Great Lakes Coastal Wetlands

An Overview of Controlling Abiotic Factors, Regional Distribution, and Species Composition

Michigan Natural Features Inventory

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Great Lakes Coastal Wetlands:

An Overview of Controlling Abiotic Factors, Regional Distribution, and Species Composition

(In 3 Parts)

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PART I

OVERVIEW OF ABIOTIC FACTORS AFFECTING GREAT LAKES COASTAL WETLANDS

Great Lakes coastal wetlands occur along the Great Lakes shoreline proper and in portions of tributary rivers and streams that are directly affected by Great Lakes water regimes (Fig. 1). These wetlands form a transition between the Great Lakes and adjacent terrestrial uplands, and are influenced by both. Over the past two decades, a wealth of detailed information has been generated on these systems, ranging from a comprehensive inventory of wetlands along the U.S. Great Lakes shoreline (Herdendorf et al. 1981a-1981f), to detailed studies on the hydrology, sediment history, water chemistry, and flora of one or a few sites. To date, however, there has been little emphasis on (or understanding of) regional variability within these wetlands and how that variability relates to environmental parameters.

This report addresses that gap, by providing a regional perspective on the abiotic variability and associated vegetation characteristics of herbaceous wetlands, including marsh, bog, fen, and wet meadow communities, of the Great Lakes coast. This study is based on field sampling conducted in over 110 coastal wetlands in Minnesota, Wisconsin, Michigan, Ohio, Pennsylvania, and New York by Michigan Natural Features Inventory (MNFI) between 1987 and 1994 (Fig. 2). The goal of MNFI's project was to identify vegetatively distinct wetland types, and to develop a wetland classification for the Great Lakes coastline that links floristic variability to controlling abiotic factors.

In order to provide baseline data on both the biotic and abiotic components of selected coastal wetlands, sampling transects were established to include the full range of **vegetation zones** present (Fig. 3), extending from the upland boundary lakeward to water depths of roughly 2 m. At 10-20 m intervals along the transect, the cover value for each species present was recorded, along with data on substrate, organics, and water depth. These data were integrated with regional information on bedrock characteristics, glacial landform, soils, topography, shoreline configuration, and water quality.

Our analyses found that patterns of species co-occurrence and distributions are determined by multiple abiotic factors. These include:

- **Aquatic System**
- **Great Lakes Water Level Fluctuations**
- **Surficial Bedrock**
- **Glacial Landform**
- **Climate**
- **Land Use and Anthropogenic Stress**

These factors operate at different scales (from regional to local), and the importance of any one factor varies markedly across the Great Lakes Basin. However, a preliminary understanding of how these factors individually and jointly influence coastal wetlands is basic to any classification of regional wetland variability.

This overview is organized in three main sections. The first introduces and briefly examines the influence of the abiotic factors listed above. The second section examines the interplay of these factors to develop a preliminary regionalization of the U.S. Great Lakes shoreline that identifies stretches of coast sharing similar types of herbaceous wetlands. The third section examines floristic variability within 102 Great Lakes coastal wetlands to provide a regional classification based on vegetation characteristics.

Figure 1. The Laurentian Great Lakes.

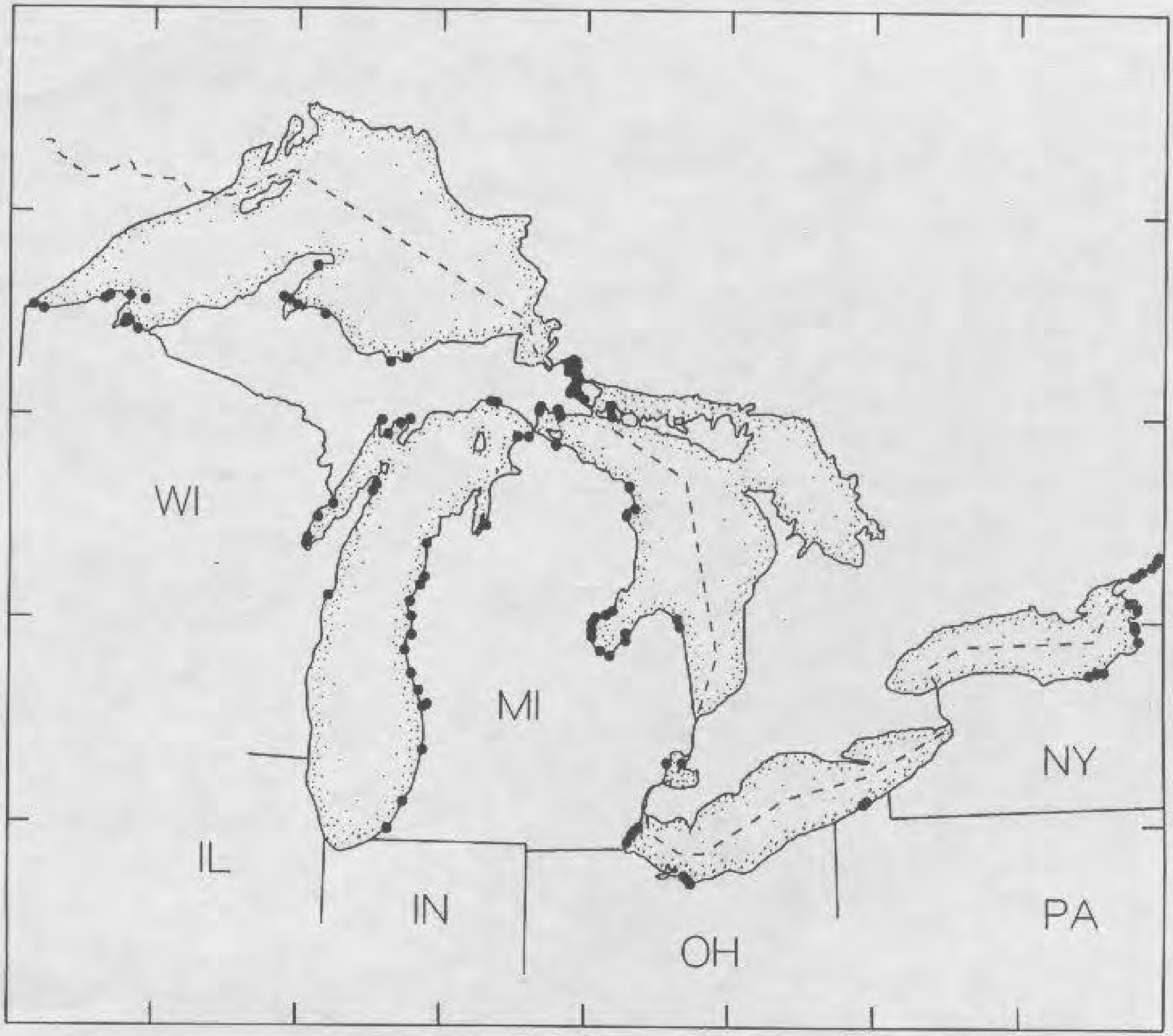

Figure 2. Distribution of Great Lakes coastal wetlands evaluated in this study.

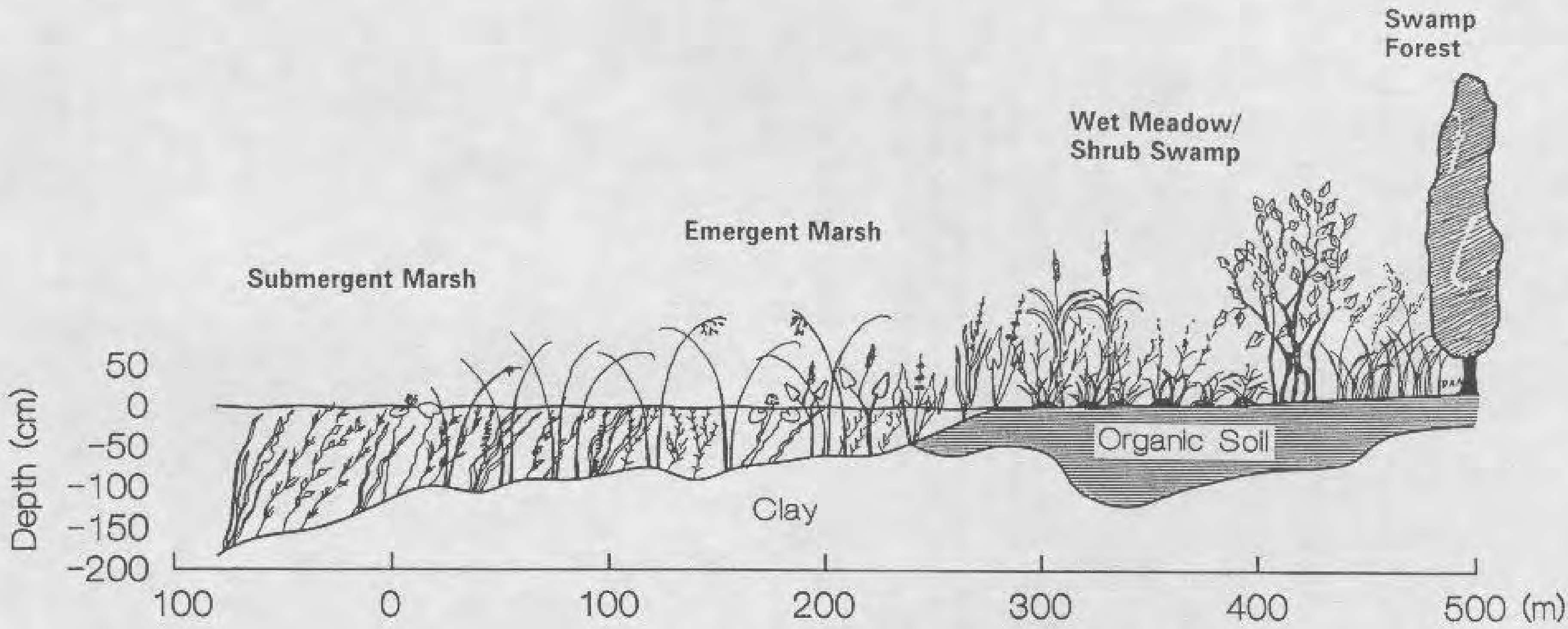

Figure 3. Characteristic vegetation zonation of Great Lakes coastal wetlands.

AQUATIC SYSTEM

The aquatic habitat classification scheme proposed by Sly and Busch (1992) identifies four major aquatic systems which are applicable to the Great Lakes Basin:

- **lacustrine,**
- **connecting channel,**
- **riverine**, and
- **estuarine.**

These four systems are defined largely on water flow characteristics and residence time.

Lacustrine systems are those controlled by waters of the Great Lakes, and involve wetlands of the Great Lakes shoreline. Estimated water residence time ranges from 173-191 years for Lake Superior, 100 years for Lake Michigan, 22 years for Lake Huron, to only 2.6 years for Lake Erie (SOLEC 1997). Water flow within the lakes is both wind and thermally driven (Liu et al. 1976). Nearshore habitats are strongly affected by littoral (longshore) currents generated by prevailing winds (Fig. 4), and by short-term storm-driven currents and wave action that shift direction and force (Bennett 1995). In comparison with the other aquatic systems, lacustrine habitats generally experience greater exposure to wind and wave action and to ice scour, the primary agents responsible for shore erosion and redeposition of sediments.

Figure 4. Persistent circulation patterns (littoral currents) in the Great Lakes due to prevailing winds that affect lacustrine habitats (after Harrington 1895).

Connecting channels refer to the major rivers linking the Great Lakes, including the St. Marys, Detroit, St. Clair, Niagara, and St. Lawrence rivers. Although they are flowing water habitats, these rivers are technically considered straits connecting two lakes (Edsall et al. 1988:3), which differ significantly from both lacustrine and riverine systems. In contrast with the Great Lakes, the shallowness and current of the connecting channels result in earlier spring warming and better oxygenation. In contrast to rivers, the connecting channels receive little contribution of water, nutrients, or sediments from their surrounding uplands; rather, their "drainage basin" is the upstream lake. As a result, the connecting channels are characterized by a large flow, but seasonally stable hydrology.[1] Longer-term (interannual) variability in water level and flow rate reflect both natural water levels in the upstream lake(s) and regulation of those levels.

All the connecting channels are modified systems. As part of the Great Lakes-St. Lawrence seaway, navigatory channels are maintained to accommodate commercial ship traffic, although shipping bypasses the Niagara River through the Welland Canal. Hydroelectric generating facilities have been constructed on the St. Marys, Niagara, and St. Lawrence rivers, and the outflows of the St. Marys and St. Lawrence rivers are regulated to achieve limited water-level control within the chain of lakes.

Overall, the connecting channels provide a broad diversity of habitats in close proximity to one another. Further, their comparatively warm, well-oxygenated currents carrying sediments and nutrients generally lead to high productivity in shallow waters and associated wetlands (Dodge and Kavetsky 1995).

Riverine aquatic systems refer to smaller rivers tributary to the Great Lakes. Water quality, flow rate, and sediment load are controlled in large part by their individual drainages. In comparison with the connecting channels, tributary rivers have a much lower volume, but seasonally more variable flow.[2] Long-term changes in water level are not directly tied to the Great Lakes, but rather are a function of variable precipitation within their individual drainage basins. The range of tributary habitats depends upon the size, slope, substrate, geology, and land-use in the drainage basin, groundwater characteristics, climate, and the nature of terrestrial vegetation (Dodge and Kavetsky 1995).

Lacustrine or freshwater **estuaries**, formed where some tributary rivers enter the lakes, are aquatic systems distinctive to the Great Lakes, with direct analogies to the tidal characteristics of marine estuaries. That is, they represent a zone of transition from stream to lake within which water level, sedimentation, erosion, and biological processes are controlled by oscillations in lake level (Bates and Jackson 1980; Brant and Herdendorf 1972; Herdendorf

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[1]Annual mean discharge of the connecting channels ranges from 2100 $m^3 s^{-1}$ for the St. Marys River, to 6739 $m^3 s^{-1}$ for the St. Lawrence River (Edwards et al. 1989), with about a 2:1 ratio of maximum to minimum flow (Hudson et al. 1992).

[2]The largest tributary (the Nipigon River entering Lake Superior) has an annual mean discharge of only 358 $m^3 s^{-1}$; of the 100 tributaries flowing into Lake Michigan, only eight have an average flow of 28 $m^3 s^{-1}$ (Hudson et al. 1992:93). Seasonal variability is pronounced in the larger tributaries, with a maximum flow generally three to seven times that of their average flow (Hudson et al. 1992:94).

1987, 1989, 1990; Herdendorf and Krieger 1989; Keough 1986, 1990).[3] The zone of lake influence can extend inland for a considerable distance; gaging stations in the Maumee River estuary showed water levels 11 km inland from Lake Erie to be identical to those of the lake (Brant and Herdendorf 1972). During short-term rises in lake level (such as wind setup or seiche events), river flows in estuaries may be temporarily reversed from downstream to upstream, with a major influx of lake water into the river mouth (Kelly et al. 1985; Bedford 1989; Keough 1990). High amplitude increases in lake level can cause flooding and erosion of the estuary several miles inland on a scale comparable to that experienced along the coast.

Within each of the four preceding aquatic systems, nearshore and wetland habitats are affected by water level, turbidity, color, pH, toxins, and nutrients of the associated body of water. Terrestrial abiotic factors affecting these variables are discussed below.

GREAT LAKES WATER LEVEL FLUCTUATIONS

Fluctuations in Great Lakes water levels occur over three temporal scales: short-term, seasonal, and interannual (U.S. Army Corps of Engineers 1987). All contribute to the dynamic character of coastal wetlands.

Short-term fluctuations in water level are caused by persistent winds and/or differences in barometric pressure. Sustained winds along the length of the lake drive or drag water from one side of a lake to the other, causing the water level on one end of the lake to rise substantially, while the level falls at the other end (Liu et al. 1976). The forced movement of the lake surface due to wind stress is known as wind tide or storm surge, and the amount of rise produced is the **wind setup** (Fig. 5). Similarly, higher barometric pressure at one end of a lake may depress the water, causing it to rise at the other end where air pressure is lower. When the wind stress decreases or when the high pressure front passes over, the water returns to hydrostatic equilibrium. However, the water oscillates back and forth several times before reaching equilibrium, creating the free oscillatory waves called **seiches**.[4]

Short-term storm surges can be dramatic: wind setup differences in water level have been recorded for Lake Erie in excess of 3 meters. Some surface oscillations, however, are

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[3]Although the term "lacustrine estuary" is now established in the literature on the Great Lakes, there has been considerable debate about the applicability of the estuarine concept to freshwater situations (e.g. Schubel and Prichard 1990). A marine estuary may be defined in terms of tidal conditions (as the lower reaches of a river subject to tidal fluctuations), or in terms of salinity (as the area where fresh river water meets and mixes with salt water from the sea) (Bird 1984:201). Direct analogies can be found in the Great Lakes for both these definitions: the ebb and flow of tides is mimicked both by seiche and wind tide events, and by inter-annual oscillations in lake level which flood the estuary (Dyer 1990; Odum 1990). The mixing of fresh and saline water in a marine estuary is analogous to the mixing of riverine and lacustrine flows with potentially different sediment, chemical, and thermal characteristics (Brant and Herderndorf 1972; Odum 1990).

[4]Wind tides are distinguished from seiches by the extreme variation in the period of wind-tide duration. Wind tides may pile up water for only a few hours or for as long as 48 hours during severe storms; in contrast, the periodicity of seiches is regular and predictable (Herdendorf et al. 1992:138).

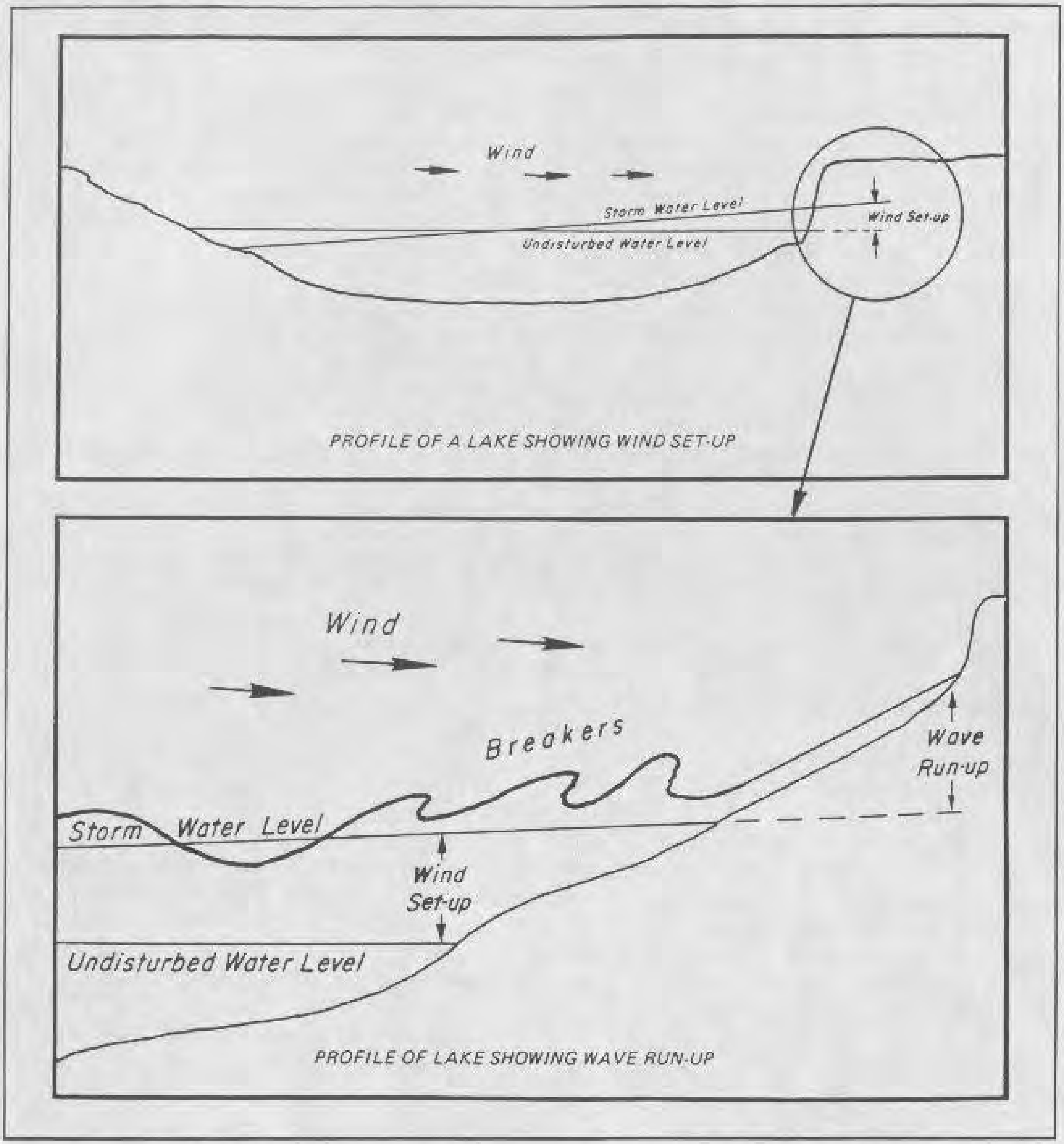

Figure 5. Effects of wind set-up on Great Lakes shoreline (from U.S. Army Corps of Engineers 1987:12).

always present, alternately flooding and exposing shoreline areas, or temporarily reversing the flow of tributary rivers (Mortimer 1971; Seelig and Sorenson 1977). The rise and fall of water level due to seiches may take from several minutes to several hours to occur; the period of the seiche is determined by basin morphology, and is predictable for a given point along the Great Lakes shoreline (Liu et al. 1976; Bedford 1989, 1992). The amplitude of seiche events, in contrast, is not predictable, since seiches are stimulated by weather patterns. Seiches with an amplitude of 10-30 cm are standard within Lake Erie tributaries (Bedford 1989), while oscillations of greater than 30 cm commonly occur at the mouth of the Mink River on the northwestern shore of Lake Michigan (Keough 1990).[5]

Seasonal fluctuations reflect the annual hydrologic cycle in the Great Lakes basin. In the spring, water levels begin to rise due to snowmelt, heavier rains, and reduced evaporation, leading to peak waters levels generally in June or July. This trend is reversed by late summer, as runoff decreases, and more persistent winds and drier air intensify evaporation, culminating in a mid-winter low in lake level. Seasonal variations in water level on the order of one foot (30 cm) are typical for Lakes Superior, Michigan-Huron, and Erie, while Lakes St. Clair and Ontario experience slightly higher seasonal oscillations.

