hubbard (1971) and Garvin and Wheeler (1971, 1973) as necessary for reliable aerial interpretation. Without the analysis described in Chapter 3, specifically the community classification and description and tidal analysis, interpretation of salt marsh environment would have been inferior.

In addition, the relationships between marsh communities and their habitats, have also been shown to remain fixed through time. The level of MHW, as identified by the Meadowgrass community, was traced over a forty-three year period in conjunction with the interpretation of marsh development from aerial photographs. The interpretation derived from the temporal analysis, concurred with known environmental changes and ecological responses.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The analyses and results of this study have been summarized in the concluding section of each chapter (Sections 3.5 and 4.5). The salient points may be highlighted here.

1) Salt marsh communities have been identified and described for three marshes within the southern Gulf of St. Lawrence. The level of detail in both the description and classification had not been previously defined. The marsh classification derived from two separate analytical procedures, Braun-Blanquet Table Method and TWINSPAN, may form the basis for further botanical, ecological and aerial studies.
2) Based on the community classification, an idealized profile illustrating the typical zonation of salt marshes was constructed. Although analyses showed that this profile was, in fact, a good representation of community relationships throughout the three study areas, evidence from the literature suggests that additional and/or alternate communities need to be included in order to extend this model to other areas within the southern Gulf of St. Lawrence.
3) Within the typical profile description the frequency of each major species in each of the communities was calculated. The occurrence of these species was then related to specific tide levels and the relationships were defined. A two-level classification describing four marsh zones and ten marsh communities was derived. Specifically, the

low marsh zone, containing the Cordgrass, Sea Lavender and, occasionally, Glasswort communities is centred about mean sea level (MSL). Within the meadow zone, the Meadowgrass, Orach and Sea Milkwort communities are found near mean high water (MHW). The level of the fourth meadow community, Black Rush, was identified as just below higher high water. The fringe zone, dominated by Baltic Rush, is always found at or about the level of higher high water (HHW).

4) A second analysis was carried out to relate tide levels to communities. By comparison of the community height (relative to a common datum) and precise tide heights calculated from tidal observations a more precise, discrete relationship was established. Specifically, the Cordgrass community is almost perfectly centred about MSL; Meadowgrass about MHW and Baltic Rush about HHW.
The results of both tidal analyses correspond closely with the species/community-tide relationships described in the literature.

5) A description and classification of salt pan and pond communities was undertaken. Using the Brackley 2B transect as an example the relationship between pan origin and pan community was defined. They were both found to be related to distance from the lagoon shore.

6) Photo community descriptions were prepared using the communities defined in the typical marsh profile as a framework. Photo communities were shown to reflect the major floristic communities. The variations, both temporal and spatial, identified in the floristic description could be readily applied to the aerial analyses.

7) An evaluation of photo scale, film type and season combinations based on the interpretation of twenty-six sets of photos determined the

optimal combination for community identification. Medium-scale summer colour photography combined with CIR fall imagery permits the delineation of all 'typical' communities.

For all communities, colour and CIR photography was superior to B&W. Large scale was better than small. The optimal season depended upon the phenological characteristics of the dominant species.

8) By extending the aerial photo interpretation into areas not specifically surveyed the following conclusions were reached: a) photo communities were consistent over space and therefore could be used to determine community distribution; and b) the typical marsh profile provided an accurate description of zonation within the three study areas.

9) Temporal extrapolation of the photo communities and a knowledge of ecological relationships and responses through time enabled the development of a marsh to be traced through the photo record.

10) It has been shown that the floristic analyses and aerial photo interpretation are complementary analytical techniques. Without the knowledge of community composition and species variability provided by the detailed ground survey, the aerial photo interpretation would have lacked the reliability and level of detail illustrated.

On the other hand, most ground surveys are limited in their ability to describe community variations over space and time. The photo record was shown to fulfill this requirement.

5.2 RECOMMENDATIONS

The recommendations offered here have been identified as the result of this study.

The major problem encountered in the course of this study was the underestimation of the variability, both floristically and physically, within the barrier marsh environment. In most cases they relate to the refinement of the methodology. This would enable more rigorous testing and wider application of the concepts and relationships derived and described in this study.

1) The recent literature (Thannheiser 1981) and the results of this study suggest that the variability in salt marsh community composition is much greater than previously acknowledged. Detailed surveys, of the type attempted in this study, need to be carried out over a wider area. Specifically, marsh communities of les Iles de la Madeleine and Miscou Island-Point Escuminac barrier systems need to be described. This would provide a basis for the comparison of marsh communities, coastal ecology and barrier development (in relation to the role played by vegetation) within barrier environments throughout the southern Gulf of St. Lawrence.

2) Although the vegetation sampling scheme designed for this study provided adequate coverage of the marsh communities, including sufficient replicate samples to classify, difficulty was encountered in trying to relate individual sites to a specific height above a datum. The variation across the marsh (and dune ridges) perpendicular to the transect was often greater than the change in elevation along the transect itself.

   The use of a continuous belt transect several meters wide would provide at least equal representation and replication and, at the same time, enable individual sites to be directly related to height.

3) The vegetation should be sampled at several times through the season. The aerial and ground level photo interpretation has clearly shown that species densities continually change relative to one another throughout the growing season. If a repetitive survey is not possible and aerial photo interpretation is the ultimate goal, ground surveys should be timed to correspond to the time of aerial photograph acquisition. In addition, the appropriate film type and scale combination should be selected in order to enhance community interpretation.

4) Only intertidal vascular species were sampled in the marsh. Further studies should be extended to include subtidal as well as algal species.

5) Precise tidal data at a number of locations is required for further analysis. A tidal gauge, levelled to each marsh profile and recording over at least a month, would provide sufficient data to firmly establish the relationship between individual species and communities and tide levels.

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APPENDIX A: Species List for Marsh/Dune Communities, Buctouche, N.B., South Richibucto Beach, N.B. and Rustico Island/Brackley Beach, P.E.I., July-August, 1978.

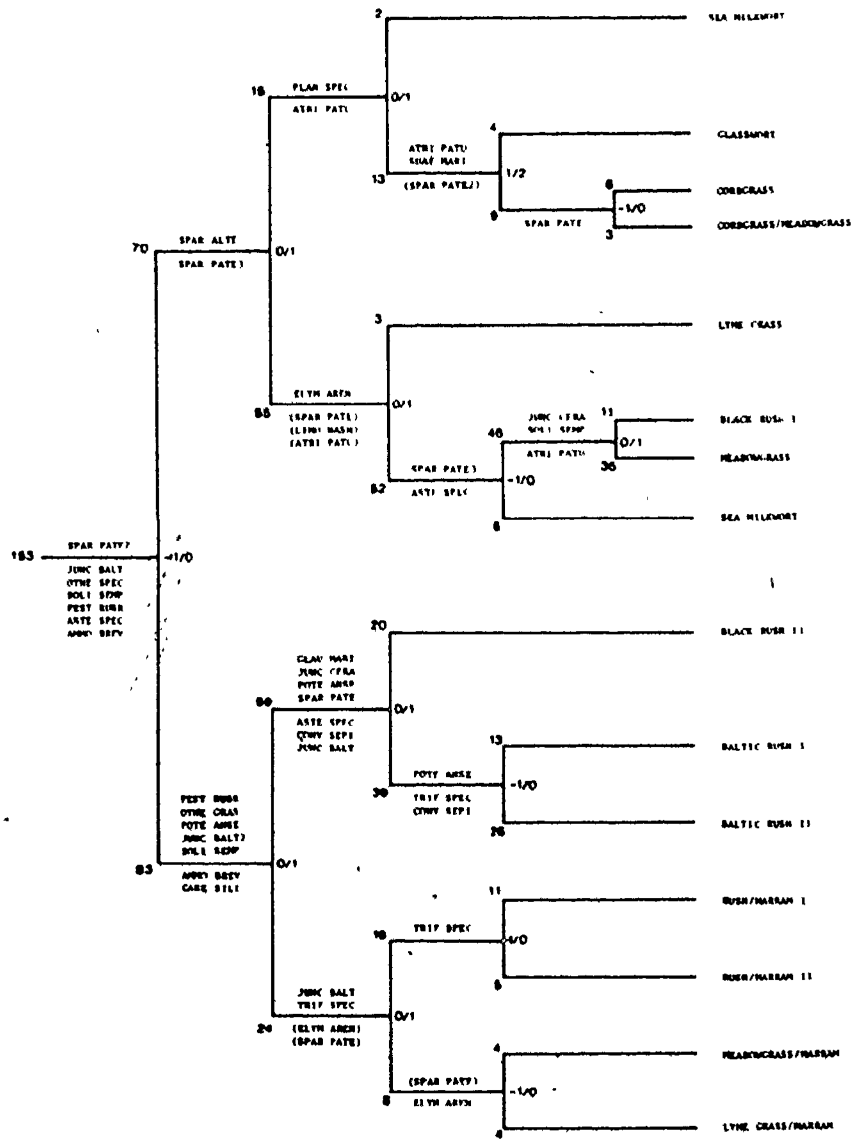
FAMILY	BOTANICAL NAME*	COMMON NAME
LYCOPERDACEAE	*Geaster triplex*	Earthstar
CLADONIACEAE	*Cladonia cristatella* Tuck	British Soldier
	C. rangiferina (L.) Wigg	
PINACEAE (Pine)	*Picea glauca* (Moench) Voss	White Spruce
	Juniperus horizontalis Moench	Creeping Savin
TYPHACEAE (Cat-tail)	*Typha latifolia* L.	Common Cat-tail
ZOSTERACEAE (Pondweed)	*Zostera marina* L.	Eelgrass
	Ruppia maritima L.	Ditch Grass
JUNCAGINACEAE (Arrow Grass)	*Triglochin maritima* L.	Arrow Grass
GRAMINEAE (Grass)	*Festuca rubra* L.	Red Fescue
	Puccinellia maritima (Huds.) Part.	Goose Grass
	Poa palustris L.	Fowl-Meadow Grass
	Distichlis spicata (L.) Greene	Spike Grass
	Phragmites communis Trin.	Reed
	Agropyron repens (L.) Beauv.	Couch Grass
	Hordeum jubatum L.	Squirrel-tail Grass
	Elymus arenarius var. *villosus* Mey	Sea Lyme Grass
	Ammophila breviligulata Fern.	Marram
	Agrostis alba var. *palustris* (Huds.) Parl.	Creeping Bentgrass
	A. gigantea Roth.	Black Bentgrass
	Spartina pectinata Link.	Freshwater Cordgrass
	S. alterniflora Loisel.	Cordgrass
	S. patens (Ait.) Muhl.	Meadowgrass
CYPERACEAE (Cyperus)	*Eleocharis* species	Spike Rush
	Scirpus americanus Pers.	Three-square Rush
	S. validus Vahl.	Great Bulrush
	S. maritimus L.	Salt Marsh Bulrush
	Carex silicea Olney	Sea Beach Sedge
	C. paleacea Wahlenb.	Sedge
JUNCACEAE (Rush)	*Juncus gerardii* Loisel.	Black Rush
	J. balticus Willd. var. *littoralis* Englem.	Baltic Rush
LILIACEAE (Lily)	*Smilacina stellata* (L.) Desf. var. *crassa* Vict.	Starry False Soloman's Seal