All the Great Lakes experience significant **interannual fluctuations** in lake-level as a result of variable precipitation and evaporation within their drainage basins. Extreme lake level fluctuations range from 3.5 to 6.5 feet (1.3-2.5 m), depending on the lake (Fig. 6). The intervals between periods of high and low levels, and the length of such periods vary widely and erratically. More than 100 years of water levels records on the Great Lakes indicate that there are no regular, predictable cycles (U.S. Army Corps of Engineers 1987), although some authors argue that high water and low water periods occur roughly every seven to ten years (Cohn and Robinson 1989; Jaworski et al. 1979). Further, high or low levels can persist for a considerable time after the factors which initially caused them have changed, owing to the vast size of the Great Lakes and the limited discharge capacities of their outflow rivers.

Limited water level control is achieved by regulating the outflows from Lakes Superior and Ontario (U.S. Army Corps of Engineers 1987, 1997). Regulating the outflow from Lake Superior (via the control works on the St. Marys River) affects the level of Lake Superior, Lakes Michigan-Huron, and to a lesser extent, Lake Erie. Regulation strives to keep the level of Lake Superior in balance with that of Lakes Michigan-Huron; to this end, water supplies are held or released so that one lake is not higher or lower in its range than the other lakes.

Regulating the outflow from Lake Ontario affects levels on that lake and on the St. Lawrence River, but has no effect on the upper lakes since Lake Ontario is separated from them by Niagara Falls. Regulation here strives to prevent erosion and damage to shoreline properties, while protecting the interests of commercial navigation and hydropower production in the St. Lawrence River. Since 1959, regulation has significantly reduced the occurrence of extreme high and low water levels on Lake Ontario. For example, although Lake Ontario receives all of the outflow from the other Great Lakes, it was the only Great Lake that did not set record high water levels in 1985-1986. This is largely owing to the dredging of the St. Lawrence River channel, which allows for the release of greater amounts of water when lake levels are high.

The difference between low and high water periods can have profound effects on the plant communities of Great Lakes coastal wetlands. A generalized model of these effects appears in Figure 7. In high-water years, rising lake-levels flood out emergent zone dominants, leading to an expansion of floating-leaved and submergent communities more tolerant of flooding (Maynard and Wilcox 1996). The ecotonal strand community, located between aquatic and terrestrial zones, is also flooded and/or eroded, resulting in the temporary loss of a

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[5]Short-term fluctuations due to lunar tides also occur in the Great Lakes, attaining up to 18 cm on Green Bay, Lake Michigan, but only 4.5 cm at Chicago, 3.0 cm on Lake Erie, and 1.5 cm on Lake Ontario (Liu et al. 1976; Herdendorf 1990).

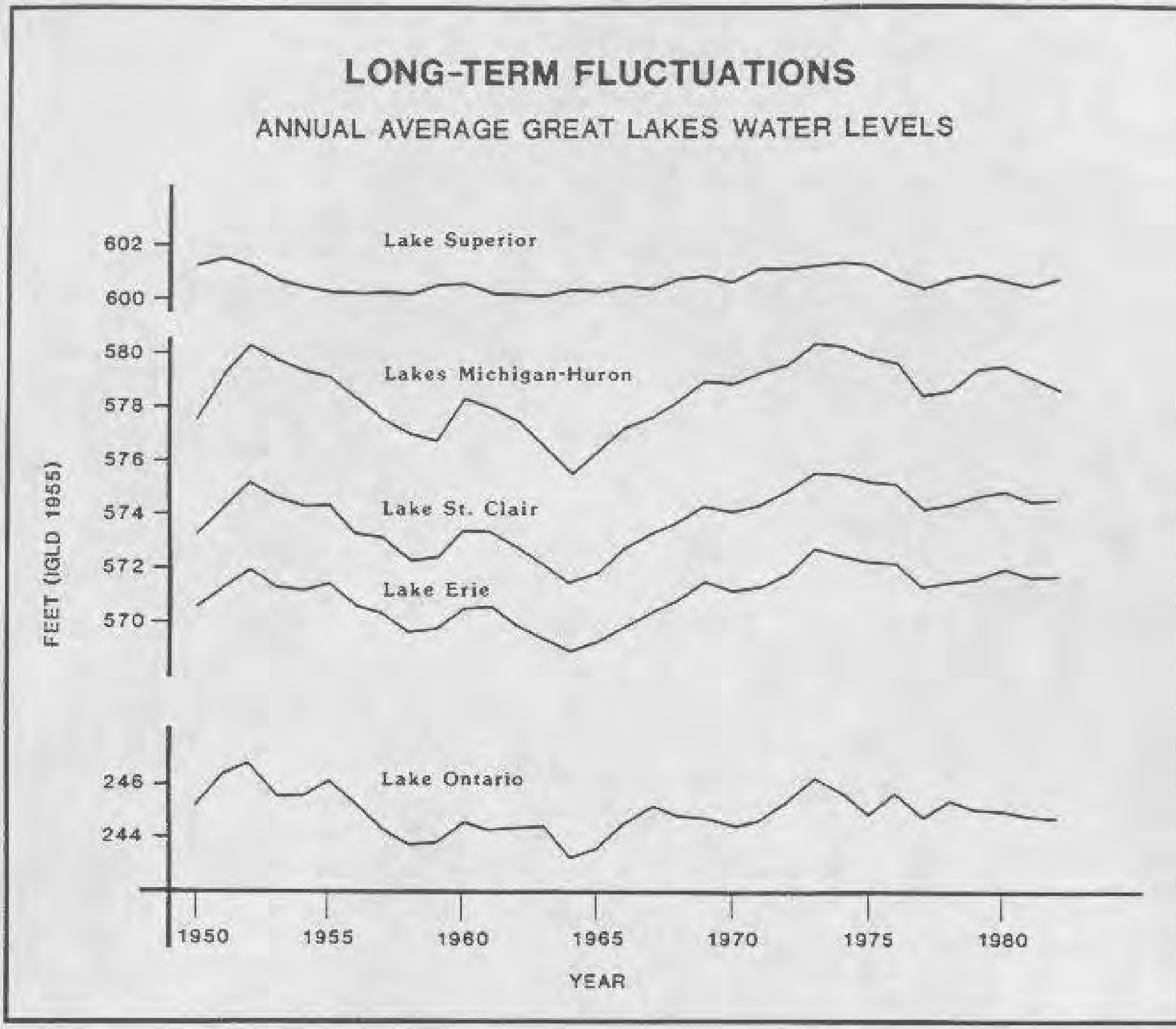

Figure 6. Interannual Great Lakes water level fluctuations 1970-1985 (U.S. Army Corps of Engineers 1987:10).

broad range of annuals adapted to the seasonal fluctuations characteristic of this zone. Inland, flooding of adjacent wet meadow and/or shrub zones leads to the die-back of woody plants and flood-intolerant perennials.

As water levels drop, marsh vegetation may again change dramatically. Aquatic communities move lakeward following receding waters and fertile mud flats are exposed along the strand. These mud flats are rapidly colonized by species emerging from reserves of buried seeds (Keddy and Reznicek 1985, 1986). Inland, in the recently flooded wet meadow, species intolerant of dry-down are replaced by a more diverse wet meadow community. During continued low water periods, the zone of woody plants expands and may encroach on the shoreline communities.

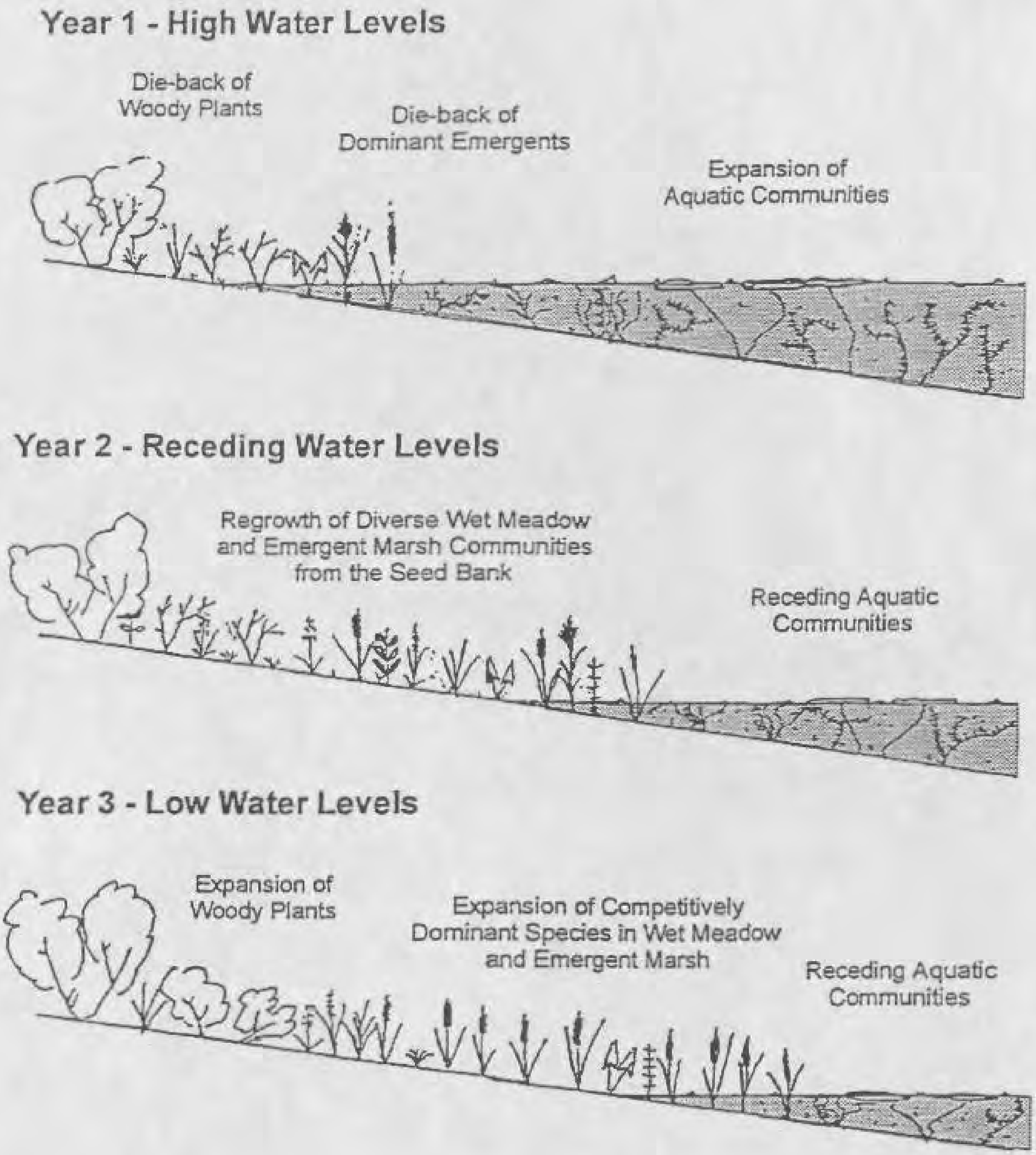

Figure 7. Simplified diagram of the effects of water-level fluctuations on coastal wetland plant communities (from Maynard and Wilcox 1996:21).

This model presents two related components species change. The first component focuses on the locational shift of vegetation zones as water levels rise and fall, with a landward shift of vegetation communities during high-water years, and a lakeward shift during low-water years. According to this plant community displacement model, a major determinant of wetland change under fluctuating lake-level regimes is site morphometry or shoreline configuration (Herdendorf et al. 1981a; Wilcox 1989; Wilcox et al. 1993). In wetlands occupying a broad, open basin, vegetation zones may shift freely and maintain considerable vegetational integrity in spite of lateral movement. Conversely, steep topography surrounding the wetland may restrict this shift, resulting in the loss of certain habitats and the extirpation of vegetation adapted to these habitats, as when high water levels completely flood shallow water habitats.[6] Shoreline slope also determines the areal extent affected by lateral shift. In a shallow wetland, a one foot (30 cm) change in lake level may affect (through inundation or dry-down) a large portion of the marsh, while in areas of steeper slope, this fluctuation would alter conditions only along a narrow fringe.

The second component, in contrast, involves a cyclical increase and decrease in the density and relative dominance within each zone of species more or less tolerant of present conditions. In this systemic view, fluctuating lake levels effect not only a change in water depth, but a broad range of associated stresses to which plants must respond, including changes in water current, wave action, turbidity (clarity or light penetration), nutrient content or availability, alkalinity, and temperature, as well as ice scour and sediment displacement (Herdendorf et al. 1981a; Patterson and Whillans 1985; Table 1).

Since individual species display different tolerance limits along one or more of these dimensions, species composition can change dramatically within a zone. Certain plastic species of the emergent zone have mechanisms that allow them to survive during high water and thus are more tolerant of a sudden rise in water level (Stuckey 1978; Keough 1987, 1990). Broad, floating-leaved species, such as *Nymphaea odorata* (sweet-scented waterlily) and *Nuphar advena* (yellow pond-lily), may grow longer petioles in response to high water levels, so that their leaves and flowers protrude above the water. Other species change form to survive suboptimal conditions. On a mud flat *Butomus umbellatus* (flowering-rush) is a stout, erect plant with many bright pink flowers; submersed it remains a vegetative plant with limp leaves, which does not flower (Stuckey 1978:68).

In contrast, common shallow-water species such as cat-tails (*Typha angustifolia*, *T. latifolia*), common arrowhead (*Sagittaria latifolia*), and arrow-arum (*Peltandra virginica*) are drastically affected by a sudden rise in water level; a rise of as little as 30 to 60 cm can partially or totally eliminate them from a marsh (Stuckey 1978; Whigham et al. 1979; Klarer and Millie 1992; Campbell 1995:102-103). Cat-tail, commonly a dominant of the emergent zone, is particularly sensitive to increased water depth; cat-tail die-back during high water periods has been linked to flooding, as well as to wave erosion and/or rafting of the rhizome mat, and ice-scour of shoreline sediments. The disappearance of these species during high-water times, however, is usually only temporary, and when water levels go down, these

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[6] Klarer and Millie (1992:626) argue that site morphometry is a significant factor determining species composition along the immediate shoreline of Old Woman Creek estuary. The steep banks surrounding much of the estuary greatly limit shallow water habitats such that during high water periods the shallow water vegetation is largely eliminated. Thus, shoreline patches of *Typha latifolia* largely disappeared during the high-water episode of 1986.

Table 1
Selected Stresses and Associated Vegetative Responses[a]

Increase in Water Depth	Decrease in Water Depth	Increased Sediment Load (Turbidity)
Physical & Chemical Changes		
- decreased alkalinity - increased turbidity - increased shoreline erosion - change in wetland size - improved circulation - increased sedimentation	- increased alkalinity - increase in rate of organic decomposition - increase in nutrient release from sediments - increased water temperature	- increased BOD - reduced light penetration - increased water temperature
Associated Vegetation Changes		

- decrease in density
- emergent die-off at inland fringe
- emergent replaced by submergent in deep water
- decreased productivity of some species
	- decreased primary productivity
	- increased species diversity
	- decrease in number of dominant species
	- change in density
	- woody shrubs may invade shallow water
	- exposure of seed bank and germination of:
	  - emergents in very shallow water
	  - submerged aquatics in standing water
	  - mud flat species in saturated soils
		- reduced primary productivity
		- development of rooted macrophytes inhibited
		- submergent vegetation reduced due to limited light penetration

[a]From Patterson and Whillans (1985:Table 4).

species will re-establish, having survived as seeds in the mud and sediments for many years (Keddy and Reznicek 1985, 1986; Siegley et al. 1988; Leck 1989).

Other wetland and aquatic species appear to respond to variables associated with increasing water depth. Researchers have identified wave action and water turbulence (Hutchinson 1975; Klarer and Millie 1992; Liston et al. 1986); sedimentation and water turbidity (Klarer and Millie 1992; Kadlec and Wentz 1974; Stuckey 1989); and ice scour and sediment displacement (Geis 1985) as key factors affecting species persistence during periods of high water. However, our understanding of how wetland communities as a whole respond to these interacting variables is still at a very rudimentary level.

Comparison of coastal marshes from Michigan indicates that inter-annual fluctuations in lake level significantly alter species composition over the short-term. The Michigan marshes were initially sampled in 1987-1989, following a period of extreme high water on all the Great Lakes (Albert et al. 1987, 1988, 1989); 28 of the marshes were revisited in 1994, during a period of near-normal lake levels. Species continuity (measured as the percent of species present at both sampling times) was found to be quite low, for both herbaceous/meadow and emergent zone communities (Minc 1997b). In most sites, less than 50% of species were recorded as present at both sampling dates; the range was 6%-64%. Variability in species continuity is partly a function of site morphometry. Sites protected from erosive wave action tended to have higher species continuity than did those that were exposed to wave action. Similarly, shallow sites that allowed for the lateral shifting of vegetation zones had higher species continuity than did topographically bounded sites with no available habitat for the inland expansion of wetland vegetation during high water events.

In contrast, the absence or reduction of natural water fluctuations, through manipulation of lake levels, leads to an overall loss of both species richness and diversity (Van der Valk 1981; Keddy 1990; Stuckey 1975a, 1989; Wilcox et al. 1993), as well as genetic diversity (Keough 1987, 1990). Disruption of the natural cycle favors species intolerant of water-depth change and associated stresses, and/or excludes species requiring periodic exposure of fertile substrates. The result is frequently a monoculture of the most light-competitive species (Keddy 1989). The dominance of cat-tails in many Lake Ontario marshes (Fig. 8), following the manipulation of outflow from this lake, exemplifies this trend toward reduced species diversity following a reduction in the amplitude of natural water-level fluctuations (Wilcox et al. 1993).