FAMILY	BOTANICAL NAME*	COMMON NAME
IRIDACEAE	*Iris Hookeri* Penny	Beachhead Iris
(Iris)	*I. versicolor* L.	Blue Flag
SALICACEAE	*Salix discolor* Muhl.	Large Pussy Willow
(Willow)	*Populus tremuloides* Michx.	Trembling Aspen
MYRICACEAE	*Myrica gale* L.	Sweet Gale
(Wax Myrtle)	*M. pensylvanica* Loisel	Bayberry
CORYLACEAE	*Betula populifolia* Marsh	White Birch
(Hazel)	*Alnus rugosa* (Du Roi) Spreng. var. *americana* (Regel) Fern.	Speckled Alder
SANTALACEAE	*Comandra umbellata* L. Nutt.	Bastard Toadflax
(Sandlewood)		
POLYGONACEAE	*Rumex Acetosella* L.	Sheep Sorrel
(Buckwheat)		
CHENOPODIACEAE	*Atriplex patula* L. var. *hastata* (L.) Gray	Halberd-shaped Orach
(Goosefoot)	*A. patula* var. *littoralis* (L.) Gray	Seashore Orach
	Salicornia europaea L. var. *simplex* (Pursh.) Fern	Glasswort (Simple)
	S. europaca L. var. *prostata* (Pall.) Fern.	Glasswort (Prostrate)
	Suaeda maritima (L.) Dumort.	Sea Blite
	S. americana (Pers.) Fern.	American Sea Blite
	Salsola Kali L.	Common Saltwort
CARYOPHYLLACEAE	*Spergularia rubra* (L.) J. & C. Presl.	Red Sand-spurry
(Pink)	*S. marina* (L.) Griseb.	Sand-spurry
	S. canadensis (Pers.) Don	Canadian Sand-spurry
	Arenaria laterifolia L.	Sandwort
	A. peploides L. var. *robusta* Fern.	Sea Beach Sandwort
	Stellaria Graminea Pursh.	Stitchwort
RANUNCULACEAE	*Ranunculus Cymbalaria* Pursh.	Seaside Crowfoot
(Crowfoot)		
CRUCIFERAE	*Cakile edentula* (Bigel.) Hook	Sea Rocket
(Mustard)		
DROSERACEAE	*Drosera rotundifolia* L.	Round-leaved Sundew
(Sundew)		
ROSACEAE	*Fragaria virginiana* Duchesne	Virginia Strawberry
(Rose)	*Potentilla tridentata* Aif.	Three-toothed Cinquefoil
	P. anserina L.	Silverweed
	Rubus species	Bramble
	Rosa nitada Willd.	Northeastern Rose
	R. carolina L.	Pasture Rose

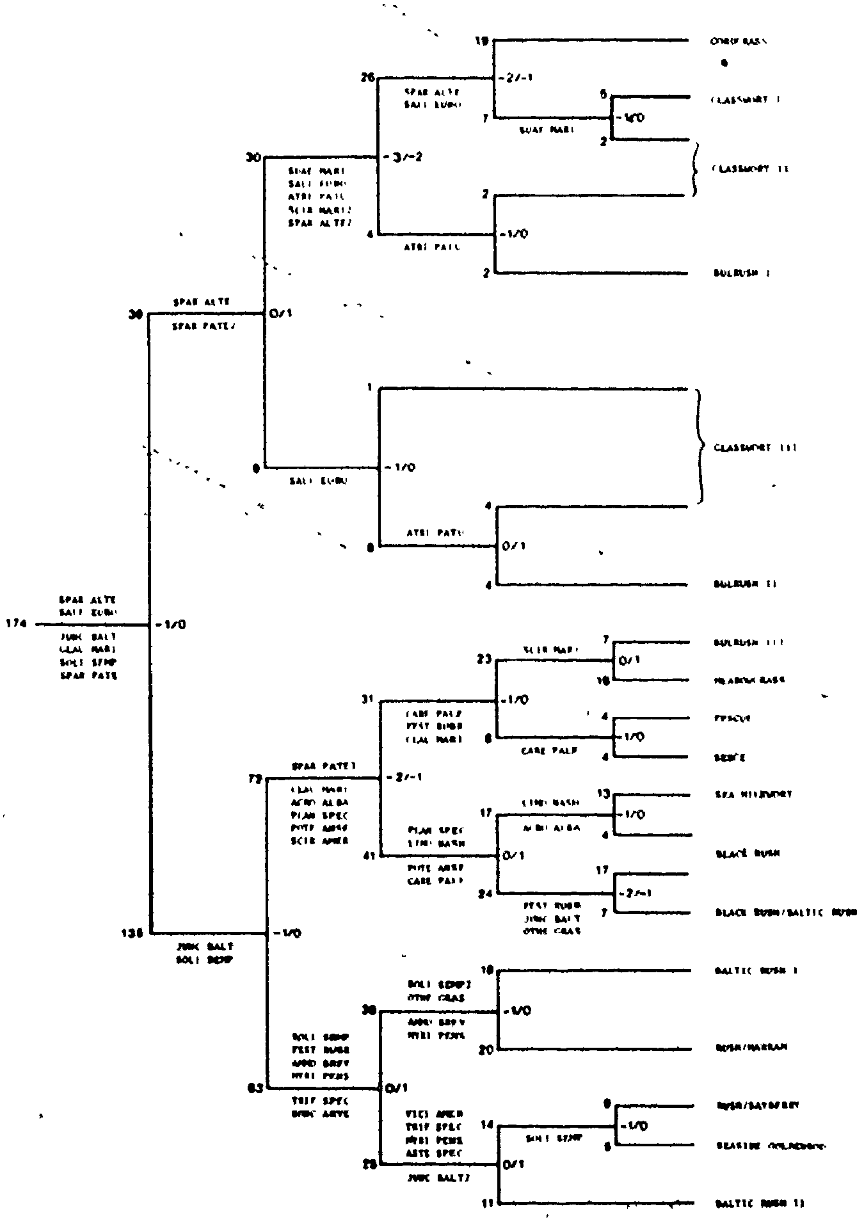
FAMILY	BOTANICAL NAME*	COMMON NAME
LEGUMINOSAE (Pulse)	*Trifolium arvense* L.	Rabbit Foot Clover
	T. agrarium L.	Yellow Clover
	T. procumbens L.	Low Hop Clover
	Vicia americana Muhl.	Vetch
	Lathyrus japonicus Willd.	Beach Pea
	L. palustris L.	Vetchling
EMPETRACEAE (Crowberry)	*Empetrum atropurpureum* Fern. & Wieg.	Purple Crowberry
ACERACEAE (Maple)	*Acer rubrum* L.	Red Maple
CISTACEAE (Rockrose)	*Hudsonia tomentosa* Nutt.	Beach Heather
	Lechea intermedia Leggett.	Pinweed
ONAGRACEAE (Evening Primrose)	*Epilobium angustifolium* L.	Fireweed
	Oenothera biennis L.	Evening Primrose
UMBELLIFERAE (Parsley)	*Lingusticum scoticum* L.	Scotch Lovage
ERICACEAC (Heath)	*Ledum groenlandicum* (L.) Oeder	Labrador Tea
	Rhododendron canadense (L.) Torr.	Rhodora
	Kalmia angustifolia L.	Sheep Laurel
	Arctostaphylos Uva-ursi (L.) Spreng.	Bearberry
	Vaccinium angustifolium Ait.	Low Sweet Blueberry
	V. Oxycoccus L.	Small Cranberry
	V. macrocarpon Ait.	Large Cranberry
PRIMULACEAE (Primrose)	*Glaux maritima* L. var. *obtusifolia* Fern.	Sea Milkwort
PLUMBAGINACEAE (Leadwort)	*Limonium Nashii* Small	Sea Lavender
CONVOLVULACEAE (Convolvulus)	*Convolvulus sepium* L.	Bindweed
LABIATAE (Mint)	*Scutellaria epilobiifolia* A. Hamilton	Common Skullcap
	Prunella vulgaris L.	Self-Heal
PLANTAGINACEAE (Plantain)	*Plantago juncoides* Lam.	Seaside Plantain
	P. oliganthos R. & S. (P. maritima L.)	Seaside Plantain
COMPOSITAE (Composite)	*Solidago sempervirens* L.	Seaside Goldenrod
	Aster species	Asters
	Anaphalis margaritacea (L.) C.B. Clarke	Pearly Everlasting
	Achillea lanulosa Nutt.	Woolly Yarrow
	Artemesia Stellariana Bess.	Beach Wormwood
	Taraxacum officinale Weber.	Dandelion
	Sonchus Arvenis L.	Field Sow Thistle
	Hieracium floribundum All.	King Devil

*Botanical nomenclature for vascular species after Fernald, 1950.

APPENDIX B1.1: TWINSPAN Hierarchy for Marsh Communities at Buctouche, N.B.

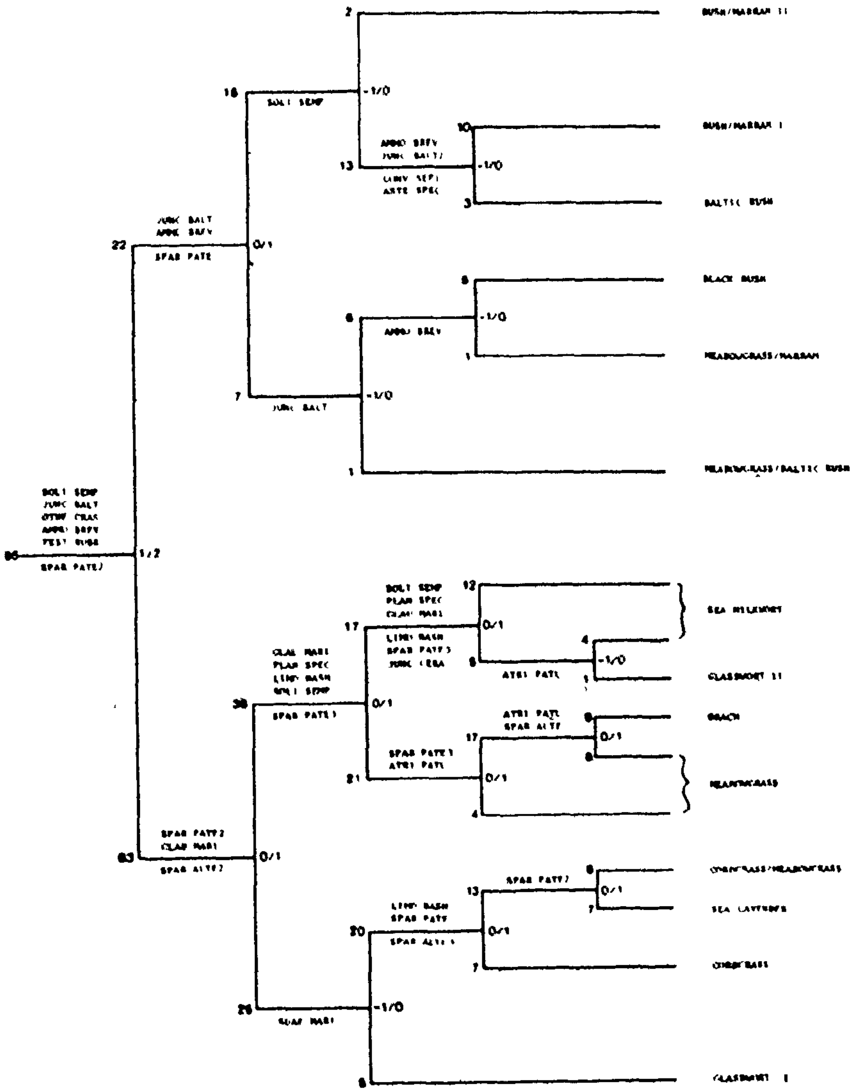


APPENDIX B1.2: TWINSPAN Hierarchy for Marsh Communities at Rustico/Brackley Beach, P.E.I.



POOR COPY
COPIE DE QUALITEE INFERIEURE

APPENDIX B1.3: TWINSPAN Hierarchy for Marsh Communities at South Richibucto Beach, N.B.



POOR COPY
COPIE DE QUA

APPENDIX B3.1: ANNOTATED TWO-WAY TABLE FOR MARSH SITES AT BUCTOUCHE, N.B.