GEOLOGY

The foundation for the present Great Lakes Basin was set about 3 billion years ago, during the Precambrian era (U.S. EPA 1995:7; Dorr and Eschman 1984; Levin 1978:237-242). During that period of intense vulcanism and orogenic activity, early sedimentary and volcanic rocks were folded and heated into complex structures and mountain ranges. Erosion later stripped away the crumpled sediments and volcanics to expose the intensely metamorphosed and intruded "roots" of the old mountains. These exposed roots are visible in the granitic and metamorphic rocks of the Canadian shield which forms the northern and northwestern portions of the Great Lakes Basin. The western end of Michigan's Upper Peninsula falls within the shield and is an area where Precambrian rock occur at the surface.

During the Paleozoic (230-600 million years ago), the southern portion of the shield was intermittently submerged beneath shallow seas. Marine and near-shore sediments were deposited over Precambrian bedrock, eventually consolidating into limestone, dolomite,

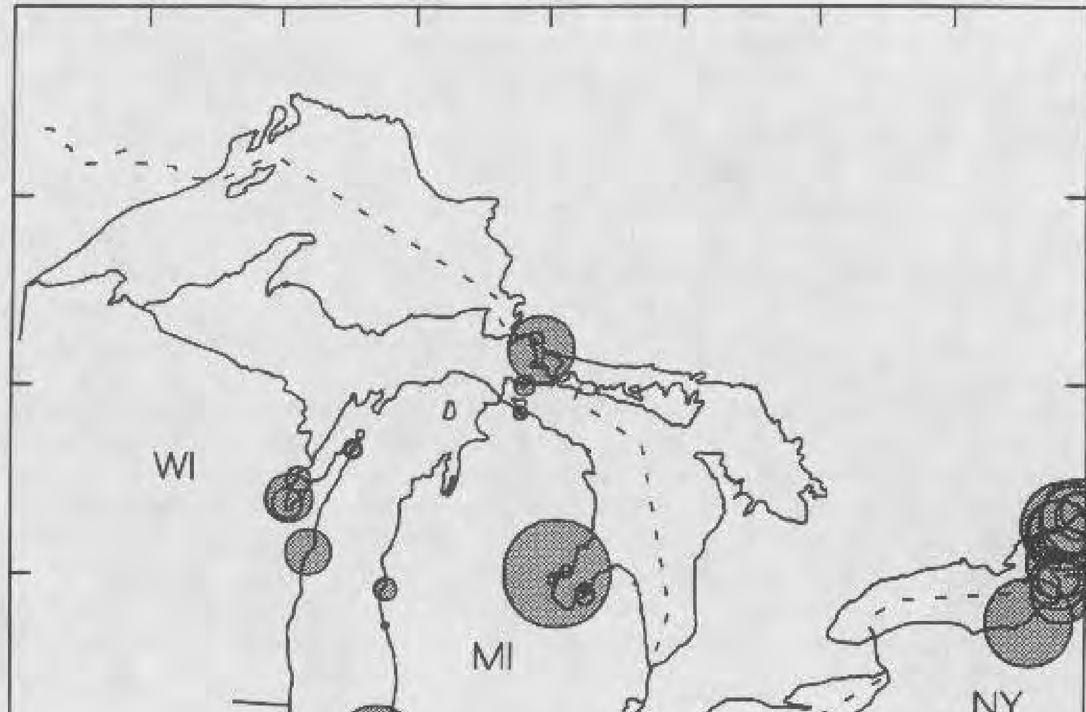


Figure 8. Distribution of narrow-leaved cattail (*Typha angustifolia*) in emergent marshes. This species is relatively intolerant of sudden changes in water depth; its concentration in Lake Ontario wetlands relates to the manipulation of outflow from the lake which has greatly reduced the amplitude of natural lake-level fluctuations. (Symbol size reflects the mean coverage value of species along sampling transects from 90 Great Lakes coastal wetlands.)

evaporites, sandstone, and shale. In fairly recent geologic times, glaciers of the Pleistocene carved the basins for the individual Great Lakes from these relatively soft bedrock types. Prior to the Pleistocene, the present floors of the Great Lakes were lowlands; glaciers moved into these valleys and scoured them deeper. As the glaciers retreated, their meltwaters collected in the vacated depressions forming the Great Lakes (Levin 1978:465).

The major bedrock distinction in the Great Lakes Basin is between Precambrian igneous and metamorphic bedrock (including granite, basalt, and rhyolite), and younger Paleozoic sedimentary bedrock (including sandstone, shale, limestone, and dolomite). Igneous and metamorphic bedrock form the north shore of Lake Superior and Georgian Bay, and line much of the St. Lawrence River; they are locally present along the southern shore of western Lake Superior as well, where they co-occur with younger sedimentary rock, primarily sandstone (Fig. 9). In contrast, the softer, sedimentary bedrock types underlie Lakes Michigan, Huron, St. Clair, Erie, and Ontario.

The physical and chemical characteristics of these different bedrock types affect wetland location and vegetation characteristics. The **physical structure** of bedrock type limits the distribution of coastal wetlands at a regional scale. The rugged Lake Superior shoreline of sandstone, igneous, and metamorphic rock lacks the shallow protected waters and fine-textured substrates that support broad coastal wetlands; coastal wetlands exist only behind protective barrier beaches or are localized at stream mouths. In contrast, the horizontally-deposited marine and near-shore sedimentary rock which underlies Lakes Michigan, Huron, St. Clair, Erie, and Ontario, provides broad zones of shallow water and fine-textured substrates for marsh development.

Where bedrock is at or near the surface, **bedrock chemistry** affects wetland species composition. Soils derived from much of the Precambrian crystalline bedrock are generally acid. In contrast, soils derived from marine deposits, including shale and marine limestone, dolomite, and evaporites, are typically more calcareous (less acid), more nutrient- and moisture-rich loams and clays. Two distinctive coastal wetland types are strongly determined by the pH of near-surface bedrock:

- **poor fen along Lake Superior**, associated with low alkalinity igneous/metamorphic bedrock and resulting acid, sandy sediments. Characteristic plant species include *Sphagna* spp. (sphagnum mosses), *Sarracenia purpurea* (pitcher-plant), and *Chamaedaphne calyculata* (leatherleaf) (Fig. 10); and

- **rich fen along the Straits of Mackinac** (northern Lakes Huron and Michigan), where the substrate is carbonate-rich clays derived from limestone/dolomite. Associated calciphiles include *Lobelia kalmii* (Kalm's lobelia) and *Carex viridula* (sedge) (Fig. 11).

GLACIAL GEOMORPHOLOGY AND SHORELINE CONFIGURATION

Much of the Great Lakes Basin was covered by ice during the Wisconsinan glaciation of the Pleistocene Epoch. Erosion of bedrock and unconsolidated materials occurred beneath the advancing glacier, and rocks and soil materials were carried on top of and in the glacial ice. These were later redeposited and formed diverse features, including moraines, drumlins, eskers, kames, and outwash plains. Modern physiography and soils are the result of postglacial erosion and soil formation processes acting on these glacial landforms and associated sediment deposits.

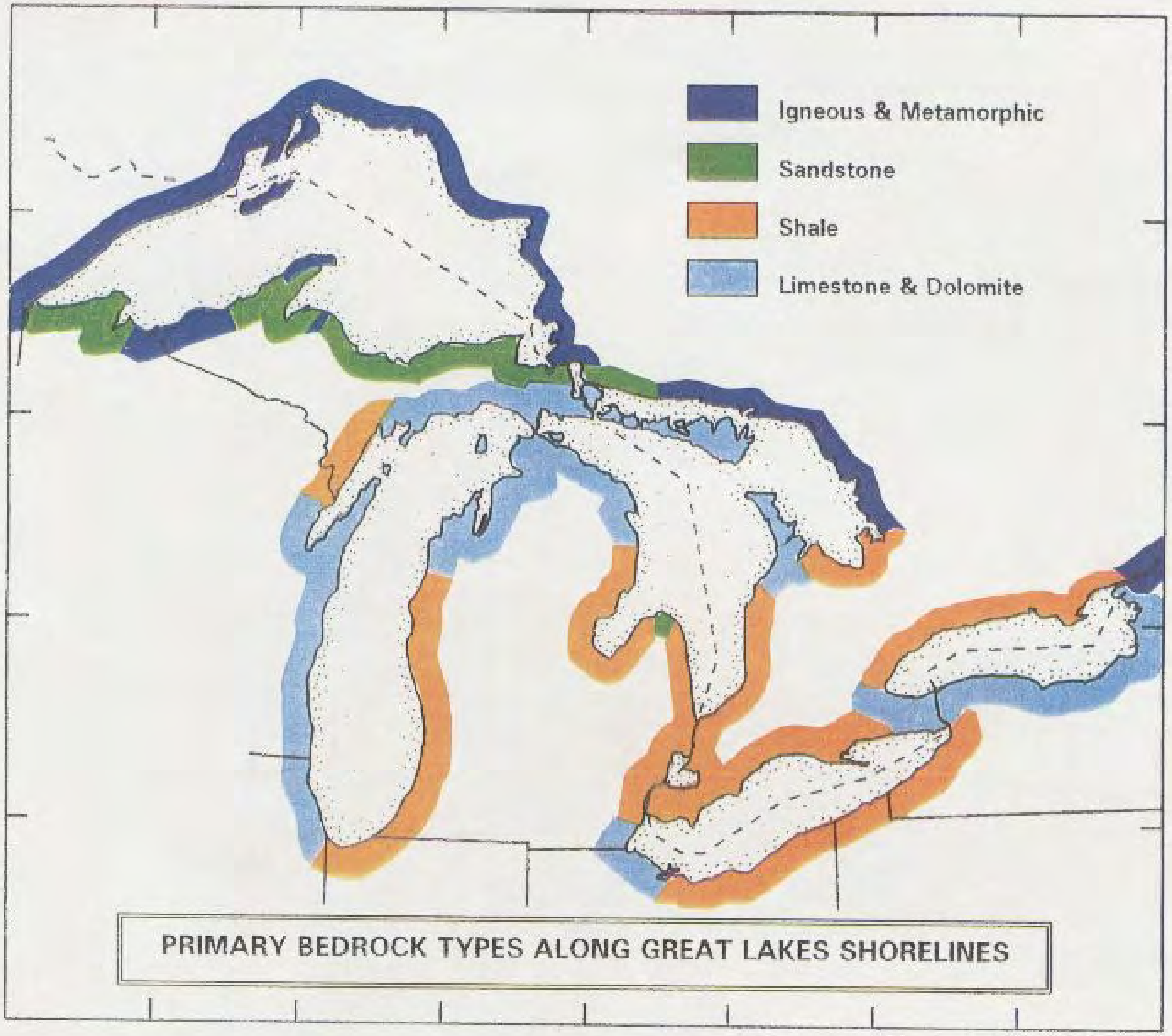
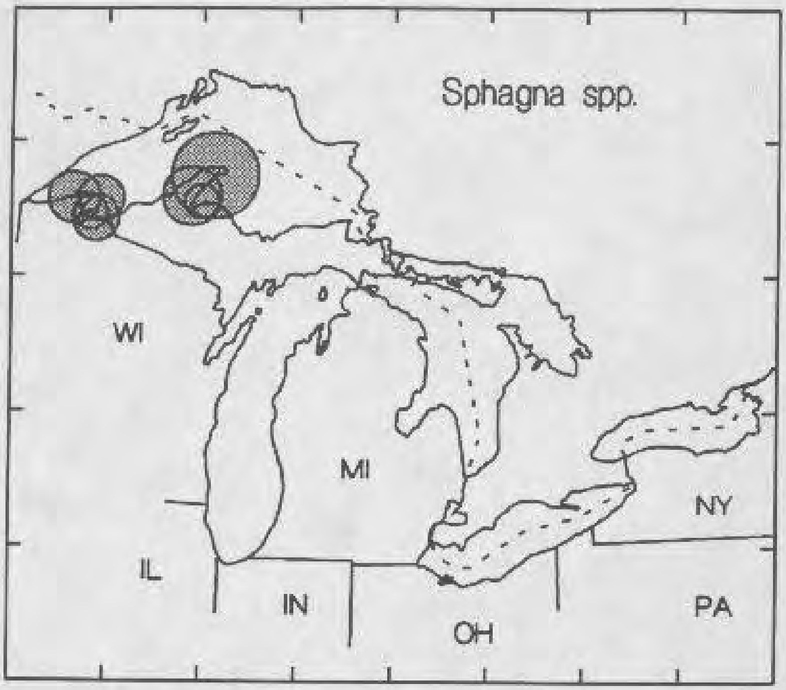


Figure 9. Distribution of primary bedrock types along Great Lakes shorelines.



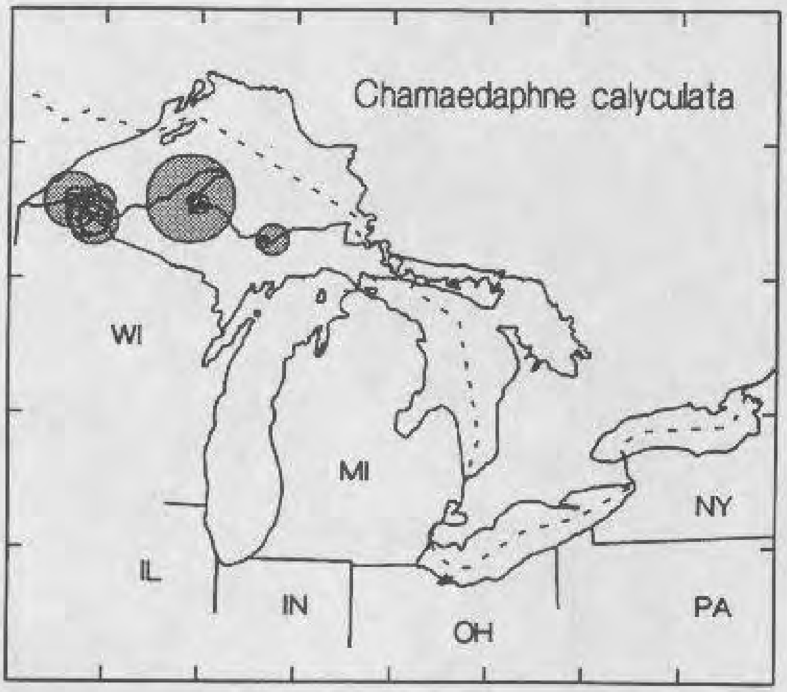


Figure 10. Wetland species distributions related to acidic surface bedrock. Characteristic **poor fen species** concentrate along the south shore of Lake Superior in areas where sandstone bedrock is near the surface. (Symbol size reflects mean cover value of species from transects placed in 90 coastal Great Lakes wetlands.)

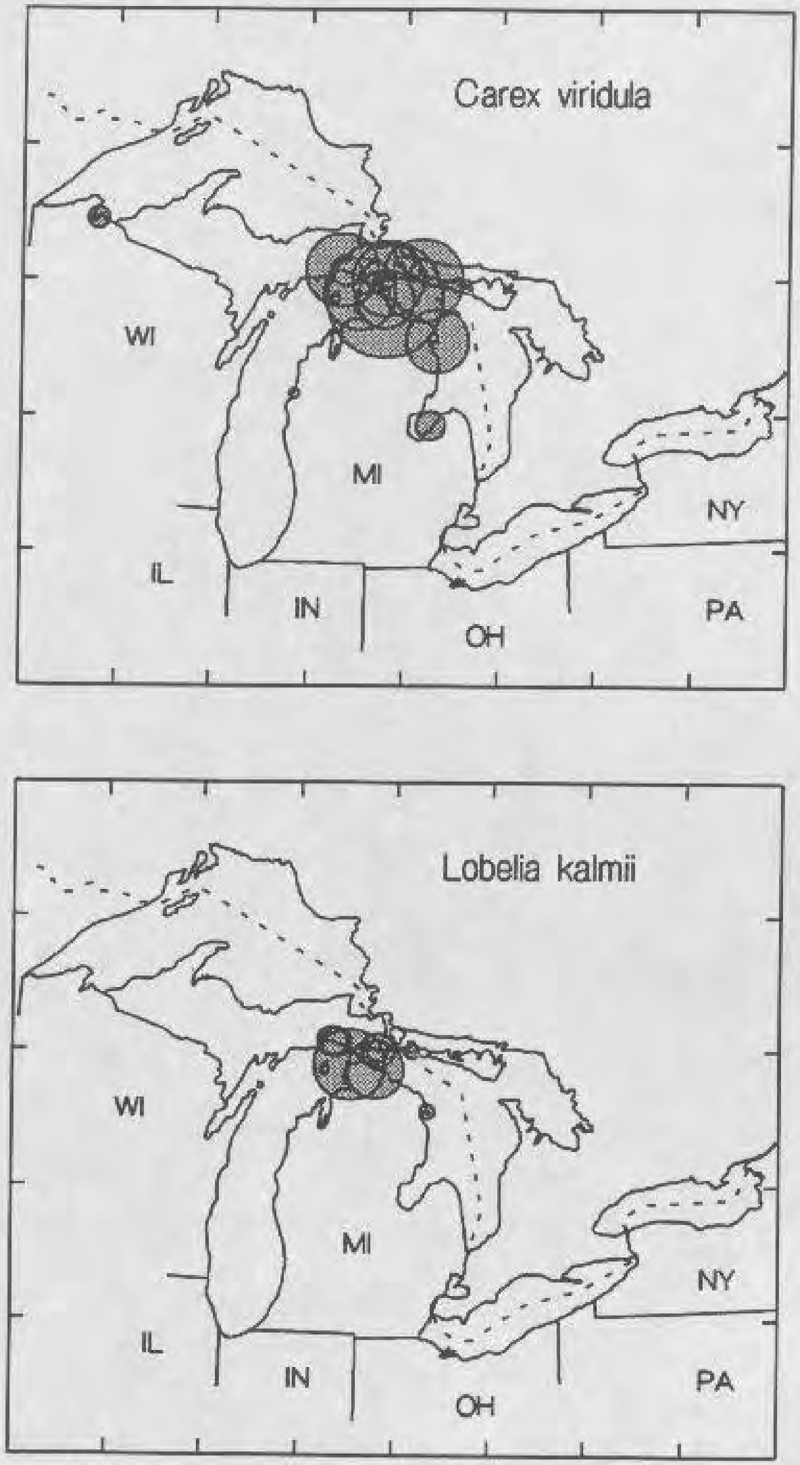


Figure 11. Wetland species distributions related to calcareous surface bedrock. Calciphiles characteristic of **rich fens** are concentrated in the Straits of Mackinac on calcareous clays and marls derived from limestone or dolomite. (Symbol size reflects mean cover value of species from transects placed in 90 coastal Great Lakes wetlands.)

Today, **glacial landforms**, in combination with recent longshore transport processes, create the prevalent physiographic features along much of the Great Lakes shoreline. Their characteristic differences in substrate, soils, slope, and drainage conditions largely determine both natural shoreline configuration and sediment composition. These, in turn, generate distinctive contexts for wetland development that vary in their exposure and resilience to lake stresses, and in their floristic composition.

Among freshwater systems, many of these geomorphic features are unique to the Great Lakes coasts, and are typically overlooked in national wetland classification schemes. However, the importance of these features for classifying Great Lakes coastal wetlands is clear (McKee et al. 1992:69). As Herdendorf et al. (1981a:110) state it, "the occurrence, distribution, and diversity of [Great Lakes] coastal wetlands is, in part, determined by the morphology of the coast. Perhaps in no other geographic environment is the relationship between landforms and vegetation so evident".

Several descriptive schemes for classifying shoreline morphology have been proposed by other researchers working within the Great Lakes Basin (Jaworski et al. 1979; International Lake Erie Study Board 1981; Geis 1979, 1985; Herdendorf et al. 1981a; Herdendorf 1988, 1989, 1992; Bowes 1989; Edsall and Charlton 1996; Reid and Holland 1996; see Table 2). From these, we have identified the major morphometric types represented in the wetland systems inventoried for this study.

Following the lead of the aquatic classification scheme proposed by Sly and Busch (1992), we organize the morphologic contexts for Great Lakes wetlands within the four major aquatic systems defined above: (1) coastal or lacustrine - wetland sites directly on the Great Lakes shoreline; (2) connecting channel - wetland sites along the major rivers connecting the Great Lakes; (3) riverine - wetland sites associated with rivers tributary to the Great Lakes; and (4) estuarine - the zone of riverine/lacustrine interface where rivers enter the Great Lakes. Site types associated with each aquatic system are described below and summarized in Table 3.