MARSH COMMUNITIES

Lyme grass II | Meadowgrass/Marram | Rush/Marram II | Rush/Marram I | Baltic Rush II | Baltic Rush I | Black Rush II | Seaside Plantain | Meadowgrass

```
              |1111| 111|1 111|        111|        11           11111|             |                  1| |11111 |          1|
             *|6666|5555|04001|33334488060|22244499002223333377866677|1111228889999|11777773888999 1111|5|555556|2555666666:|
              |0123|3798|76022|25671557494|57924979151340134889457801|3679682313456|0545367 68901271286|4|012347|42789012565|
  4 AMMO BREV |2222|2222|12222|22111112221|---11-2-1------1----------|-------------|-------------------|1|------|-----------| 00000
 17 HUDS TOME |----|----|1----|-----------|--------------------------|-------------|-------------------|-|------|-----------| 00000
 29 SCIR MARI |----|----|-----|2----------|--------------------------|-------------|-------------------|-|------|-----------| 00000
  1 ACHI LANU |----|----|-----|-11-11-----|---111--------------------|-------------|-------------------|-|------|-----------| 00001
 10 CAKE SILI |----|----|-----|111111111--|111-11---1----------------|-------------|-------------------|-|------|-----------| 00001
 22 MYRI PENS |----|----|---2-|-----------|---1----------------------|-------------|-------------------|-|------|-----------| 00001
 35 SPER MARI |----|----|--1--|-112-1-----|1----1-1------------------|-------------|-------------------|-|------|-----------| 00001
 38 TRIF SPEC |----|----|-----|11122111112|222-121--11121---11-1-111-|-------------|-------------------|-|------|-----------| 00010
 34 SPAR PECT |2-22|-1--|-----|-----------|1----1----1-1-1-11-1-211-1|----1---1--1-|1-1----------------|-|-1----|-----------| 00011
  6 ASTE SPEC |----|----|-----|1111111----|111111112--111-111221-1-11|----2---11111|-------------------|-|------|-----------| 00100
 11 CONV SEPI |1---|----|-----|----------1|1--1-1-11-2112112111-11--1|--------11-1-|-------------------|-|------|-----------| 00100
 18 IRIS SPEC |----|----|-----|-----------|------------1111-1--------|-------------|-------------------|-|------|-----------| 00100
 19 JUNC BALT |----|----|11221|-11111111-1|21122112122221122222-22-21|1222122222112|-2-1----121--1--21-|-|------|-----------| 00101
 30 SCLI SEMP |----|-1--|-----|1111-1---11|111-11-1111211111211222222|2122221-11-1-|-1211---------22212|1|------|-----------| 00101
 24 OTHE GRAS |----|1---|--1--|---11-1----|11-121111-2222222222222212|11122-2223111|1212112222-222-----|1|------|-----------| 00110
 25 POTE ANSE |----|----|-----|-----------|--------------------------|-211112112323|11222222212222-111-|-|------|-----------| 00110
 15 FEST RUBR |----|----|-----|-1---------|--111111--111111-11-1-1-11|-12211-111111|222-111111-11111---|-|----1-|1----------| 00111
 16 GLAU MARI |----|----|-----|-----------|------------1-------------|-------------|1---111-211111-1112|-|-----1|2---1---11-| 01
 20 JUNC GERA |----|----|-----|-----------|---------------------1--2-|-------------|2-212-21--121-12-2-|-|11-1--|-----------| 01
 14 ELYM AREN |2111|----|-----|-----------|--------------------------|-------------|-------------------|-|------|----------1| 1100
 21 LIMO NASH |----|----|-----|-----------|---------------1----------|-------------|-----------------1-|-|1111-2|--1111--111| 11010
 23 PLAN SPEC |----|---1|-----|-----------|--------------------------|-------------|1------------------|-|222121|-1-1--2-11-| 11010
 28 SCIR AMER |----|----|-----|-----------|--------------------------|-------------|---1---------------|-|------|1----------| 11010
 33 SPAR PATE |----|111-|-----|-----------|--------------------------|-------------|111-122--------2122|1|2-1312|33233335331| 11010
  7 ATRI PATU |----|----|-----|-----------|--------------------------|-------------|-------------------|-|------|----1-----1| 11011
 26 PUCC MARI |----|----|-----|-----------|--------------------------|----------1--|-------------------|-|--21--|-----------| 11011
 32 SPAR ALTE |----|----|-----|-----------|--------------------------|-------------|-------------------|-|------|---1-------| 1110
 27 SALI EURO |----|----|-----|-----------|--------------------------|-------------|-------------------|-|------|-----------| 111
 37 SUAE MARI |----|----|-----|-----------|--------------------------|-------------|-------------------|-|------|-----------| 1111

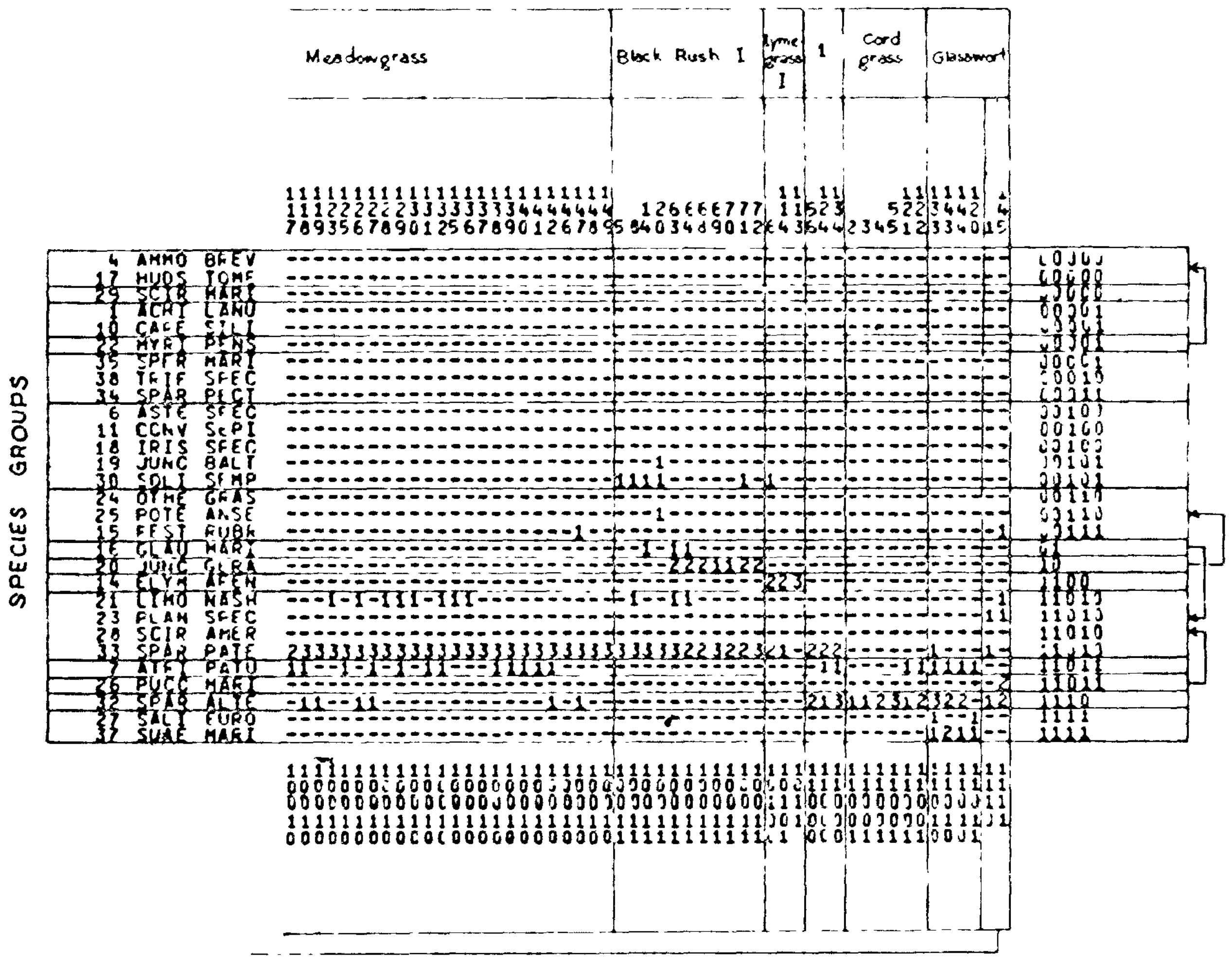
              |0000|0000|00000|00000000000|00000000000000000000000000|0000000000000|0000000000000000000|0|111111|11111111111|
              |0000|0000|00000|00000000000|11111111111111111111111111|1111111111111|1111111111111111111|1|000000|00000000000|
              |0000|0000|11111|11111111111|00000000000000000000000000|0000000000000|1111111111111111111|1|000000|00000000000|
              |0000|1111|00000|11111111111|00000000000000000000000000|1111111111111|0000000000000001111|1|000000|11111111111|
              |0111|0001|01111|00000000001|00000000000111111111111111|0000000011111|0000111111111111000|1|000001|00000000000|
```

* Site Numbers:

1- 49	Transect 1A
50-112	Transect 1B
113-159	Transect 2A
160-171	Transect 3A

...B5

MARSH COMMUNITIES



```
                 Meadowgrass              Black Rush I Lyme  1   Cord  Glasswort
                                                       grass     grass
                                                        I
                 111111111111111111111111              11 11    111111 1
                 111222222333333334444444  126666777 11523   5223442 4
                 78935678901256789012678958403489012643644234512334015
  4 AMMO BREV    -----------------------------------------------------  00000
 17 HUDS TOME    -----------------------------------------------------  00000
 29 SCIR MARI    -----------------------------------------------------  00000
  1 ACRI LANO    -----------------------------------------------------  00001
 10 CAFE SILI    -----------------------------------------------------  00001
 22 MYRI PENS    -----------------------------------------------------  00001
 35 SPER MARI    -----------------------------------------------------  00001
 38 TRIF SPEC    -----------------------------------------------------  00010
 34 SPAR PECT    -----------------------------------------------------  00011
  6 ASTE SPEC    -----------------------------------------------------  00100
 11 CCNV ScPI    -----------------------------------------------------  00100
 18 IRIS SPEC    -----------------------------------------------------  00100
 19 JUNC BALT    ---------------------------1-------------------------  00101
 30 SOLI SEMP    ------------------------1111-----1-1-----------------  00101
 24 OTHE GRAS    -----------------------------------------------------  00110
 25 POTE ANSE    ---------------------------1-------------------------  00110
 15 FEST RUBR    ---------------------1-------------------------------1  00111
 16 GLAU MARI    --------------------------1-11-----------------------  01
 20 JUNC GERA    ----------------------------2221122------------------  10
 14 ELYM AREN    -----------------------------------223---------------  1100
 21 LIMO NASH    ---1-1-111-111-----------1--11-----------------------1  11010
 23 PLAN SPEC    ---------------------------------------------------11  11010
 28 SCIR AMER    -----------------------------------------------------  11010
 33 SPAR PATE    23333333333333333333333333333223223 21-222------1---1-  11010
  7 ATRI PATU    11--1-1-1-11---1111---------------------11----111111--  11011
 26 PUCC MARI    ------------------------------------------------------2  11011
 32 SPAR ALTE    -11--11------------1-1---------------------213112312322-12  1110
 27 SALI EURO    -----------------------------------------------1--1--  1111
 37 SUAE MARI    -----------------------------------------------1211--  1111

                 11111111111111111111111111111111111111111111111111111
                 00000000000000000000000000000000000000111111111111111
                 00000000000000000000000000000000000111000000000000011
                 11111111111111111111111111111111111001000000000111101
                 000000000000000000000000111111111111 1000111111000 1
```

1. Cordgrass/Meadowgrass

APPENDIX B2.2: ANNOTATED TWO-WAY TABLE FOR MARSH SITES AT RUSTICO/BRACKLEY BEACH, P.E.I.