Lacustrine wetlands along the Great Lakes coastline generally occupy sites that offer some protection from the force of wind and waves. In contrast, where the shoreline is exposed to the full erosive forces of wind, wave, and ice, high wave energies and the absence of stable substrates preclude wetland development. Protection from the lake may be created by upland topography and shoreline configuration, by a variety of nearshore barriers (including barrier-beaches, sand spits, shoals, and islands), or by gently sloping and shallow bottom topography that attenuates wave height and reduces wave energy. Distinctive coastal features that provide protection for wetland development include:

- **open embayments** - curving sections of shoreline open to the lake, but in areas where shallow water depth and gently sloping bottom topography reduce wave height and energy; often formed within glacial lakeplains.

  On **sand lakeplain**, broad and shallow embayments are created through nearshore transport of sand; shifting sediments generally limit emergent wetlands to a narrow fringe (Fig. 12). SAND LAKEPLAIN.

  On **clay lakeplain**, the fine-textured substrates are ideal for aquatic macrophyte establishment and persistence, resulting in a continuous ring of wet meadow and emergent marsh such as that rimming large portions of Saginaw Bay (Fig. 13). CLAY LAKEPLAIN.

Table 2
Examples of Great Lakes Wetland Classifications based on Shoreline Configuration

Intl. Lake Erie Study Board (ILESB 1981)	Geis and Kee (1977)/ Geis (1985)	Prince et al. (1992) (after ILESB 1981)	Herdendorf et al. (1981a)/ Herdendorf (1992)
basis: geomorphological setting	**basis**: exposure to lake level fluctuations, and wind and wave action	**basis**: shoreline morphology and lake hydrologic regime	**basis**: processes providing favorable sites for wetlands
LACUSTRINE/COASTAL			
open shoreline - shoreline exposed to erosive forces of ice and wave action.			
shallow sloping beach - very gentle to flat slopes on sandy substrates; sand bars often give some protection from waves.			
unrestricted bay - open to the lake, but in shallow, sheltered areas protected from the full force of wave action; also includes open shoreline areas sheltered by an island or peninsula.	**embayed wetlands** - areas cut into shoreline bedrock or resistant soil materials; tributary streams may flow into the basin, and organic and mineral sediments derived from adjacent uplands may accumulate.	**embayed wetlands** - complexes that develop in bays lacking protective barriers; however, bays provide some protection from wind and wave energy, allowing extensive development of diverse wetlands in shallow areas.	
lake-connected inland wetlands - occur within their own basins but have an outlet to the lake and are subject to lake-level fluctuations; inflowing streams from the drainage basin contribute to the water supply.			
			solution lagoons - roughly circular indentations in the bedrock which owe their origin to the solution processes in the carbonate rock.

Intl. Lake Erie Study Board (ILESB 1981)	Geis and Kee (1977)/ Geis (1985)	Prince et al. (1992) (after ILESB 1981)	Herdendorf et al. (1981a)/ Herdendorf (1992)
LACUSTRINE/COASTAL (cont.)			
barrier beach - occurs when nearshore processes deposit a sand beach across a bay, resulting in an embayment connected to the lake by a channel, but protected from wave action by the beach. During periods of low lake levels or low flow from incoming streams, the lake connection can be temporarily closed by sand deposition.	**flood pond** or **barrier and lagoon system** - shallow depression immediately landward of the shoreline edge. Glacial drift materials of varying texture usually form the upland boundaries; barriers are created by water-laid sand, gravel, or cobbles. Barriers reduce wave energy and erosion, allowing sediments to accumulate and vegetation to become rooted. Lake-level influence is expressed through permanent or intermittent connecting channels or underground seepage; water levels are usually augmented by tributary streams.	**lagoon wetlands** - located inland from the shoreline and protected from the adjacent lake's wave energy by some natural barrier. Direct contact with the lake is limited to connecting channels or ground water.	**coastal lagoons** - the shifting of sediments by nearshore currents can form basins where wetlands eventually develop. If sediments are deposited across the mouth of an embayment, a tributary outlet, or a freshwater estuary, the blockage may result in the formation of a new pond or lagoon. Wave activity can also form bars of sand and gravel, which likewise close off the mouths of embayments.
	island and shoal - shallow water sites which provide minimal protection from wind and waves; high energy sites with unstable sediments.	**islands and shoals** - shallow water sites offer little protection from wave energy and wind; little emergent vegetation, limited to lacustrine aquatic beds.	
RIVERINE/RIPARIAN			
	streamside wetlands - riparian wetlands hydrologically distinct from lagoons, with greater influence of upstream sources on floodplain hydrographs and in vegetation patterns, with more discrete lateral patterning of communities along topographic gradients which run perpendicular to stream channels	**riparian wetlands** = streamside wetland (in Geis [1985]).	

Intl. Lake Erie Study Board (ILESB 1981)	Geis and Kee (1977)/ Geis (1985)	Prince et al. (1992) (after ILESB 1981)	Herdendorf et al. (1981a)/ Herdendorf (1992)
RIVERINE/RIPARIAN (cont.)			
	riverine bay - bay cut into the shoreline of the river and protected from open water by islands, shoals, or upland peninsulas; hydrologic connection with the river is usually permanent		
river delta - low islands and shallow zones formed by sedimentary deposits at a river mouth; the normally gentle slope allows for extensive shifting of vegetation zones when water levels fluctuate.		**deltas** - sediments carried by a river are deposited and accumulate at the mouth.	**Deltas:** **bird-foot delta** - this type requires a gently sloping lake bottom in front of the river mouth on which natural levees can be built up quickly. **estuarine delta** - fills a long narrow estuary that resulted from drowning of the lower part of the river valley because of a rise in lake level; characterized by depositional islands at the mouth of the river.
ESTUARINE			
restricted riverine or drowned river-mouth - wetlands characterized by marsh vegetation bordering a river course upstream from the lake; protected from the direct effects of waves, but are subject to river currents than can reverse in response to lake-level changes.		**freshwater estuaries** - occur where the lower reaches or rivers are influenced by the hydrologic regime of the receiving lake. They can extend several miles inland and are particularly extensive along streams that have low, wide floodplains.	**estuaries** - estuarine or drowned stream mouths; as water enters the estuary from the river, its velocity abruptly diminishes due to gradient (except during runoff events), causing sedimentation of suspended particles; the deposits have formed a series of islands.

Table 3

Wetland Site Types Proposed for the Great Lakes

Aquatic Context	Site Type	Definition	Landform Context	Wetland Development
Lacustrine	**Open embayment.**	Embayment open to the lake, but in areas where shallow water depth and gently sloping bottom topography reduce wave height and energy.	Sand lakeplain.	Shifting sediments and wave energy limit wetland development to a narrow fringe.
			Clay lakeplain.	Fine-textured substrates are ideal for aquatic macrophytes, resulting in continuous wet meadow and emergent marsh.
	Protected embayment.	Deep indentation or embayment in upland shoreline that provides protection from wind and wave energy.	Bedrock, moraine ridges, or clay lakeplain.	Extensive emergent wetland development.
	Barrier-beach lagoon.	Sand and gravel deposition create a barrier bar across the mouth of an embayment resulting in the formation of a shallow pond or lagoon.	Sand accumulation over bedrock, till, or lakeplain.	Extensive shallow water emergent vegetation; composition reflects degree of connectivity with Great Lakes.
	Sand-spit embayment and **Sand-spit swale.**	Sand spits projecting along the coast create and protect shallow embayments on their landward side. Large, compound sand spits may enclose small swales along their length.	Gently sloping and curving sections of shoreline where sand transport is not impeded.	Sheltered embayments allow for sediment accumulation and wetland development; sand spits are exposed shallow water sites with unstable sediments.

Lacustrine (continued)	**Dune and swale complexes.**	Low sand dunes or beach ridges alternate with swales.	Sand lakeplain.	Swales adjacent to lake may contain herbaceous wetlands and/or open water.
	Tombolo.	Island connected to the mainland by a series of beach ridges	Sand accumulation over bedrock.	Enclosed lagoons can contain a dense growth of aquatic vegetation; embayment leeward of tombolo may contain a fringe of emergent and submergent vegetation.
Connecting Channel & Riverine	**Channel-side wetland.**	Stream-side site fronting the main channels of connecting river and exposed to current and wave action.	Diverse contexts, including glacial lakeplain and till plain.	Vegetation is frequently limited to a thin fringe paralleling the shore.
	Channel embayment.	Embayment along connecting river channels which provide some protection from erosive elements.		Extensive monotypic wetland development can occur.
	Delta.	Stream sediments are deposited and accumulate at the mouth of a river creating multiple shallow channels, low islands, and abandoned meanders.	Areas of low gradient flow with weak nearshore currents; glacial lakeplain.	Extensive diverse wetland development can occur.
Estuarine	**Open estuary.**	Drowned river mouth displaying open, branching inlet form.	Sand lakeplain or till plain.	Protected, fertile wetland habitat that may extend inland for several miles.
	Barred estuary.	Drowned river mouth with partial barrier bar or dune across the mouth.		

● **protected embayments** - indentations or embayments cut into resistant materials of the upland shoreline which provide protection from wind and wave energy; tributary streams may flow into the basin, and organic and mineral sediments derived from adjacent uplands may accumulate, allowing development of diverse wetlands. Protected embayments are common where glacial scouring has carved the bedrock, such as at Drummond Island near the Straits of Mackinac, and within the Thousand Islands of the upper St. Lawrence River. Glacial deposition and subsequent modification of till created the protected embayments along the complex shoreline of the Les Cheneaux Islands, which are drumlinized ground moraine features (Fig. 14). BEDROCK, MORAINE RIDGES, or CLAY LAKEPLAIN.

● **barrier-beach lagoon systems** - deposition of sand and gravel by nearshore currents create a barrier bar across the mouth of an embayment resulting in the formation of a shallow pond or lagoon sheltered from the lake's wave energy. The barrier may largely or wholly block the embayment, creating a variety of lagoon types ranging from protected to completely enclosed. Enclosed barrier-beach lagoons are frequently bounded by irregular, steep coastline topography in areas down-current from major sand-producing features where deep embayments trap sands. Sediments accumulate in the lagoon basin and vegetation can become rooted. Although water levels in the lagoon may be augmented by tributary streams and groundwater seepage, coastal lagoon wetlands are also controlled by the Great Lakes, through permanent or intermittent connecting channels, wave overwash, or cross-bar seepage. Sediment deposition and vegetative composition reflect the degree of connectivity with the Great Lakes, as well as the extent to which the lake influences the hydrology, resulting in a stable vs. a fluctuating water regime.

Concentrations of lagoon wetlands occur along the till bluffs of Bayfield Peninsula, between exposed bedrock points on the Door Peninsula, and along the drumlin fields of Lake Ontario (Fig. 15). Along the eastern end of Lake Ontario, predominant wind and water currents have accumulated sands eroded from glacial tills to the west, creating a nearly continuous stretch of lagoons and wetlands between the barrier and the irregular till upland (Fig. 16). Sand accumulation over BEDROCK, TILL, or LAKEPLAIN.

● **sand-spit embayment systems** - narrow, shallow "embayments" created and protected by sand spits projecting along the coast; formed along gently sloping and curving sections of shoreline where sand transport parallels the shore. The spits are exposed to both wave activity and overwash. On their landward side, however, the spits generally provide good protection from wind and waves, allowing organic and fine mineral sediment accumulation and wetland development in the sheltered embayments. Large, recurved and compound sand spits may also enclose small swales or larger lagoons which offer a protected habitat for emergent vegetation; major sand spit features include Chequamegon Point (Lake Superior), Waugoshance Point (Lake Michigan), and Presque Isle (Lake Erie). Smaller sand-spit embayments are common in Green Bay and Saginaw Bay (Fig. 17). Areas of sand accumulation along shallow coast; often SAND LAKEPLAIN.

● **dune and swale complexes** - alternating upland and wetland features that formed as receding Great Lakes deposited a series of low sandy dunes or beach ridges (0.5 - 4 m high) (Comer and Albert 1993). From the air, these ridges appear as a series of arcs, extending inland up to 3 or 4 kilometers, generally parallel to the present shoreline (Fig. 18). The flow of surface and ground water through these complexes can foster wetland development in the swales between beach ridges; water levels in lakeside swales are directly tied to Great Lakes water level fluctuations, while those further inland are not. Swales adjacent to the lake may contain open water and/or herbaceous wetlands; swales further inland, above the level of Great Lakes influence, more often support swamp forest or shrub swamp, although open water and herbaceous wetlands also occur. Associated with relatively flat shoreline, often SAND LAKEPLAIN.

- **tombolos** - islands connected to the mainland by current-deposited sands, which frequently form a series of beach ridges. The bars or ridges may enclose a series of shallow interdunal swales, or larger lagoons within which thick organic soils and a dense growth of aquatic vegetation develop. The embayment created on the leeward side of the tombolo may receive sufficient protection from Great Lakes' wave action that a fringe of emergent and submergent vegetation persists. Sand accumulation over BEDROCK.

Great Lakes wetlands develop in distinct aquatic contexts along the **major connecting channels** (including the St. Marys, St. Clair, Detroit, Niagara, and St. Lawrence rivers) that flow between the Great Lakes, and at the mouths of **tributary rivers**, where water levels are controlled by the Great Lakes. As the connecting rivers flow into the Great Lakes, they form wetland habitat either as free-flowing streams or as deltaic systems; tributary rivers provide habitat for Great Lakes coastal wetlands primarily through delta formation.

- **channel-side wetlands** - stream-side sites along the major connecting rivers which link the Great Lakes. Sites fronting the main channels are exposed to wave action from boat traffic, and vegetation is frequently limited to a thin fringe paralleling the shore (Fig. 19). Relative to other riverine sites, channel-side wetlands experience greater current, deeper water, and little or no organic accumulation in the emergent marsh zone. Channel-side wetlands are common along the St. Marys River, and portions of both the St. Clair and Detroit rivers owing to the flat, poorly drained glacial lacustrine topography. In contrast, steeper banks, low bluffs, and/or greater flow preclude wetland development along much of the Niagara and St. Lawrence rivers.

- **channel embayments** - shallow stream-side embayments along the major connecting rivers which provide additional protection from erosive elements. Effects of channel current and boat wash are reduced, organic sediments can accumulate, and wetland vegetation is more extensive than in channel-side wetlands.

- **river deltas** - stream sediments are deposited and accumulate at the mouth of a river creating multiple shallow channels, low islands, and abandoned meanders that allow for extensive wetland development (Fig. 20). Wetland habitats range from the generally sandy or gravel substrates and swift current of the main channel, to the more protected secondary channels, where the slow to non-existent current permits thick accumulations of organics. Deltas form in areas of low gradient flow, where nearshore currents are relatively weak and thus do not rapidly remove deposited material. Deltas are common along sheltered portions of flat glacial lakeplain, such as the shallow waters bordering Saginaw Bay, Lake St. Clair, and western Lake Erie. The St. Clair River, a main connecting river, forms the largest freshwater delta in the world as it enters Lake St. Clair. More commonly, deltaic systems are formed by large tributary rivers as they enter the Great Lakes or their connecting rivers. Well-developed examples of tributary river deltas include the Sturgeon and Kakagon rivers on Lake Superior; the Munuscong River delta on the St. Marys River; the Peshtigo and Oconto rivers on Lake Michigan; the Pine, Rifle, and Saganing rivers on Saginaw Bay, Lake Huron; the Maumee River on Lake Erie; and the Black River on Lake Ontario. LAKEPLAIN.

Estuarine wetlands form in the zone of riverine/lacustrine interface along the lower stretches of tributary rivers, where water levels are controlled by the Great Lakes:

- **lacustrine estuaries** - stream channels cut during an earlier time were later drowned or buried by the subsequent rise in the Great Lakes to present water levels, creating an estuary whose water levels are controlled by the Great Lakes. Fairly steep upland slopes help shield the estuary, while reduced water velocities lead to deep accumulations of organics; the result is a protected, fertile (but topographically circumscribed) wetland. Longshore transport and infilling may modify the submerged river mouth, leading to distinct estuarine forms with different wetland habitat.

  Lacustrine estuaries of the Great Lakes occur in two major forms. Estuaries that are **open** to the lake typically display a branching inlet form, clearly revealing their origin as a drowned river mouth (Fig. 21). Open estuaries experience continuous flows between river and lake, and are subject to the direct impact of lake-level fluctuations and storm events. Alternatively, lacustrine estuaries may be **barred**, when nearshore currents deposit a partial berm or barrier dune across their mouths (Fig. 22). These barriers create a relatively sheltered inland "lake" or pond[7] connected to Great Lakes water levels by an outlet channel, but protected from the direct force of wind and wave action off the lake.

  Because estuaries are typically areas of active sedimentation, they provide extensive sites for wetland development. As water enters the estuary from the river, its velocity abruptly diminishes (except during major run-off events), causing the river to drop its sediment load (Herdendorf 1989; 1992). These deposits may create a series of islands or shoals which foster wetland formation. Progressive infilling occurs in the upper reaches of the estuary, creating a broad shallow-water zone characterized by deep, poorly consolidated organic substrates ideal for emergent marsh vegetation.

  Lacustrine estuaries are a dominant wetland feature along southeastern Lake Michigan and western Lake Erie, although they occur in Lake Superior and Lake Ontario as well. Virtually all of the tributaries entering Lake Erie on the Ohio shore have estuarine-type lower reaches and attendant wetlands (Brant and Herdendorf 1972; Herdendorf 1989). Similarly, barred estuaries occur in most tributaries along the shoreline of southwestern Lower Michigan, where large dune features have partially blocked riverine flows. SAND LAKEPLAIN or TILL PLAIN.

Several of these morphometric types can co-occur. Open estuaries frequently form deltaic deposits at their mouths, while tributary rivers may deposit deltas along the main channels of the connecting rivers adjacent to channel-side wetland sites. Other types are gradational. Barred estuaries differ from barrier-beach lagoons fed by streams based on the extent to which the hydrology is dominated by riverine vs. lacustrine waters. Enclosed barrier-beach lagoons are similar to the lakeside swales of a larger dune and swale complex. The site types are not mutually exclusive categories, rather the types illustrate how the convergence of landform and lake create and influence wetland and aquatic habitats. However, the floristic diversity of a wetland is dependent on the diversity of wetland habitats; thus the variety of morphometric types represented is significant for understanding the vegetational characteristics of a site.

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[7]The ponds of barred estuaries have also been considered "lagoons"; however, we reserve the term lagoon for wetlands formed in shallow embayments, as defined above.