MARSH COMMUNITIES

SPECIES GROUPS

```
            |Baltic Rush|Golden-|Rush /   |Rush / Marram       |Baltic Rush I     |Black Rush/|Black Rush           |Sea Milkwort|
            |II         |rod    |Bayberry |                    |                  |Baltic Rush|                     |            |

            |1111111  11|11111  |111111111|11111111111111111111| 111111111111     |           |         11111111 111|    11111   |
           *|12233339923|28880  |222223337|35777344444555566677|248888888999988999|8888899    | 67777788211111116001|  9900000   |
            |98912564550|10123  |234673487|74145936789057926803|105456789012358123|1367907    |263678904823456781790|488901234   |

 1 ACHI LANU|-----------|1---2  |1--------|--------------------|------------------|-------    |---------------------|---------   | 00000
 5 AREN LATE|-11--------|-21--  |---1-----|-------1--11--------|------------------|-------    |---------------------|---------   | 00000
18 IRIS SPEC|-----------|-----  |--212----|--------------------|------------------|-------    |---------------------|---------   | 00000
31 SONC ARVE|------11111|--2-1  |-11--1-1-|--------------------|1-----------------|11-----    |---------------------|---------   | 00000
38 TRIF SPEC|21---12----|22-1-  |12122-122|2-------------------|-2----------1-----|-------    |------------11-1-----|---------   | 00000
39 VICI AMER|-----------|-1111  |---11---1|-------1------------|---------1-1------|-------    |---------------------|---------   | 00000
 4 AMMO BREV|-----------|-----  |---------|111--2211112221-2111|111---------------|------2    |1---------------1----|---------   | 00001
 6 ASTE SPEC|-----------|1-1--  |-1---1-11|----------1---------|----11---1---11-11|-------    |---------------------|---------   | 00001
10 CARE SILI|-----------|-----  |1------1-|1------11-1--11--1-1|--------------1---|-------    |---------------------|---------   | 00001
11 CONV SEPI|-------22--|-----  |---------|--------------------|---------------211|-------    |---------------------|---------   | 00001
19 JUNC BALT|22222222222|---1-  |222222211|22222121111111112112|-21333332222312211|222222-    |---------1---2------2|---------   | 00001
22 MYRI PENS|-----------|1--11  |1-1--222-|22-32--222222-2222-2|-------------22-2-|-------    |---------------------|---------   | 00001
30 SOLI SEMP|----------1|11222  |---------|------1-122211111--1|212112222222212-2-|-------    |2-----------11--1----|1--------   | 00001
24 OTHE GRAS|-------22--|-----  |---------|--------------------|-1---------1-22212|-1222-1    |---------------------|---------   | 00010
15 FEST RUBR|-----------|-----  |--------1|-1-1----1-11-11111--|2------111---11212|1211-11    |1--------------------|---1-----   | 00011
 2 AGRO REPE|1---1-1--1-|-----  |--1--1---|--------------------|------------------|-------    |---------------------|------111   | 00100
34 SPAR PECT|11-----1---|-----  |---------|--------------------|--------------1---|-------    |-------------222-----|---------   | 00100
26 PUCC MARI|-----------|-----  |--------1|--------------------|------------------|-------    |---------------------|--1--1---   | 00101
 3 AGRO ALBA|11---11----|-1---  |-----112-|1-------------------|--------1---------|----111    |-11112--2-222--111111|1------1-   | 00111
 9 CARE PALE|-----------|-----  |---------|--------------------|------------------|--1122-    |-1-12----111-1-------|---------   | 00111
13 ELEO SPEC|-----------|-----  |---------|--------------------|------------------|-------    |--------1--------2---|---------   | 00111
16 GLAU MARI|-----------|-----  |---------|--------------------|-----------------1|1-22221    |222--22322222222-3222|131222222   | 00111
20 JUNC GERA|-----------|-----  |---------|--------------------|------------------|-------    |---1-22-1-1----------|---------   | 00111
21 LIMO NASH|-----------|-----  |---------|--------------------|------------------|-------    |---------------------|21111-11-   | 00111
25 POTE ANSE|2----------|-----  |---------|--------------------|------------------|111121-    |---211----1--11-2----|---------   | 00111
28 SCIR AMER|-----------|-----  |---1-2---|--------------------|------------------|22-----    |--1-1-1111--1----111-|---------   | 0100
23 PLAN SPEC|-----------|-----  |---------|--------------------|------------------|-------    |---------111------222|112221112   | 0101
33 SPAR PATE|-----------|-----  |---------|--------------------|2-----------------|22---21    |2222222221---12211-1-|211-11111   | 011
29 SCIR MARI|-----------|-----  |---------|--------------------|------------------|-------    |---------------------|---------   | 10
 7 ATRI PATU|-----------|-11-1  |---------|--------------------|------------------|-------    |---------------------|---------   | 1100
27 SALI EURO|-----------|-----  |---------|--------------------|------------------|-------    |---------------------|--1-111--   | 1101
37 SUAE MARI|-----------|-----  |---------|--------------------|------------------|-------    |---------------------|---------   | 1110
32 SPAR ALTE|-----------|-----  |---------|--------------------|------------------|-------    |---------------------|-1-------   | 1111

            |00000000000|00000  |000000000|00000000000000000000|000000000000000000|0000000    |000000000000000000000|000000000   |
            |00000000000|00000  |000000000|00000000000000000000|000000000000000000|1111111    |111111111111111111111|111111111   |
            |00000000000|00000  |000000000|11111111111111111111|111111111111111111|0000000    |000000000000000000000|000000000   |
            |00000000000|11111  |111111111|00000000000000000000|111111111111111111|0000000    |000000000000000001111|111111111   |
            |00000001111|00000  |111111111|00000111111111111111|000000000000011111|0000000    |111111111111111110000|111111111   |
```

*Site Numbers:
1- 95 Transect 2B
96-119 Transect 3B South
120-138 Transect 3B North
139-177 Transect 4A
178-197 Transect 4B

...B7

MARSH COMMUNITIES

Sedge
Fescue
Meadow-grass I
Meadow-grass II
Bulrush III
Bul-rush II
Glass-wort III
Bulrush I
Glass-wort I
Glass-wort II
Cordgrass

SPECIES GROUPS

```
             1111                                       1
             01996667    344445555667777555556663455343474-1 11111121112222222233333423
             51457890356751789136902124520248345125795408432901356934780124568923678670
 1 ACHI LANU ---------------------------------------------------------------------------- 00000
 5 AREN LATE -------------------------------------------------------------------------- 00000
18 IRIS SPEC -------------------------------------------------------------------------- 00000
31 SONC ARVE -------------------------------------------------------------------------- 00000
38 TRIF SPEC -------------------------------------------------------------------------- 00000
39 VICI AMER -------------------------------------------------------------------------- 00000
 4 AMMO BREV --------1------------------------------------------------------------------ 00001
 6 ASTE SPEC -------------------------------------------------------------------------- 00001
10 CARE SILI -------------------------------------------------------------------------- 00001
11 CONV SEPI -------------------------------------------------------------------------- 00001
19 JUNC BALT ----------1--------------------------------------------------------------- 00001
22 PYRI PENS -------------------------------------------------------------------------- 00001
30 SOLI SEMP --------1-2--------------------------------------------------------------- 00011
24 OTHE GRAS -------------------------------------------------------------------------- 00010
15 FEST RUBR --21----221--------------------------------------------------------------- 00011
 2 AGRO REPE 12------------------------------------------------------------------------ 00100
34 SPAR PECT -------------------------------------------------------------------------- 00100
26 PUCC MARI -------------------------------------------------------------------------- 00111
 3 AGRO ALBA ----1--------------------------------------------------------------------- 00110
 9 CARE PALE ----1122------------------------------------------------------------------ 00111
13 ELEO SPEC -------------------------------------------------------------------------- 00111
16 GLAU MARI 22121-1----1-------------------------------------------------------------- 00111
20 JUNC GERA -------------------------------------------------------------------------- 00111
21 LIMO NASH 1-11-----212-------------------------------------------------------------- 00111
25 POTE ANSE -------1------------------------------------------------------------------ 00111
28 SCIR AMER -1---------------------------------------------1-------------------------- 0100
23 PLAN SPEC 1122-------1----------------------------------1------------------1---------- 0101
33 SPAR PATE -1123222233333333233232332233232322-3222222---1----------------------------- 011
29 SCIR MARI ------------------------------------1211212-1:------22-------------------1-- 10
 7 ATRI PATU ------------1-1---1----------------------------1122221------------------------- 1100
27 SALI EURO -----------------------------------11111122-1111121212 2-----------------11 1101
37 SUAE MARI ----------------------------------------1-21-1111-------------------------- 1110
32 SPAR ALTE ------------------------------------1---21--22332222222212221222221111111111 1111

             00000000000000000000000000000000000111111111111111111111111111111111111111
             11111111111111111111111111111111111000000000111111111111111111111111111111
             00001111111111111111111111111111111000000001000011111111111111111111111111
             11110000000011111111111111111111111000011111 001100000001111111111111111111
             11110000111100000000000000001111111011100 11 010100111110000000000000000011
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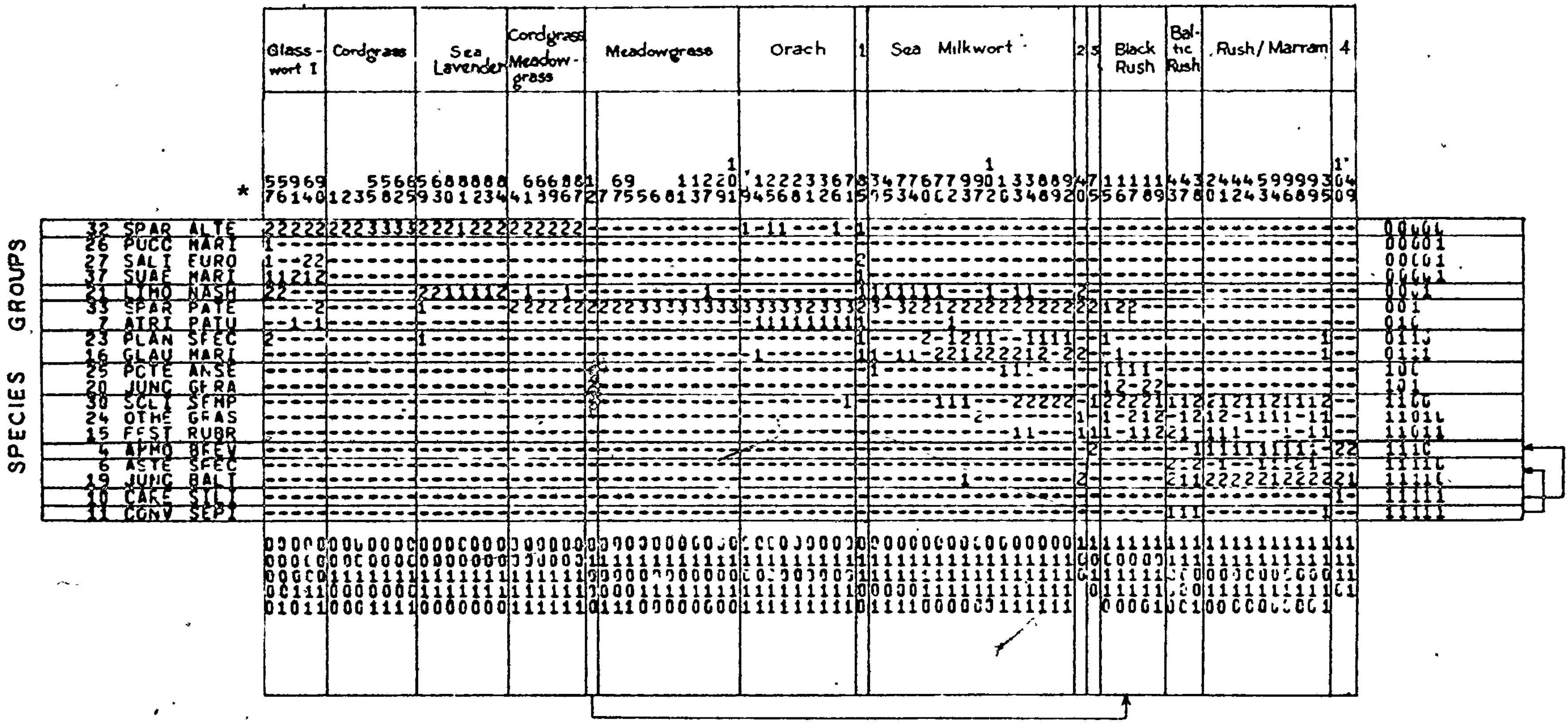
APPENDIX B2.3: ANNOTATED TWO-WAY TABLE FOR MARSH SITES AT SOUTH RICHIBUCTO BEACH, N.B.

MARSH COMMUNITIES



```
                                                  1                   1                          1
            *  55969   55665688888 666881 69   11220 12223367834776779901338894711111443244459999304
               7614012358259301234413967277556813791945681261575340023720348920556789378012434689509
32 SPAR ALTE   2222222233332221222222222------------1-11---1-1-------------------------------------- 00000
26 PUCC MARI   1------------------------------------------------------------------------------------ 00001
27 SALI EURO   1--22-----------------------------------------2-------------------------------------- 00001
37 SUAE MARI   11212-----------------------------------------1-------------------------------------- 00001
21 LIMO NASH   22----------2211112-1--1----------1-----------1111111---1-11---2--------------------- 0001
33 SPAR PATE   ----2-------1------222222222233333333333332333 23-32212222222222221 22------------------ 001
 7 AIRI PATU   --1-1---------------------------------111111111------1------------------------------- 010
23 PLAN SPEC   2-----------1---------------------------------1----2-1211--1111--1----------------1-- 0110
16 GLAU MARI   --------------------------------------1-------11-11-221222212-22--1---------------1-- 0111
25 PCTE ANSE   -----------------------------------------------1---------11------1111---------------- 100
20 JUNC GERA   -----------------------------------------------------------------12-22--------------- 101
30 SCLI SENP   ---------------------------------------------1------111---22222-1222211122121121112-- 1100
24 OTHE GRAS   -------------------------------------------------------2-------1-1-212-1212-1111-11-- 11010
15 FEST RUBR   ----------------------------------------------------------11---111-11221-111---1-11-- 11011
 4 AMMO BREV   ----------------------------------------------------------------2-------1111111111-22 1110
 6 ASTE SPEC   ----------------------------------------------------------------------2-2-1--11-21--- 11110
19 JUNC BALT   ------------------------------------------------------1--------2------2112222212222 21 11110
10 CAKE SILI   -----------------------------------------------------------------------------------1- 11111
11 CONV SEPI   ----------------------------------------------------------------------111---------1-- 11111