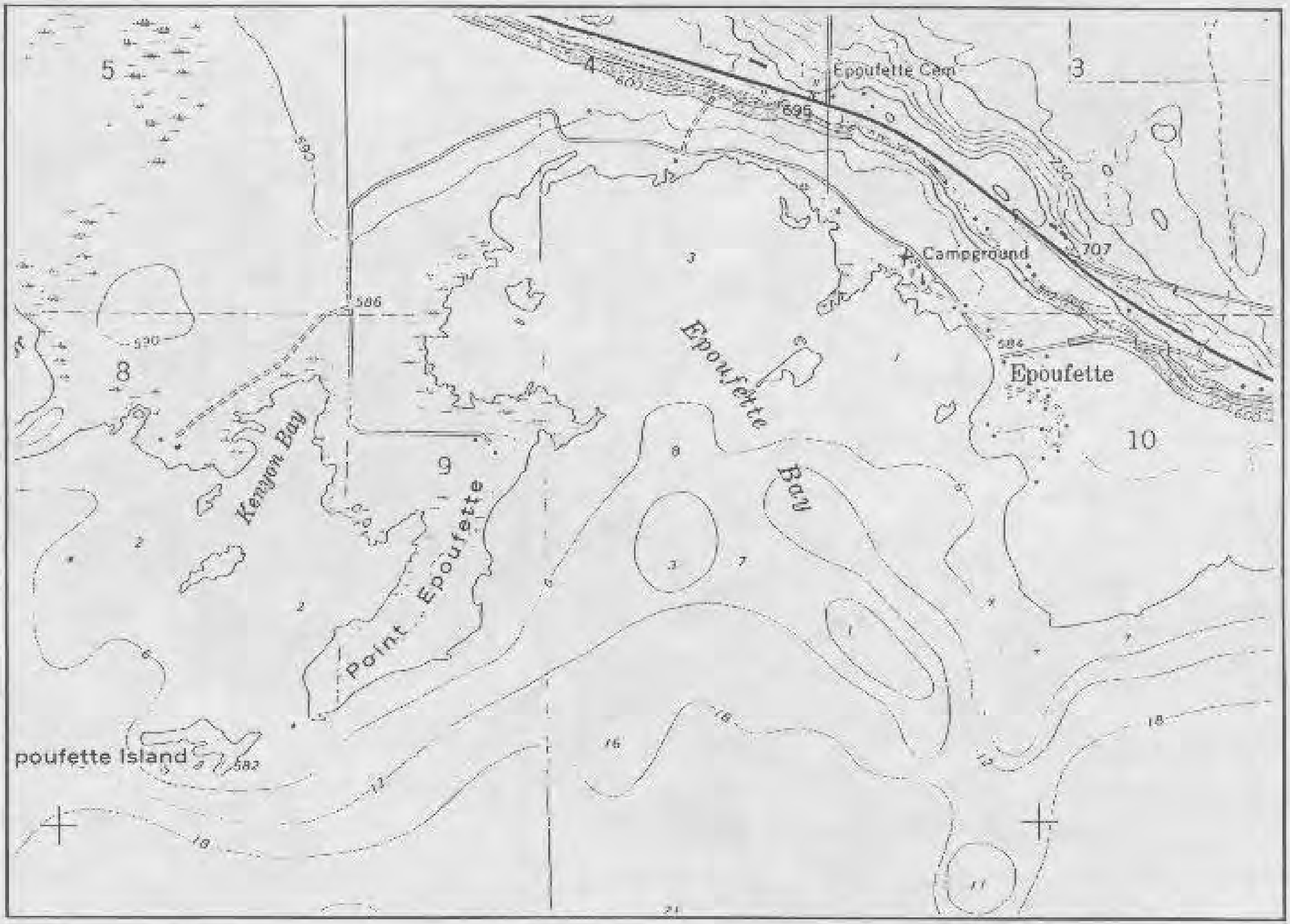


Figure 12. Open embayment of the sand lakeplain (Epoufette Bay, Upper Peninsula, Michigan). Unstable sandy substrates preclude wetland development, except in the most sheltered portions of the bay. Seasonal storms frequently erode shoreline sands, shifting marsh locations and altering community composition.

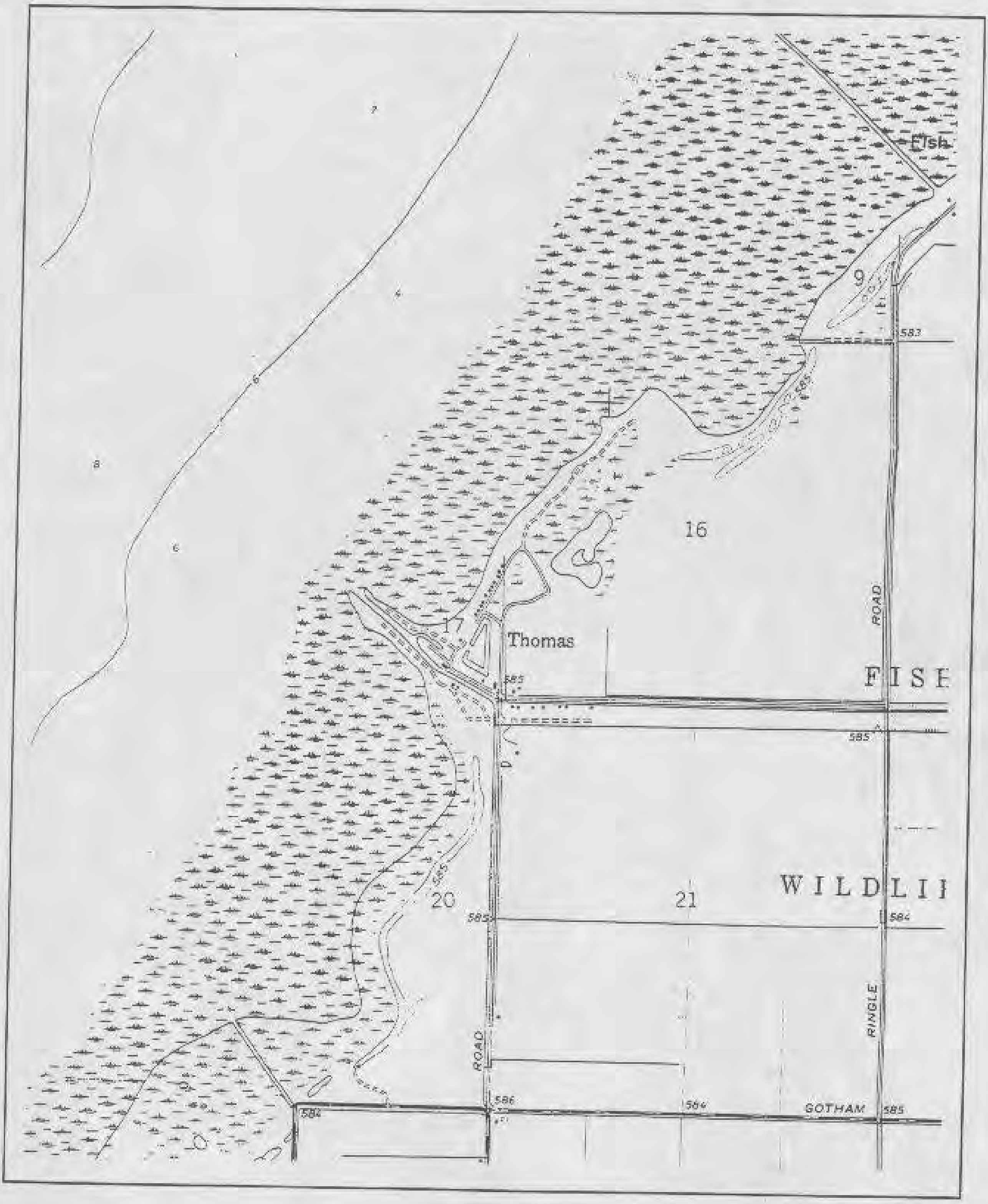


Figure 13. Open embayment of the clay lakeplain (Saginaw Bay). Saginaw Bay is a large embayment open to Lake Huron; however, the relatively shallow waters dampen wave energies. Substrates consist of a thin veneer of sand over clay, which supports extensive emergent wetland development.

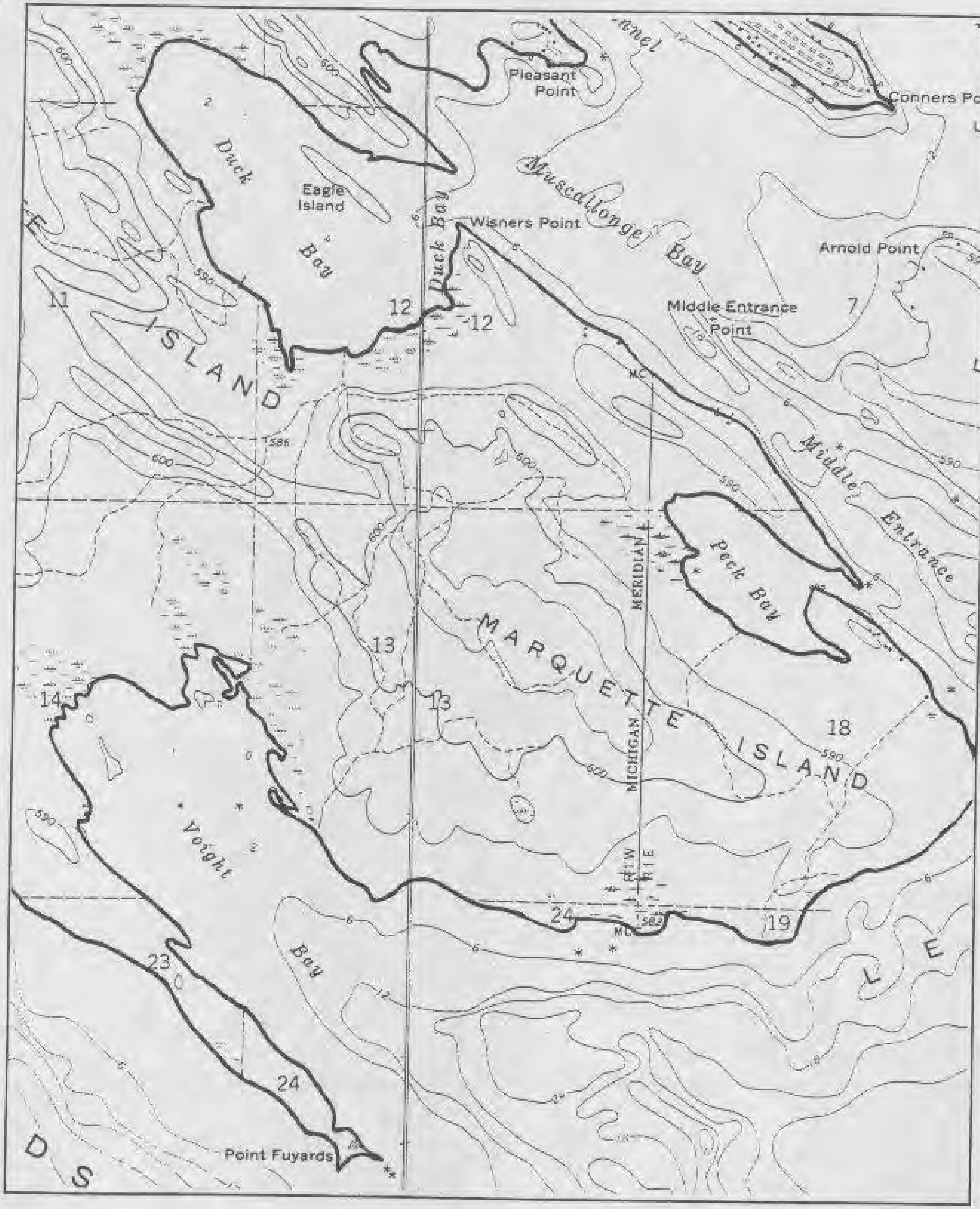


Figure 14. Protected embayments within drumlinized ground moraine at Les Cheneaux Islands (Duck Bay). The protection from wave action results in well-developed emergent marsh and allows emergent vegetation to extend into much deeper waters (up to 2 m) than in less protected sites.

Figure 15. Barrier-beach lagoons within the drumlin field along Lake Ontario (Black Creek and Red Creek). Longshore sand transport has formed barrier beaches across the mouths of embayments between drumlin ridges, creating a series of shallow lagoons protected from Lake Ontario.

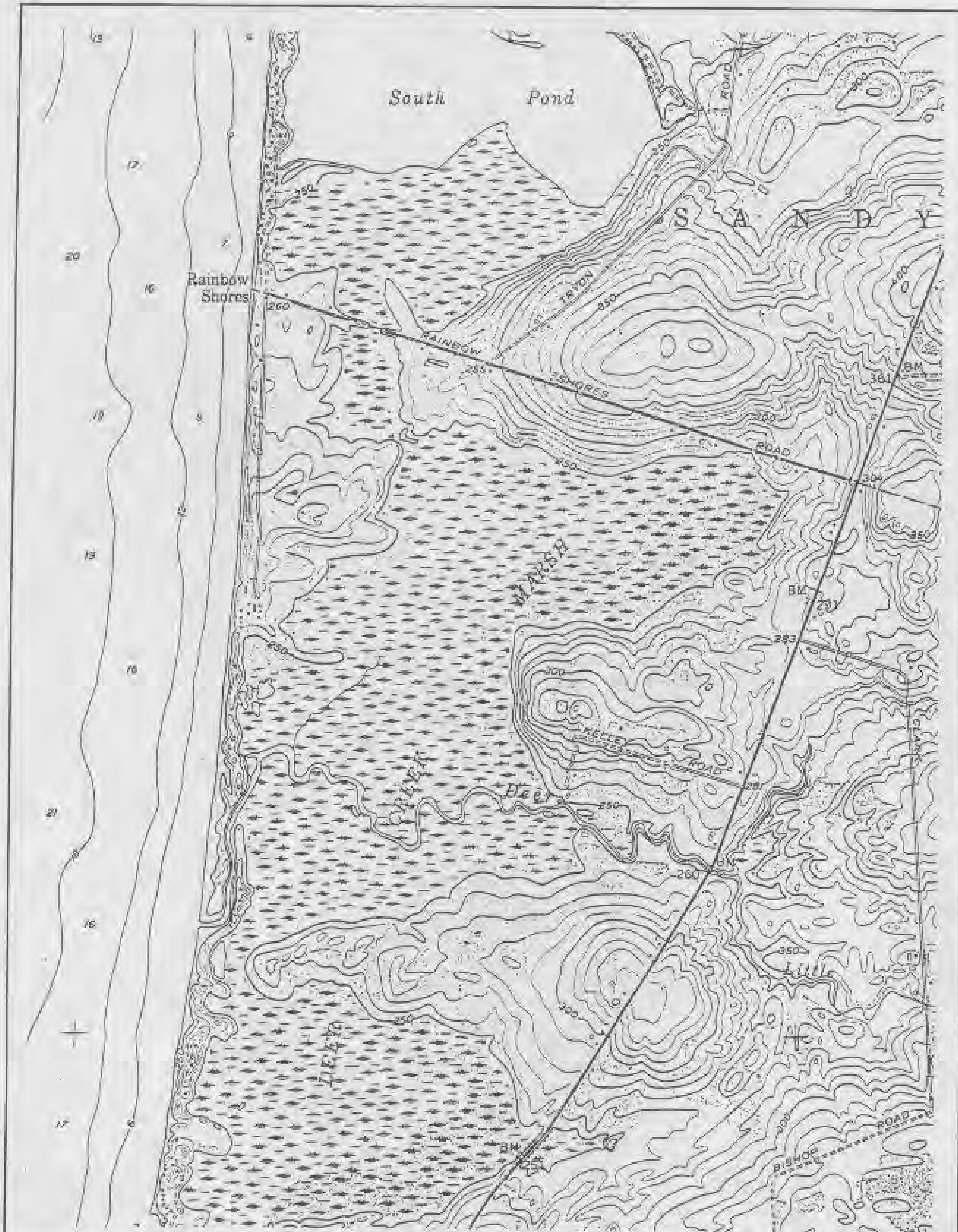


Figure 16. Barrier-beach lagoons along eastern Lake Ontario (Deer Creek Marsh). Dominant longshore currents accumulate sand at the east end of Lake Ontario, forming narrow, but high (15 m) barrier beaches. Extensive lagoons are trapped between these coastal barriers and the steep, irregular uplands.

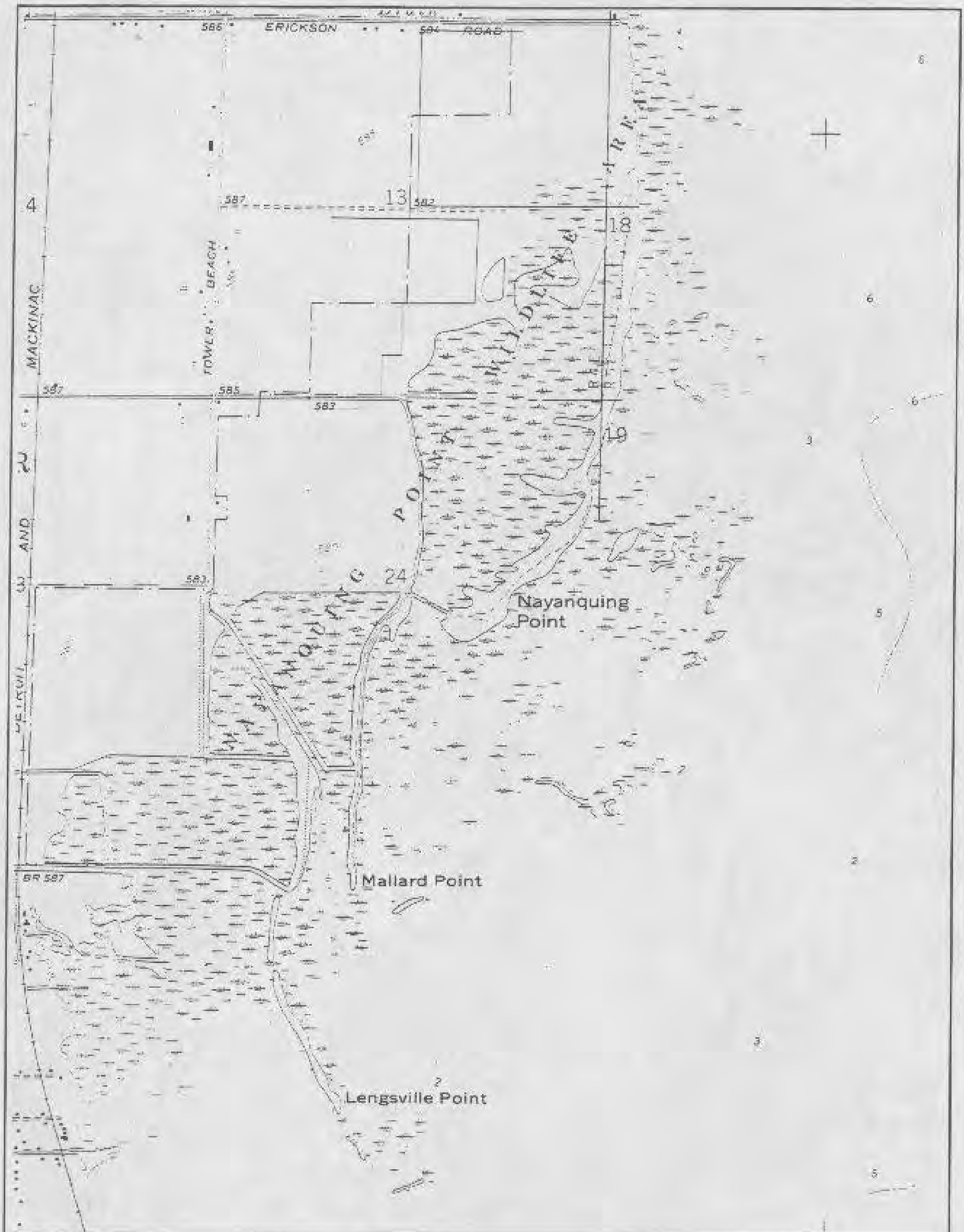


Figure 17. Sand-spit formation and "embayment" at Nayanquing, Saginaw Bay, Lake Huron. Sand transport along the coast has created the Nayanquing sand spit, which almost encloses a very sheltered embayment on its landward side. Extensive emergent marsh flourishes in this shallow, protected environment.

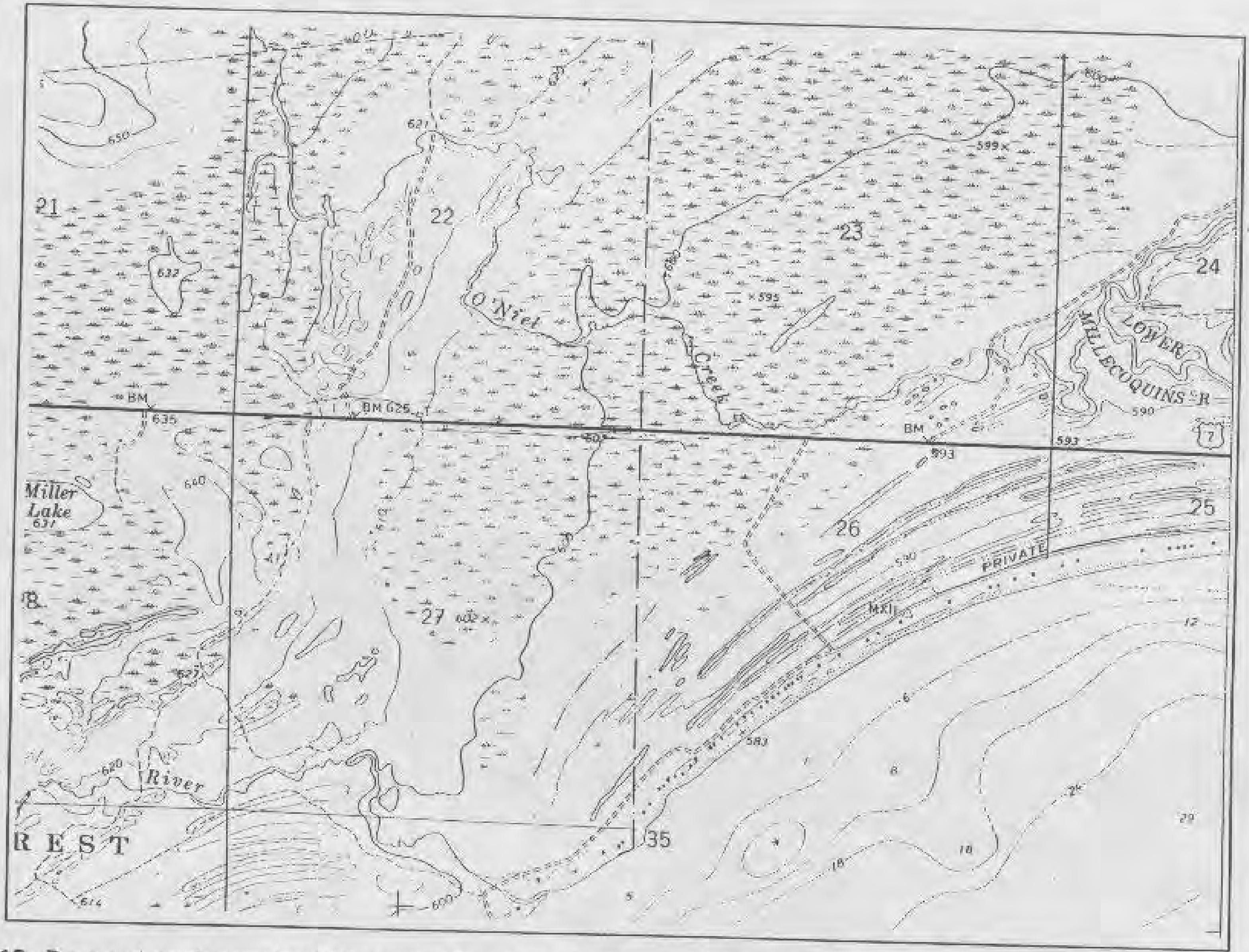


Figure 18. Dune and swale complex (Millecoquins River, Lake Michigan). Shallow beach ridges and swales arc inland from the shore, creating a distinctive series of wetland features. In swales near the coast, the hydrology is controlled by the Great Lakes, while those further inland are typically perched above the lake. These complexes often extend 2-3 km inland.

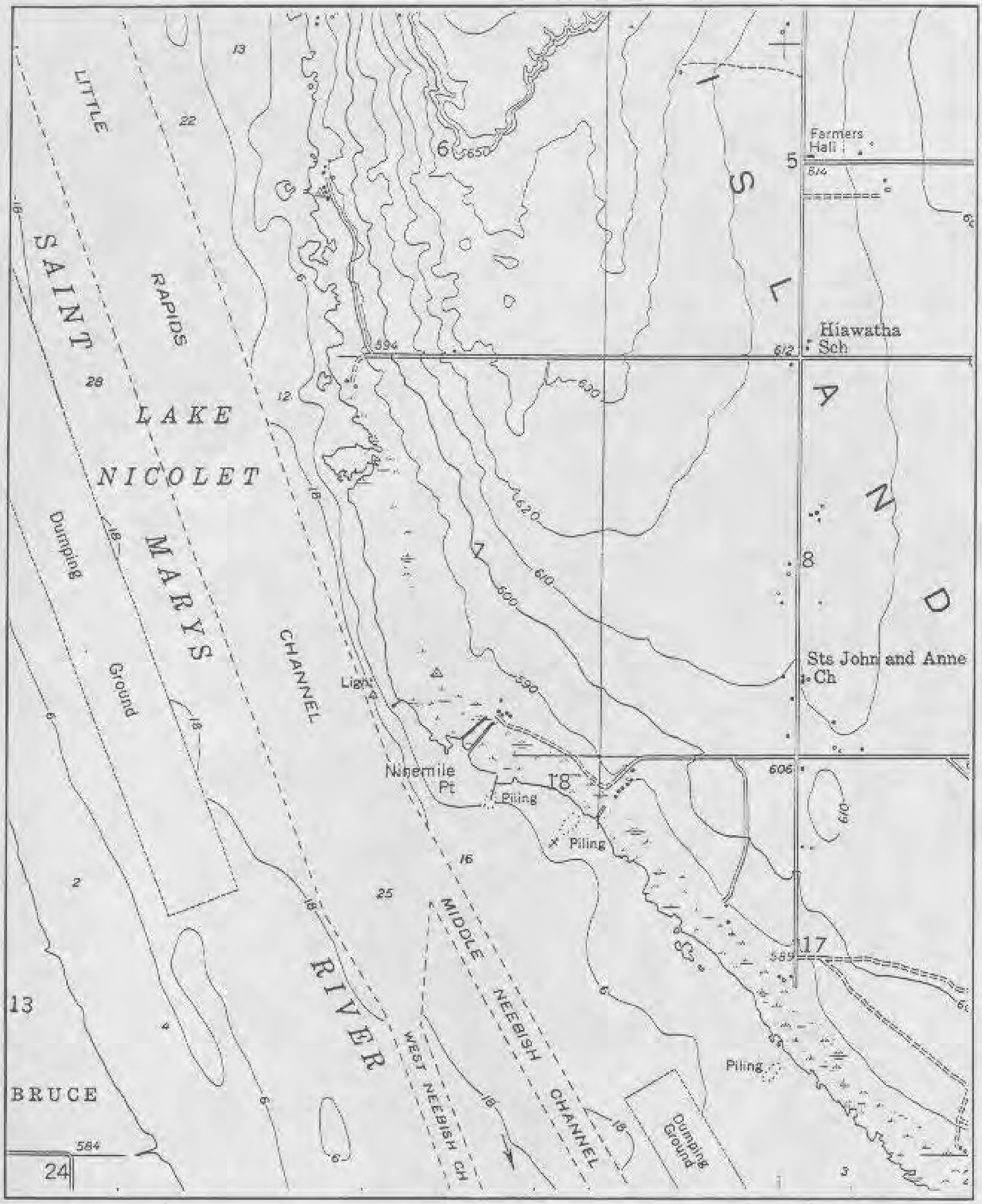


Figure 19. Channel-side wetlands of the St. Marys River. A fringe of emergent marsh lines the shallow margins of the St. Marys River; stands of emergent vegetation are particularly well-developed where wind and waves are not a prominent feature of the shore-zone environment. Emergent zone vegetation along the lower St. Marys is dominated by *Scirpus acutus*, *Sparganium eurycarpum*, and *Eleocharis smallii*.

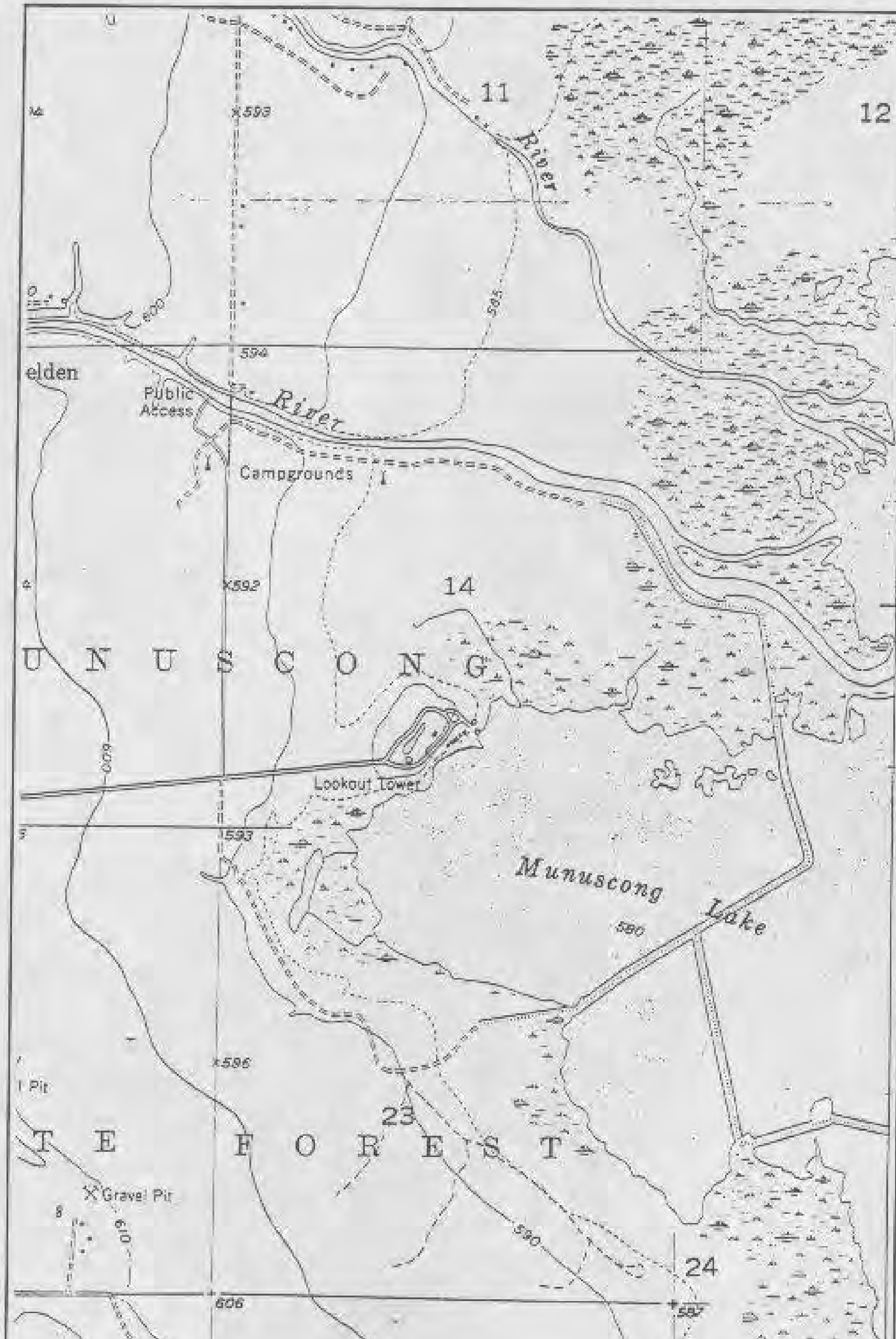


Figure 20. Tributary river delta (Munuscong River). The Munuscong and Little Munuscong Rivers branch into multiple channels as they enter Munuscong Lake (a broad embayment of the St. Marys River) creating a shallow, diverse wetland heavily utilized by migratory waterfowl.

Figure 21. Open lacustrine estuary (Pokegama River, Lake Superior). The branched inlets reflect its origin through the partial submergence or drowning of river valleys following post-glacial rise in lake level. Sediments deposited in the upper reaches of the estuary support extensive marsh and wet meadow.

Figure 22. Barred lacustrine estuary (Betsie River, Lake Michigan). The mouth of the Betsie River has been drowned or buried by the post-glacial rise in lake level, and the outlet to the lake partially barred by massive sand dunes, creating a protected inland "pond" influenced by Great Lakes water level fluctuations.

CLIMATE

Regional patterns of climatic variability within the Great Lakes Basin are largely determined by latitude, with the modifying influence of the lakes (i.e. lake effect) operating at a more local level (Derecki 1976; Eichenlaub et al. 1990). The strong latitudinal gradient, from southern Lake Erie to northern Lake Superior, creates marked differences in length of growing season and annual input of solar energy across the region. These differences, in turn, are reflected in the regional distributions of a number of species common to Great Lakes wetlands. While most aquatic macrophytes are widely distributed, species with known southern affinities make their appearance, as do those of the boreal forest (Stuckey 1989; Keddy and Reznicek 1985, 1986; Table 4). Lake Erie wetlands, for example, are rich in southern marsh species at the northern edge of their range which rarely occur along the other Great Lakes (Table 5); a southern wet-prairie floristic element is apparent there as well. Both of these southern floras differ significantly from the complex of boreal, subarctic, and arctic species found in the northern portions of Lakes Huron, Michigan, and Superior (Prince et al. 1992:676-677). Other species common to Great Lakes coastal wetlands reveal regional concentrations corresponding to a North-South gradient; these are species with wide distributions which achieve a greater density toward either the northern or southern edge of the Great Lakes Basin (Figs. 23 and 24).

Table 4
Great Lakes Wetland Species with Regional Distributions[a]

Southern Marsh Species	Southern Rich Wet Prairie	Fens and Wet Meadows of Northern Great Lakes
Hibiscus moscheutos	*Helianthus* spp.	*Carex capillaris*
Hibiscus laevis	*Platanthera leucophaea*	*Pinguicula vulgaris*
Nelumbo lutea	*Pycnanthemum* spp.	*Selaginella selaginoides*
Nuphar advena	*Solidago riddellii*	*Scirpus cespitosus*
Sagittaria montevidensis	*Vernonia* spp.	
Senecio glabellus	*Veronicastrum virginicum*	

[a]From Keddy and Reznicek (1986:34).

Regional divisions maps for the Great Lakes Basin generally distinguish a southern unit with a warmer and longer growing season from northern units, but exact placement of the dividing line varies (Albert 1995; Bailey and Cushwa 1981; Bailey et al. 1993; Denton 1985; Keys et al. 1995). The ecoregional map of Keys et al. (1995) distinguishes a northern Unit 210 (the Humid Warm-Summer Continental Division) from the more southerly Unit 220 (the Humid Hot-Summer Continental Division) (Fig. 25). This division boundary cuts across Wisconsin and the Lower Peninsula of Michigan, placing Lake Superior, the northern half of Lake Michigan, and Lake Huron north of Saginaw Bay in the northern division, as well as the extreme eastern end of Lake Ontario south of the St. Lawrence river. Conversely, the southern half of Lake Michigan, the Saginaw Bay and "thumb" area of Lake Huron, the entire U.S. shoreline of Lakes St. Clair and Erie, and most of the Lake Ontario shoreline fall in the southern division.

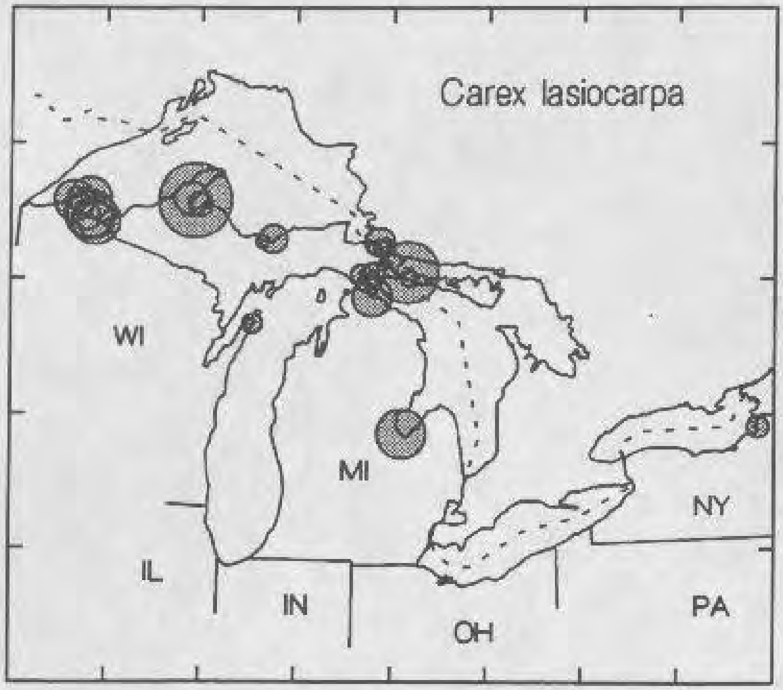
The regional map of wetland types based on vegetational characteristics developed by Kadlec and Wentz (1974) makes a similar north-south division across the Great Lakes Basin (Fig. 26). This map, however, places a greater part of Saginaw Bay and all of Lake Ontario within the northern region.

Table 5
Wetland Species with Regional Distributions Reported from Western Lake Erie

Southern Species[a]	SE-SW (Prairie-Fen) Species[a]	Northern Aquatic Species[b]
Amaranthus tuberculatus	*Agalinis purpurea*	*Megalodonta beckii*
Ammannia robusta	*Carex crawei*	*Myriophyllum exalbescens*
Amphicarpaea bracteata var. *bracteata*	*Ceratophyllum echinatum*	*Najas gracillima*
Amphicarpaea bracteata var. *comosa*	*Cyperus diandrus*	*Najas flexilis*
Boltonia asteroides	*Eleocharis compressa*	*Potamogeton amplifolius*
Carex frankii	*Eleocharis quadrangulata*	*Potamogeton friesii*
Carex hyalinolepis	*Eleocharis rostellata*	*Potamogeton gramineus*
Carex lurida	*Eragrostis frankii*	*Potamogeton natans*
Carex muskingumensis	*Fimbristylis autumale*	*Potamogeton perfoliatus*
Cyperus inflexus (squarrosus)	*Helenium autumnale*	*Potamogeton praelongus*
Echinocystis lobata	*Hemicarpha micrantha*	*Potamogeton richardsonii*
Eclipta alba (prostrata)	*Juncus brachycephalus*	*Potamogeton robbinsii*
Euphorbia humistrata	*Juncus torreyi*	*Potamogeton strictifolius*
Hibiscus laevis	*Liatris spicata*	*Potamogeton zosteriformis*
Hypericum mutilum	*Lysimachia quadriflora*	
Justicia americana	*Lythrum alatum*	
Iris brevicaulis	*Parnassia glauca*	
Iris virginica	*Proserpinaca palustris*	
Leucospora multifida	*Pycnanthemum virginianum*	
Lycopus rubellus	*Rhynchospora capillacea*	
Ludwigia palustris	*Sabatia angularis*	
Nelumbo lutea	*Sagittaria brevirostra*	
Pilea fontana	*Sagittaria graminea*	
Phyla lanceolata	*Sagittaria rigida*	
Physostegia virginiana	*Salix rigida (eriocephala)*	
Polygonum pensylvanicum var. *durum*	*Satureja arkansana*	
Polygonum scandens	*Scirpus pendulus*	
Rorippa sessiliflora	*Solidago ohioensis*	
Rotala ramosior	*Solidago riddellii*	
Rumex altissimus		
Rumex verticillatus		
Salix nigra		
Sagittaria montevedensis (=Lophotocarpus calycinus)		
Samolus parviflorus		
Saururus cernuus		
Sicyos angulatus		
Strophostyles helvola		

[a]From Stuckey (1989:217-218).

[b]From Stuckey (1989:230, 235); most are known from historical records but are now scarce in Lake Erie. Their disappearance may reflect changes in water quality (see text).



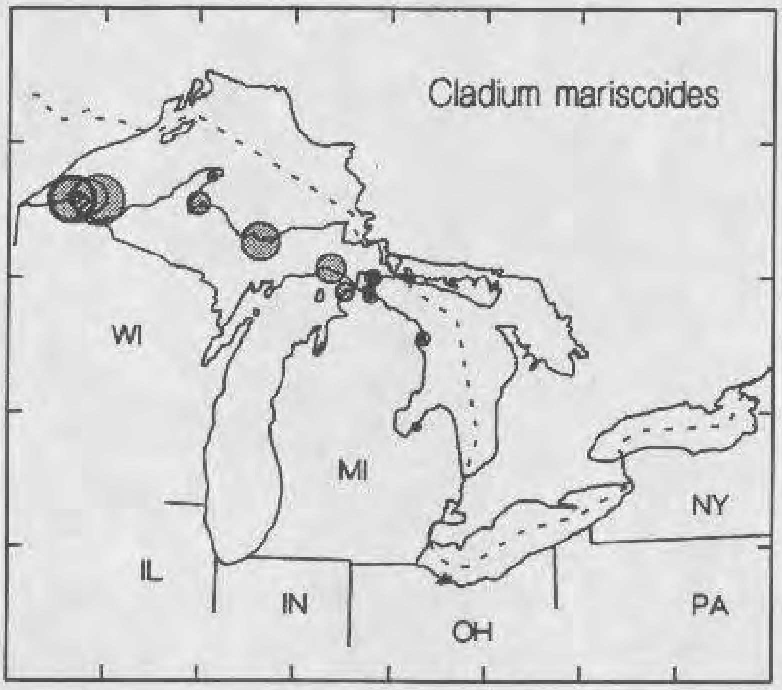


Figure 23a. Wetland species distributions related to climate/latitude: **northern species.** Numerous species exhibit a more northerly distribution, in part because there are many more intact marshes along the northern Great Lakes. Distribution/density maps are included for *Carex lasiocarpa* (sedge) and *Cladium mariscoides* (twig-rush). (Symbol size reflects mean cover value of species in the herbaceous zones of 90 coastal Great Lakes wetlands.)