               0000000000000000000000000000000000000000000000000000000000000001111111111111111111111
               0000000000000000000000000111111111111111111111111111111111111110000000111111111111111
               0000011111111111111111111000000000000000000000111111111111111110111111000000000000011
               0011100000001111111111111000011111111111111111000001111111111110111110001111111111 01
               0101100011110000000111111011100000000111111111011110000001111110000010010000000001
```

1. GLASSWORT II
2. MEADOWGRASS/BALTIC RUSH
3. MEADOWGRASS/MARRAM
4. RUSH/MARRAM

* Site Numbers:

1- 25	Transect 1A
26- 54	Transect 1B
55- 79	Transect 2A
80-102	Transect 3A

APPENDIX B3.1: SUMMARY OF SPECIES FREQUENCY AND COVER (PERCENT) FOR COMMUNITIES AT BUCTOUCHE, N.B.

	GLASSWORT I		GLASSWORT II		CORDGRASS		SEA LAVENDER		CORDGRASS/ MEADOWGRASS		MEADOWGRASS		ORACH		SEA MILKWORT		BLACK RUSH		BALTIC RUSH		MEADOWGRASS/ BALTIC RUSH		MEADOWGRASS/ MARRAM		RUSH/MARRAM I		RUSH MARRAM II		Marsh Total	
	N=5		N=1		N=7		N=7		N=6		N=11		N=9		N=16		N=6		N=3		N=1		N=1		N=10		N=2		N=85	
	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	Frequency	Cover
Goose Grass	20	3																											1	3
Sea Blite	100	13	100	5																									7	9
Glasswort	60	14	100	20																									5	16
Cordgrass	100	38	100	3	100	79	100	36	100	37			44	3															35	41
Sea Lavender	40	31	100	5			100	11	33	33	9	5			56	5					100	20							27	12
Orach	40	3	100	5									89	3	6	3													14	3
Meadowgrass	20	25	100	29			14	3	100	26	100	78	100	76	94	46	67	24			100	29	100	20					60	52
Sea Milkwort			100	3									11	3	81	23	17	5			100	29			10	3			22	19
Seaside Plantain	20	29	100	3			14	3							56	11	17	3							10	3			18	10
Black Rush																	83	29											7	29
Silverweed															19	3	67	4											9	4
Seaside Goldenrod													11	5	50	15	83	20	100	9			100	5	100	12			32	13
Other Grasses															6	3	67	16	67	13	100	5			80	9			19	11
Red Fescue															13	4	67	5	67	11	100	5	100	3	60	4			19	5
Baltic Rush															6	5			100	10	100	20			100	20	100	25	20	18
Bindweed																			100	5					10	3			5	5
Asters																			100	4					60	7			11	6
Marram																			33	20			100	29	90	11	100	25	15	15
Sea Beach Sedge																											50	5	1	5
Percent Cover: Range	50-95				60-100		5-90		40-80		20-100		75-100		50-100		60-80		25-95						25-70		45-50			
Average	68		75		62		49		69		78		93		79		71		60		95		55		55		48			

APPENDIX B3.2: SUMMARY OF SPECIES FREQUENCY AND COVER (PERCENT) FOR COMMUNITIES AT RUSTICO/BRACKLEY BEACH, P.E.I.

	CORDGRASS		GLASSWORT I		GLASSWORT II		GLASSWORT III		FESCUE		MEADOWGRASS I		MEADOWGRASS II		BULRUSH I		BULRUSH II		BULRUSH III	
	N=18		N=4		N=7		N=6		N=4		N=7		N=9		N=3		N=3		N=7	
	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C
Sea Blite			100	9			33	15							33	3				
Glasswort	11	3	100	13	100	15	83	13							67	5	100	5		
Cordgrass	100	17	100	61	100	21	33	33							100	43	33	3		
Orach							83	13			43	2			67	12				
Salt Marsh Bulrush															100	20	67	5	100	8
Meadowgrass			25	5			67	36	100	82	100	93	100	72			100	60	100	57
Seaside Plantain									25	3					33	5				
Three-square Rush															33	5				
Sea Lavender									75	15										
Sedge																				
Spike Rush																				
Black Rush																				
Silverweed																				
Sea Milkwort									25	5										
Creeping Bentgrass																				
Couch Grass																				
Goose Grass																				
Freshwater Cordgrass																				
Other Grasses																				
Red Fescue									75	15										
Seaside Goldenrod									50	13										
Baltic Rush									25	5										
Asters																				
Bayberry																				
Sea Beach Sedge																				
Bindweed																				
Marram									25	3										
Sow Thistle																				
Clover																				
Vetch																				
Sandwort																				
Woolly Yarrow																				
Iris																				
Percent Cover: Range	5-60		5-75		45-60		50-100				75-100		50-95		10-80		40-100		50-100	
Average	24		71		39		81		100		94		76		57		65		68	

	SEDGE		SEA MILKWORT I		SEA MILKWORT II		MILKWORT/ BALTIC RUSH		BALTIC RUSH I		BALTIC RUSH II		GOLDENROD		ROSE/ BAYBERRY		ROSE/ MARRAM		Marsh Total	
	N=4		N=13		N=21		N=7		N=18		N=11		N=5		N=9		N=20		N=174	
	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	Frequency	Cover
Sea Blite																			4	10
Glasswort			31	2															14	10
Cordgrass			8	1															20	25
Orach													60	3					7	8
Salt Marsh Bulrush																			7	11
Meadowgrass	100	56	85	25	76	24	57	29	6	63									41	48
Seaside Plantain			100	15	29	15													13	14
Three-square Rush			8	5	48	4	29	36							22	3			9	8
Sea Lavender			77	9															7	10
Sedge	100	34			33	4	57	32											9	19
Spike Rush					10	31													1	31
Black Rush					24	13													3	13
Silverweed	25	5			33	15	86	8			9	29							9	12
Sea Milkwort	50	4	100	35	86	57	86	32	6	5									24	41
Creeping Bentgrass	25	3	15	4	71	11	43	3	6	5	36	3	20	3	33	3	5	5	18	7
Couch Grass			38	7							36	3			22	3			6	5
Goose Grass			15	3											11	5			2	4
Freshwater Cordgrass					14	8			6	5	27	5							4	11
Other Grasses							71	34	39	35	18	20							8	33
Red Fescue			23	8			86	6	50	11					11	3	50	3	19	7
Seaside Goldenrod			8	5	19	14			89	11			100	20			55	10	23	12
Baltic Rush					14	20	86	34	94	59	100	54	20	15	100	32	100	15	39	36
Asters									39	4			40	3	44	5	5	5	8	4
Bayberry									17	4			60	15	56	35	75	65	15	51
Sea Beach Sedge									6	3					22	4	40	4	6	4
Bindweed									17	13	18	29							3	19
Marram					10	3	14	20	17	5							85	15	14	12
Sow Thistle							29	3	6	3	45	3	40	12	44	3			8	4
Clover					14	4			11	17	36	20	60	22	89	12	5	20	12	15
Vetch									11	5			80	5	33	4	5	3	6	5
Sandwort											18	3	40	17	11	3	15	5	5	7
Woolly Yarrow													40	17	11	5			2	13
Iris															33	15			2	15
Percent Cover: Range	50-100		10-100		65-100		20-100		75-100		40-100				50-100		5-100			
Average	86		64		91		83		97		74		100		82		83			

APPENDIX B3.3: SUMMARY OF SPECIES FREQUENCY AND COVER (PERCENT) FOR COMMUNITIES AT SOUTH RICHIBUCTO BEACH, N.B.

	GLASSWORT		CORDGRASS		CORDGRASS/ MEADOWGRASS		MEADOWGRASS		SEASIDE PLANTAIN		BLACK RUSH I		BLACK RUSH II		BALTIC RUSH I		BALTIC RUSH II		RUSH/MARRAM I		RUSH/MARRAM II		SEA LYME GRASS I		SEA LYME GRASS II		MEADOWGRASS/ MARRAM		Marsh Total	
	N=4		N=6		N=3		N=29		N=14		N=11		N=19		N=13		N=26		N=11		N=5		N=3		N=4		N=5		N=153	
	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	F	C	Frequency	Cover
Sea Blite	75	10																											2	10
Glasswort	50	3																											1	3
Orach	100	4	33	3	67	3	45	3	7	1																			14	3
Cordgrass	75	46	100	38	100	44	21	16	21	22																			14	31
Meadowgrass	25	5			100	37	100	77	86	64	100	72	58	22									67	17			80	7	48	58
Sea Lavender							38	4	71	7	27	2	5	1			4	3											17	5
Seaside Plantain									93	30			5	5													25	5	10	27
Goose Grass									21	20					8	3													3	16
Three-square Rush									7	1			5	1															1	1
Sea Milkwort									36	7	27	3	74	10			4	3											15	8
Black Rush									21	4	64	20	63	13			8	12											16	14
Silverweed											9	5	89	18	92	25													20	20
Red Fescue							3	3	14	4			74	11	85	7	69	3	9	3									31	6
Other Grasses													68	16	92	32	92	31	27	4	20	5					40	5	36	25
Seaside Goldenrod											45	7	47	24	77	17	92	9	64	3			33	5			40	3	38	12
Baltic Rush											9	1	42	15	100	23	92	16	82	9	100	10							39	16
Asters															46	6	81	9	64	3									22	7
Bindweed															23	3	69	7	6	3					25	5	20	3	15	6
Iris																	19	3											3	3