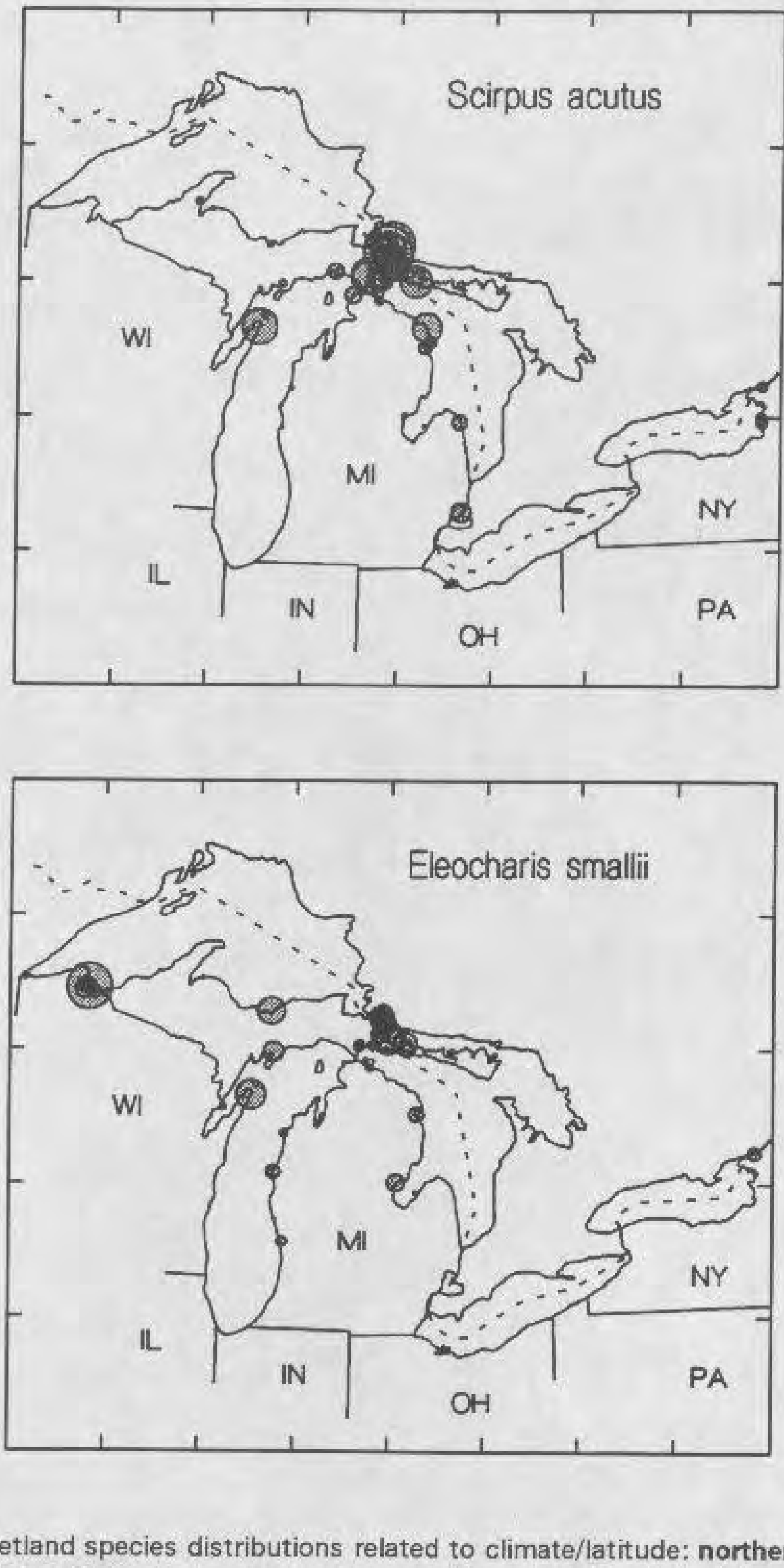


Figure 23b. Wetland species distributions related to climate/latitude: **northern species** (cont). Other species that reveal a strong northern trend include *Scirpus acutus* (hardstem bulrush) and *Eleocharis smallii* (spike-rush). (Symbol size reflects mean cover value of species in the emergent zones of 90 coastal Great Lakes wetlands.)

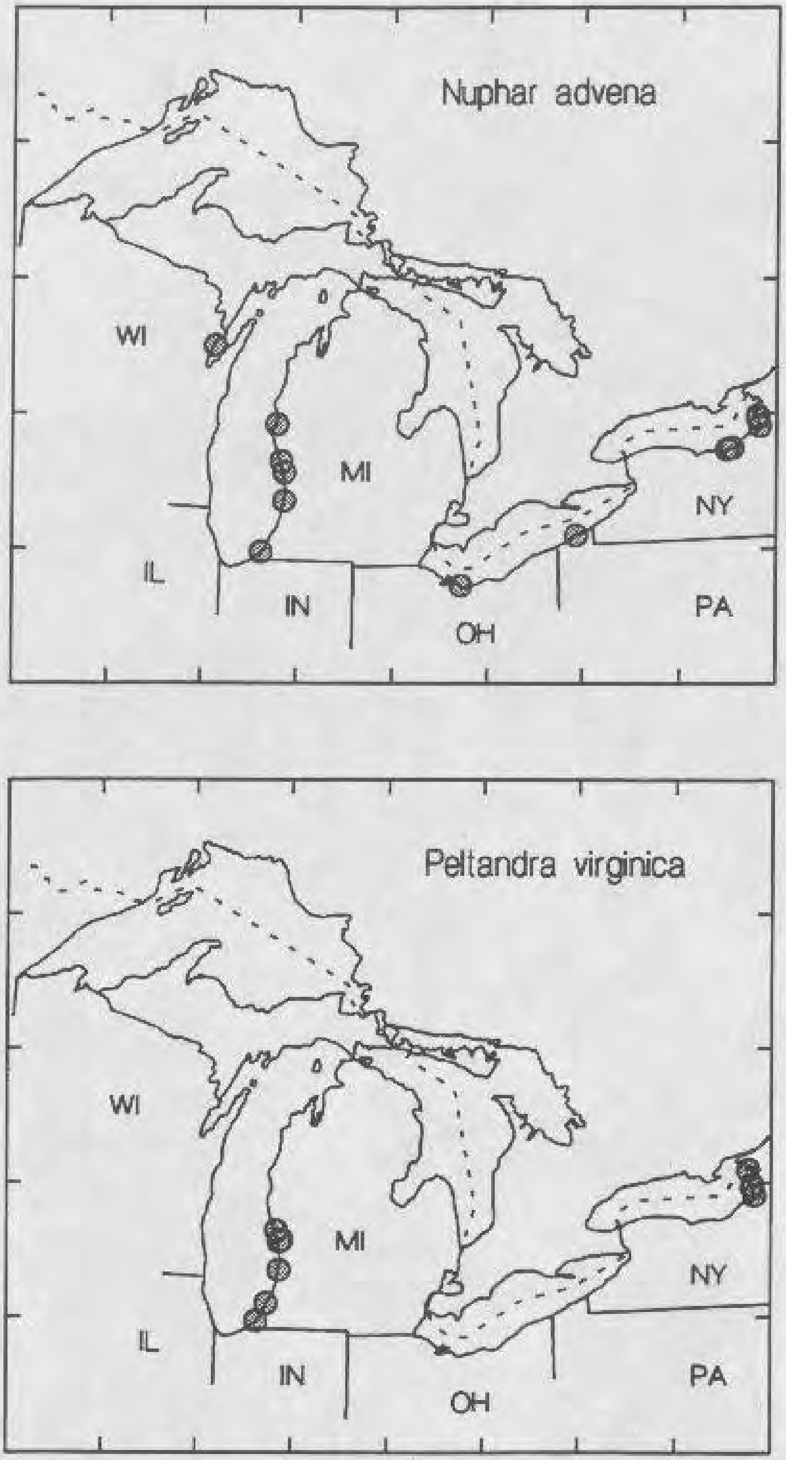


Figure 24. Wetland species distributions related to climate/latitude: **southern species.** Species with southern distributions are more poorly represented in the Great Lakes, where they occur only locally in Lake Erie, Lake Ontario, or southern Lake Michigan. Maps show occurrences of *Nuphar advena* (yellow pond-lily) and *Peltandra virginica* (arrow-arum); other southern species include *Sagittaria montevidensis* (arrowhead), *Nelumbo lutea* (American lotus), and *Hibiscus moscheutos* (swamp mallow).

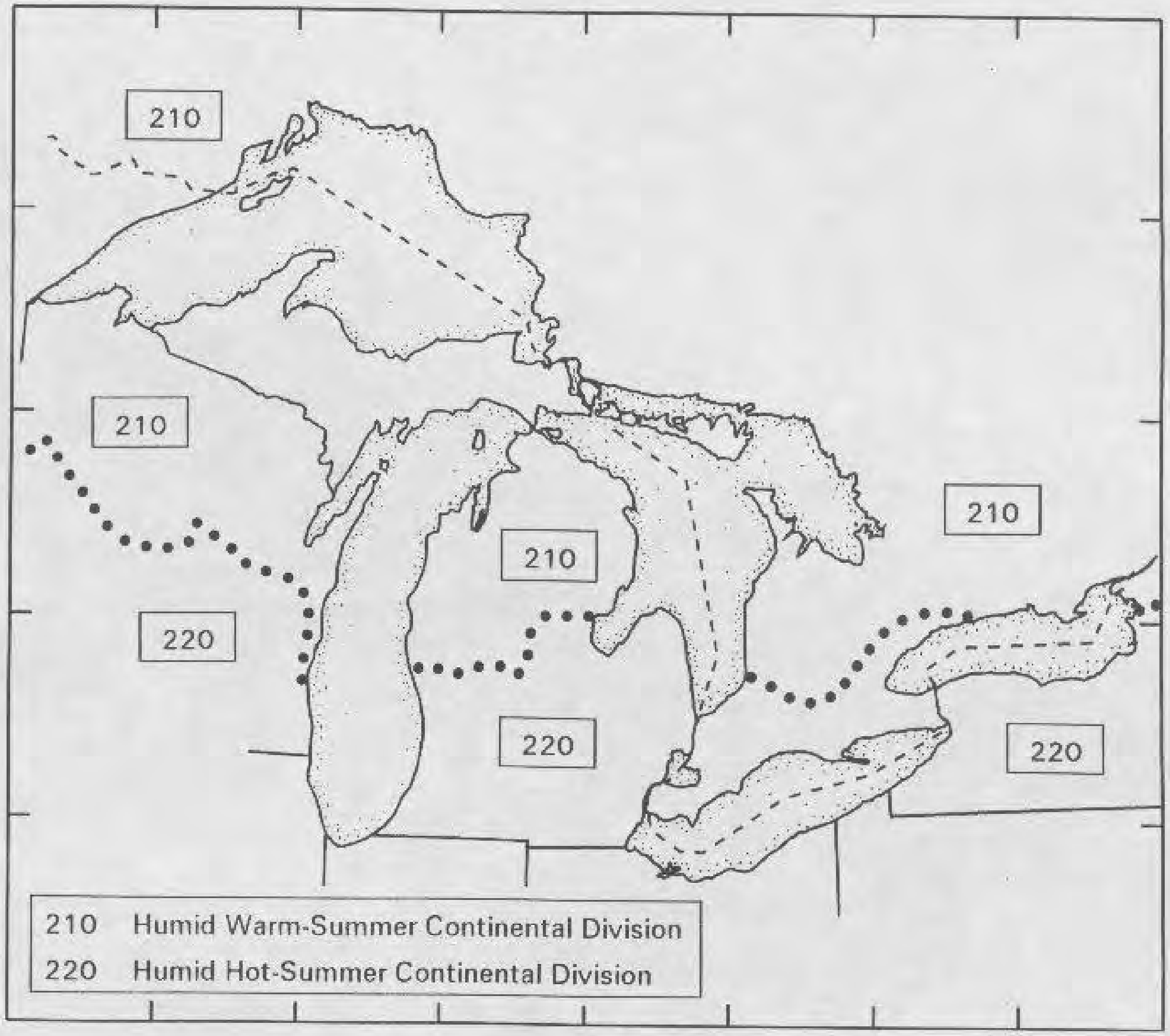


Figure 25. Climatic regions of the Great Lakes Basin (after Bailey and Cushwa [1981] and Keys et al. [1995]).

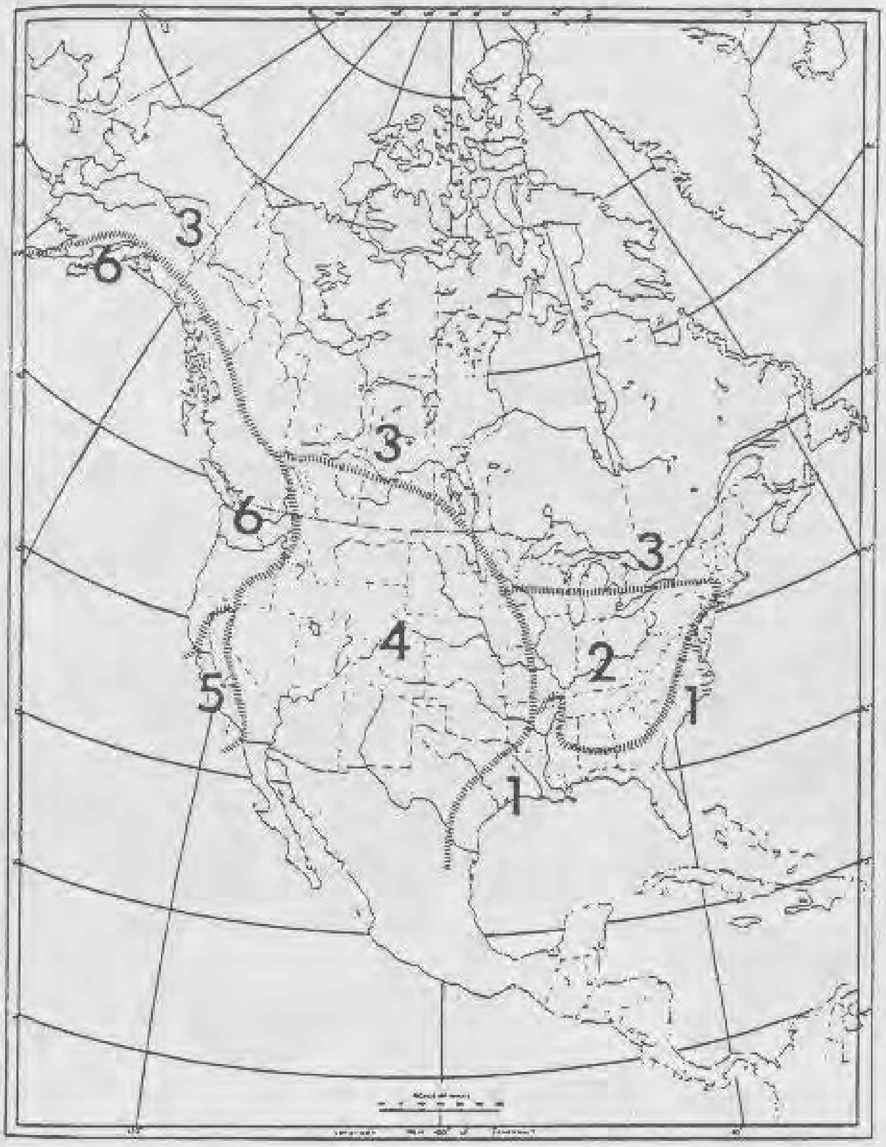


Figure 26. Geographic regions of North America based on wetland vegetational characteristics (from Kadlec and Wentz 1974).

Overall, regional floristic surveys are scant for Great Lakes wetlands and the applicability of these specific climatic divisions for Great Lakes coastal wetlands remains largely unknown. Lake effects do substantially ameliorate coastal conditions. The air near the coast cools more slowly in the fall, such that growing season length (frost-free period) along the shoreline exceeds that of the adjacent interior by 20-40 days (U.S. EPA 1995:8). These shoreline conditions may locally alter the response of coastal aquatic and wetland systems to the latitudinal gradient.

HUMAN LAND USE and ANTHROPOGENIC STRESS

Differences in land use -- whether **urban, agricultural, or forested** -- create regional differences in the extent and quality of wetlands, as well as in their species composition. To a large extent, land use is a composite variable reflecting climate, physiography, and soils. The

Tension zone, a rough climatic boundary separating the forested north from the more agricultural south, closely follows regional differences in summer mean daily air temperature (Fig. 27). Urban development, in contrast, reflects the early location of good harbors and the distribution of natural resources such as timber and mineral ores.

Urban and agricultural development have resulted in the severe degradation and loss of coastal marshes through upland management, ecosystem alteration, and pollution:

- **Urban development**
- Armoring of the shoreline and dredging of channels to create harbors has resulted in marsh elimination.
- Dumping of waste materials such as sawdust and sewage, and a wide variety of chemicals has mechanically and chemically altered the shallow-water marsh environment, increasing turbidity, reducing oxygen concentrations, and altering the pH.
- Shipping traffic has mechanically eroded shoreline vegetation.
- Water-level control of the Great Lakes and connecting rivers has altered natural wetland dynamics.

- **Agriculture**
- Drainage has eliminated large areas of marshes and coastal wetlands (Fig. 27).
- Sedimentation has greatly increased turbidity, eliminating submergent species requiring clear water.
- Nutrient loading has locally reduced oxygen levels, prompted algal blooms, and led to the dominance of high-nutrient tolerant species such as cat-tails.
- Heavy agricultural sedimentation has led to the deposition of rich organic mud in the wet meadows and along the shoreline, favoring the dominance of early successional species (Fig. 28).
- Introduction of exotic plants has altered macrophyte species composition (Fig. 29).

Of these factors, **agricultural siltation and turbidity** have been repeatedly identified as significant stressors to coastal wetlands (Herdendorf 1987, 1992; Jude and Pappas 1992). Continued high turbidity levels reduce the amount of light penetrating into the water, thereby limiting photosynthesis and inhibiting aquatic plant growth (Meyer and Heritage 1941; Meyer et al. 1943; Stuckey 1979, 1989; Schumacher 1980).

Common submerged plants which bear most of their leafy growth below the water, such as *Elodea canadensis* (common waterweed) and many species of the pondweed *Potamogeton*, are particularly sensitive to turbidity (Haslam 1978:118; Kadlec and Wentz 1974; Klarer and Millie 1992; Marshall 1977). In contrast, submergents which are principally "canopy-formers" (i.e. having most of their foliage near the water surface) such as *Ceratophyllum demersum* (hortwort, coontail), *Potamogeton pectinatus* (sago pondweed), and *Myriophyllum spicatum* (Eurasian water milfoil), are well adapted to turbid, light-limited conditions. In portions of the Great Lakes characterized by high turbidity, a change in submergent species composition toward species more tolerant of turbidity, such as free-floating and canopy-forming species can therefore be expected.