Freshwater Cordgrass									7	5			11	3	23	2	46	4	9	20					75	29			15	8
Clover																	65	8	100	9									18	8
Woolly Yarrow																	12	2	36	4									5	3
Sea Beach Sedge																	23	3	82	3									10	3
Red Sand-Spurry																	12	4	36	7	20	3							5	5
Bayberry																	4	5			20	29							1	17
Marram																	19	3	100	17	100	11			100	30	100	24	20	17
Beach Heather																					20	5							1	5
Sea Lyme Grass																							100	46	100	8			5	
Percent Cover: Range	10-95		5-80		75-100		10-100		75-100		70-100		50-100		50-100		35-100		10-85		20-55		20-95		45-80		30-80			
Average	60		35		85		90		90		60		77		75		70		41		31		52		58		47			

APPENDIX B4.1: HEIGHT AND DISTANCE MEASURES FOR MARSH COMMUNITIES BY TRANSECT AT BUCTOUCHE, N.B. MEASURES STATED ARE RELATIVE TO MEAN SEA LEVEL. BRACKETTED VALUES INDICATE NON-CONTINUOUS ZONES.

	TRANSECT															
	1A				1B				2A				3A			
	HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)	
COMMUNITY	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range
CORDGRASS (SHORE)	-.14 .18	.32	-2.29 2.59	4.88	-.21 -.13	.08	-4.03 -1.60	2.43								
(INLAND)									.38 .54	.16	23.31 175.71	(152.40)				
GLASSWORT									.41 .67	.26	23.00 175.71	(152.71)				
CORDGRASS/ MEADOWGRASS					.40 .50	.10	38.95 41.08	(2 13)	.44 .56	.12	62.32 107.74	(45.42)				
MEADOWGRASS	.21 .40	.19	9.91 30.94	21.03	.40 .50	.10	38.95 59.68	(20.73)	.49 .62	.13	19.34 195.21	(175.87)				
SEA MILKWORT					.46 .51	.05	59.68 80.40	(20.71)	.49 .63	.13	190.03 219.90	(29.87)				
BLACK RUSH I	.25 .32	.07	30.94 51.36	20.42	.49 .60	.11	66.69 113.32	(46.63)								
II	.32 .36	.04	51.36 72.09	20.73	.60 1.00	.40	113.38 148.68	35.36								
BALTIC RUSH I	.33 .64	.31	72.09 79.40	7.31	.75 1.25	.50	179.47 240.42	(60.95)								
II	.48 .82	.34	79.40 140.97	(61.57)	1.11 1.25	.14	238.90 264.20	25.30					.49 .77	.28	24.93 49.62	24.69
RUSH, MARRAM I	.71 1.04	.33	126.34 198.88	(72.54)	.83 1.58	.75	166.36 286.75	(120.39)					.72 .75	.03	49.62 54.49	4.86
II	1.03 1.20	.17	198.88 219.91	21.03	1.48 1.58	.10	264.03 286.75	(20.72)								
MEADOWGRASS/ MARRAM					.50 .76	.26	33.77 38.95	5.18	.63 .71	08	219.90 228.13	8.23				
LYMEGRASS I	.40 .45	.05	8.69 9.91	1.22					.55 .83	.28	5.63 13.86	8.23				
II													.54 .86	.32	7.86 24.93	17.07
TOTAL RANGE	1.34		222.20		1.79		290.78		.45		222.50		.37		46.63	

APPENDIX B4.2: HEIGHT AND DISTANCE MEASURES FOR MARSH COMMUNITIES BY TRANSECT AT RUSTICO ISLAND/BRACKLEY BEACH, P.E.I. MEASURES STATED ARE RELATIVE TO MEAN SEA LEVEL. BRACKETTED VALUES INDICATE NON-CONTINUOUS ZONES.

	TRANSECT																			
	2B				3A (SOUTH)				3B (NORTH)				4A				4B			
	HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)	
COMMUNITY	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range
CORDGRASS (INLAND)	-.07 -.01	.15	38.03 150.03	(112.00)																
GLASSWORT I	-.04 -.01	.03	38.03 46.03	(8.00)																
II	-.07 .03	.10	46.03 89.03	(43.00)																
III	.02 .14	.12	130.03 193.03	(63.00)																
FUCUS	.11 .51	.40	6.03 25.03	19.00																
MEADOWGRASS I	.07 .24	.17	150.03 246.03	(96.00)																
II	.20 .30	.10	246.03 347.53	(101.00)																
BULRUSH I	.13 .22	.09	190.03 210.03	(20.00)																
II	.17 .24	.07	199.03 243.03	(44.00)																
III	.20 .24	.04	201.03 265.03	(64.00)																
SEDGE	.26 .30	.04	288.03 296.03	8.00																
SEA MILKWORT I	-.01 .51	.52	2.03 38.03	(36.00)	.91 1 31	.40	66.00 89.04	23 04									1.24 2.15	.91	83.90 93.92	9.92
II	.24 .30	.06	288.03 347.53	(59.50)	1.31 1.84	.53	89.04 109.02	19.98												
SEA MILKWORT/ BALTIC RUSH	.24 .41	.17	347.53 368.03	(20.50)	1.00		66.00													
BALTIC RUSH I	.24 .41	.17	347.53 368.03	(20.50)	1.84 2.06	.22	109.02 114.01	(4.99)									1.24 2.15	.91	63.91 83.90	19.99
II	.41 1.30	.89	368.03 410.03	42.00	1.84 2.06	.22	109.02 114.01	(4.99)	-.11 18	.29	161 28 181 27	(19.99)								
GOLDENROD									- 50		146 30						1.24		58.91 63.91	5.00
RUSH/BAYBERRY									- 50 .72	1.22	146.30 191 25	(44.95)	1.88		93.08					
RUSH/MARRAM													-.18 1.98	2.16	-3.43 93.08	96.51				
TOTAL RANGE		1.37		408.00		1.15		48.01		1 22		44 95		2 16		96.51		.91		34.91

APPENDIX B4.3: HEIGHT AND DISTANCE MEASURES FOR MARSH COMMUNITIES BY TRANSECT AT SOUTH RICHIBUCTO BEACH, N.B. MEASURES STATED ARE RELATIVE TO MEAN SEA LEVEL. BRACKETTED VALUES INDICATE NON-CONTINUOUS ZONES.

	TRANSECT															
	1A				1B				2A				3A			
	HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)		HEIGHT (M)		DISTANCE (M)	
COMMUNITY	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range	Minimum Maximum	Range
CORDGRASS (SHORE)	-.08		-11.30 - 8.6	2.7	-.05 -.03	.02	-4 72 -1.98	2 74	.10 .31	.21	5.09 60.25	(55.17)				
GLASSWORT I									10 .16	.06	21 68 55 99	(32.31)	.22 .27	.05	20.17 21.39	(1.22)
II													.22		20.17	
SEA LAVENDER									.19 .31	.12	11.79 21 85	10.06	.10 .27	.17	1.88 13.16	(11.28)
CORDGRASS/ MEADOWGRASS	-.03		- 5.81						.10 .37	.27	60.26 82,51	(22 25)	27 .31	.04	20.17 27.79	(7.62)
MEADOWGRASS	-.08 .33	.41	- 8.56 35.64	(44 20)	-.05 .27	.32	-1.98 32.77	(34 75)	.16 .37	.21	55 99 82.51	(16.46)	.27 .69	.42	13.16 49.43	(36.27)
ORACH	.00 .18	.18	.89 18.57	(17.68)	.21 .27	.06	13.87 32 77	(18.90)	.28 .37	.09	66 05 82.51	(16.46)				
SEA MILKWORT	.18 .21	.03	18.57 23.15	4.58	.27 .63	.36	32.77 50 45	17.68	.37 .53	.16	82.51 93.48	10.97	49 .62	.13	60.71 74.12	13.41
BLACK RUSH	.18 .74	.56	18.57 51.29	(32 62)	.41 .43	.02	70 56 79.10	8.54								
BALTIC RUSH					.63 .93	.30	50.45 108.36	(57 91)								
MEADOWGRASS/ BALTIC RUSH					.82		55.76									
MEADOWGRASS/ MARRAM									53 .91	38	93 48 100 49	7 01				
RUSH/MARRAM I	.74 .82	.08	51.19 61.85	10 66	.43 .67	.24	70 56 108 36	(37 80)					59 1 03	44	49.43 82 96	(33.53)
II					.46 .90	.44	87 63 94 64	7.01					59 1.03	.44	74.12 82.96	(8.8)
TOTAL RANGE	.90		73.15		.98		113.08		.81		95 40		93		81.08	

APPENDIX C: LIST OF AERIAL PHOTOGRAPHS.

AREA	DATE	SCALE	FORMAT*	ROLL	FRAMES
Buctouche, N.B.	14-18/10/54	1:15,840	B&W	1476	221,222
				1487	47,48
				1514	58-60
	18/7/59	1:16,200	B&W	A16741	46-48
	10/5/65	1:16,000	B&W	A18848	78-80, 102-106
	21/5/67	1:18,000	B&W	A19884	17-19, 21-25
	22/7/73	1:30,000	Colour Transparency	RSA 30779	3-8, 29-34
			Colour Print		29-31
	30/5/73	1:10,200	B&W	73032	72,73,132
				73027	21,22,114, 116,171,172, 226,227
Rustico Bay/ Brackley Beach, P.E.I.	8/8/35	1:15,200	B&W	A5054	74,75
				A5055	2,3,70
				A5062	59,60,62,63
				A5063	32-35
	1/9/53	1:7,200	B&W	A13864	66-72, 95-98
	27/9/56	1:7,600	B&W	A15560	57-69, 74-76
	29/6/58	1:15,840	B&W	A16113	61,62,111, 112,116,169, 170
	19/7/58	1:15,840	B&W	A16100	100,101
	26/11/60	1:6,000	B&W	A17146	106-109
	25/11/60	1:6,000	B&W	A17275	179-187
	20/8/64	1:25,000	B&W	A18515	74-76
	8/5/65	1:7,200	B&W	A18849	7-21

AREA	DATE	SCALE	FORMAT*	ROLL	FRAMES
	9/5/68	1:12,000	B&W	A20358	136-139, 190-204
	6/8/72	1:4,966	B&W	A22410 A22411	25-43,55-80 100-123
	17/8/73	1:12,000	CIR Print	RSPA 30826IR	25,26
	18/8/73	1:12,000	CIR Print CIR CIR Transparency	RSPA 30827IR	15-17, 16-29 16-29
	12/8/74	1:10,000	Colour Print	74121	74-83, 206-208
	14/5/76	1:10,250	B&W	A24369	100-107, 115-122
	16/8/77	1:10,250	B&W	A24772	6-10,50-62, 79-82
	12/10/78	1:3,000	CIR Print	A31227	142-145, 171-175
			CIR Transparency		172-173
South Richibucto Beach, N.B.	14/10/54	1:15,840	B&W	1482	155-158, 161-164
	10/5/65	1:16,000	B&W	A18848	19,85-87
	24/5/67	1:18,000	B&W	A19883	158-160, 204,206
	18/7/73	1:9,600	B&W	A23435	3-5,43-53
	7/6/74	1:9,600	Colour Transparency	A30953	151-153, 159-162
	18/7/74	1:9,600	B&W	A23796	3-5,45-49, 53-59
	16/8/77	1:9,600	B&W	A24772	171,176-180, 192
	4/6/77	1:20,000	CIR Transparency	RSPA 30688IR	88

Black and