Within the Great Lakes as a whole, several areas are considered excessively turbid: western Lake Erie, Saginaw Bay of Lake Huron, and lower Green Bay of Lake Michigan (Upchurch 1976; Pinsak 1976; Jude and Pappas 1992; Richards and Baker 1993). All three areas lie on flat, clay lakeplain which has been intensively farmed with row crops (Albert 1995:102, 127-129, 157), and much of the water turbidity and sedimentation is attributed to

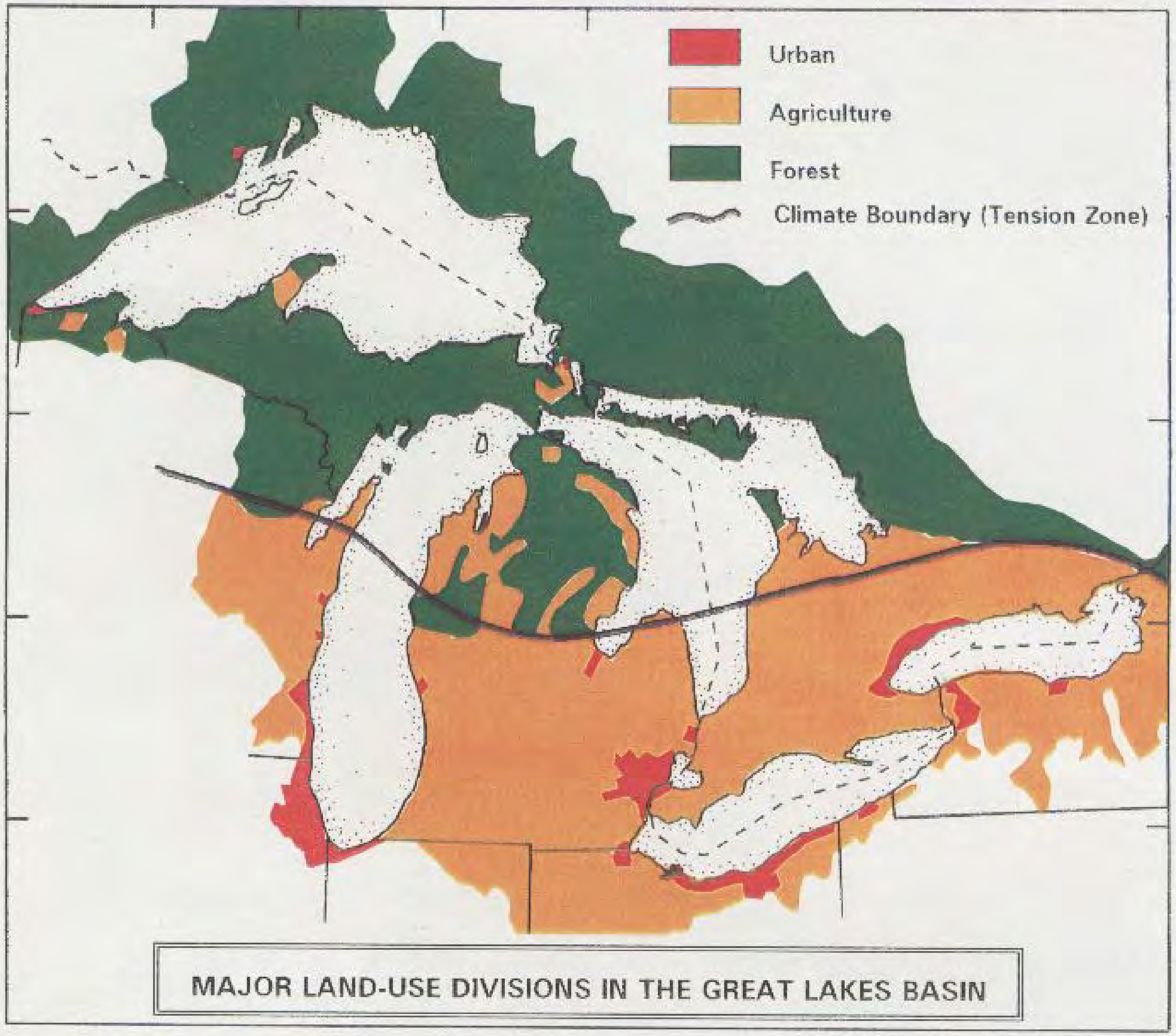


Figure 27. Major land-use divisions in the Great Lakes Basin. The **Tension zone,** a rough climatic boundary, separates the forested north from the more agricultural south.

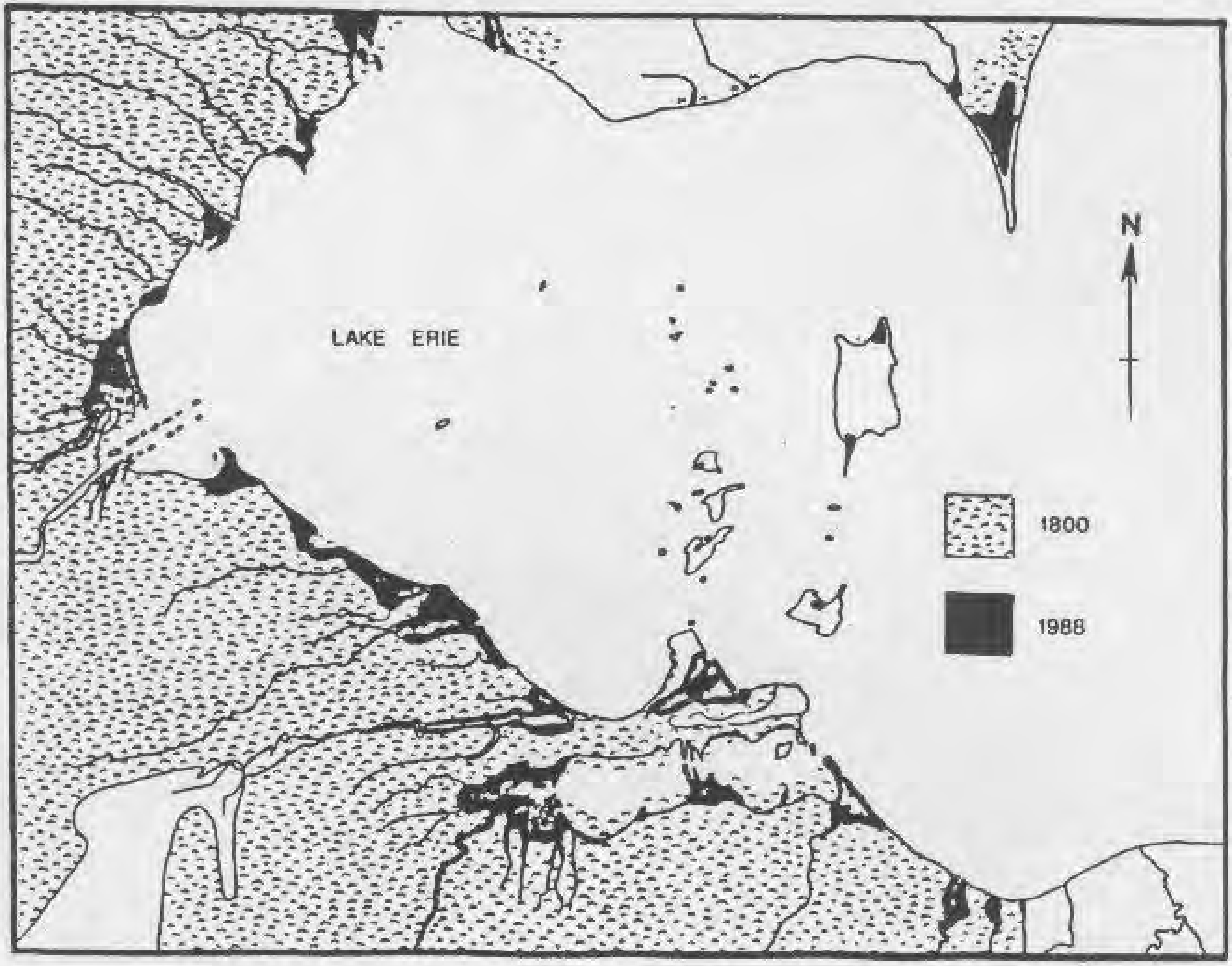


Figure 28. Loss of coastal wetlands surrounding western Lake Erie 1800-1988. Over 90% of the extensive marshes and swamps along the western Lake Erie shoreline were eliminated before 1900, both by drainage for agriculture and shoreline modification. Similar levels of marsh destruction occurred along Lake St. Clair, Saginaw Bay on Lake Huron, and Green Bay on Lake Michigan. (Drawing from Herdendorf 1987).

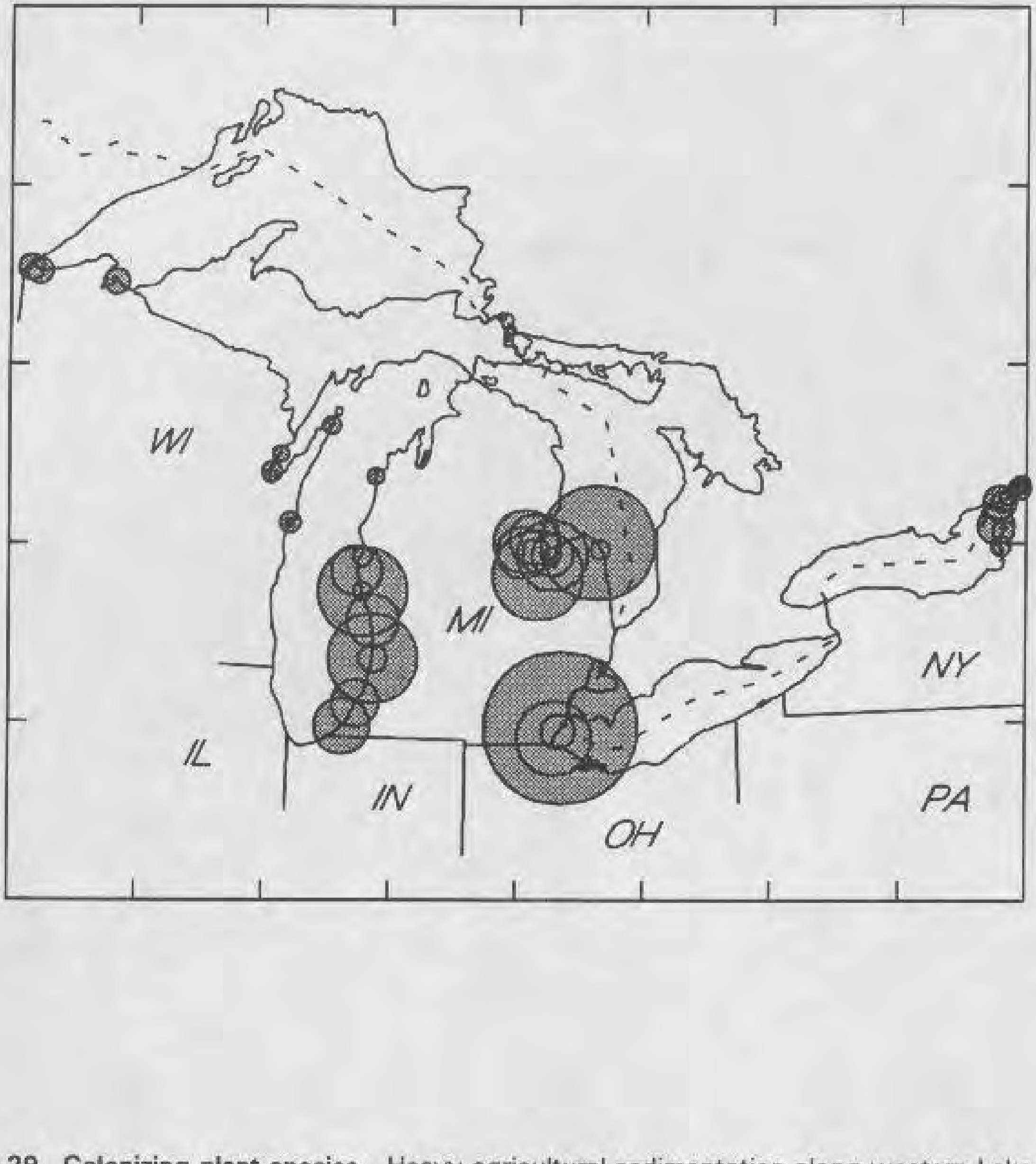


Figure 29. Colonizing plant species. Heavy agricultural sedimentation along western Lake Erie, Saginaw Bay, and tributaries to southern Lake Michigan results in the deposition of rich organic muds in the wet meadows and along the shoreline, which are the favored habitat of early successional species such as ***Polygonum lapathifolium*** (nodding smartweed), ***Bidens cernuus*** (nodding bur-marigold), ***Rorippa palustris*** (yellow cress), and ***Scirpus validus*** (softstem bulrush). (Symbol size reflects the mean coverage value of colonizing species along sampling transects from 90 Great Lakes coastal wetlands.)

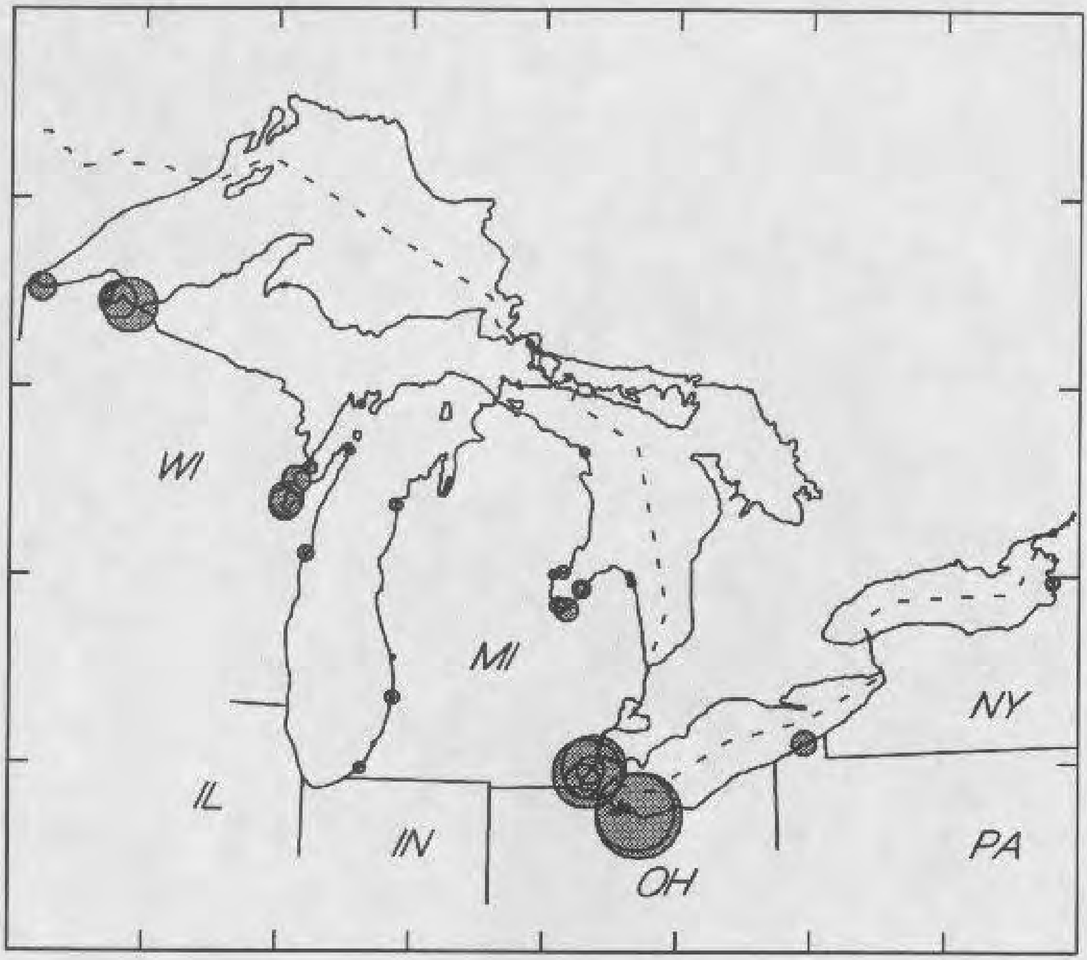


Figure 30. Exotic plant species. The greatest concentration of exotic plants occurs in marshes associated with either urban or agricultural areas, including western Lake Erie, Saginaw Bay, and Green Bay. Marshes located within forested areas with low population densities, as along most of Lake Superior, the St. Marys River, and northern Lakes Michigan and Huron, have very low coverage values for exotic plants. (Symbol size reflects the mean coverage value of exotic species along sampling transects from 90 Great Lakes coastal wetlands.)

erosion from agricultural activities upstream (Baker 1985; Maynard and Wilcox 1996:57-58; Matisoff and Eaker 1992; Reeder 1990). In these areas, excessive sedimentation and continued high turbidity levels appear to have reduced or excluded those submersed species that normally inhabit clear, well-oxygenated waters. Surviving are only a few tolerant native submersed species and invasive Eurasian species adapted to turbid conditions (Stuckey 1989:234; see Table 6).

Table 6
Aquatic Species Intolerant and Tolerant of Turbid Water Conditions[a]

Native Species Intolerant of Turbidity	Native Species Tolerant of Turbidity	Eurasian Species Tolerant of Turbidity
Megalodonta beckii	*Ceratophyllum demersum*	*Butomus umbellatus*
Myriophyllum exalbescens	*Elodea canadensis*	*Myriophyllum spicatum*
Najas flexilis	*Heteranthera dubia*	*Najas minor*
Potamogeton amplifolius	*Potamogeton foliosus*	*Potamogeton crispus*
Potamogeton gramineus	*Potamogeton pectinatus*	
Potamogeton robbinsii	*Potamogeton pusillus*	
Potamogeton zosteriformis	*Ranunculus longirostris*	
Potamogeton friesii		
Potamogeton strictifolius		
Vallisneria americana		

[a]After Stuckey 1989:234.

In addition, agricultural erosion and the heavy deposition of fine sediments may alter the substrate composition for both aquatic and shoreline zones, thereby affecting species composition. For example, agricultural siltation is apparently responsible for the loss of wild rice (*Zizania aquatica*) throughout much of the lower Great Lakes. Wild rice tolerates only a narrow range of conditions, and grows best in poorly consolidated, mucky soils. In the late 1800s, the Middle Grounds of Saginaw Bay were very productive wild rice fields. Since that time, however, the deep muck soils of pre-agricultural times have been buried by a layer of hard-packed sand and clay, effectively eliminating wild rice habitat (Pirnie 1935:178-179). Similarly dramatic changes in substrate are reported at Pt. Mouillee (McDonald 1951). At Old Woman Creek, Ohio, the deep muck soils characteristic of lacustrine estuaries have been buried by silts and clays derived from agricultural run-off (Reeder 1990). However, the impact of these historical changes in substrate on natural vegetation is not known.

Agricultural siltation also creates the potential for extensive, fertile mud flats along the shoreline following a drop in lake level, and favor species adapted to the cyclical exposure of this habitat. High densities of early successional species, including ***Polygonum lapathifolium*** (nodding smartweed), ***Bidens cernuus*** (nodding bur-marigold), ***Rorippa palustris*** (yellow cress), and ***Scirpus validus*** (softstem bulrush), are closely associated with areas of high upland erosion and turbidity such as western Lake Erie, Saginaw Bay, and Green Bay (Fig. 29). As a complex, these colonizing species may be useful indicators of coastal wetlands adversely affected by agricultural runoff.

Finally, both agricultural and urban disturbance favor the introduction of exotic shoreline species, particularly *Lythrum salicaria* (purple loosestrife), *Phalaris arundinacea* (reed canary grass), and *Phragmites australis* (giant bulrush). The greatest concentration of exotics occurs in marshes within heavily disturbed areas (Fig. 30). In contrast, marshes located within the forested portions of the Great Lakes region have very low coverage values for exotic plants.

PART TWO

REGIONALIZATION OF U.S. GREAT LAKES SHORELINE

The following preliminary regionalization of the U.S. Great Lakes shoreline divides the Great Lakes coast into stretches characterized by distinctive conditions for coastal wetland development, based on differences in climate, bedrock geology, glacial geomorphology, shoreline configuration, and soils, as well as land use and disturbance factors. In many stretches, this regionalization does not match existing natural division maps of the Great Lakes area based on upland characteristics. This is because coastline conditions reflect a combination of upland and nearshore characteristics. That is, the location of stretch relative to prevailing winds and persistent littoral currents, and to areas of erosion (sources of sediment moved along coast) are of equal importance to the shoreline configuration as are topography and substrates of immediately adjacent uplands.

The regionalization is organized as a circumnavigation of the Great Lakes shoreline, beginning with Lake Superior at the international boundary between Ontario, Canada and Minnesota, proceeding south and then east along the Lake Superior coast to the St. Marys River and Drummond Island. From the St. Marys, we turn back west along the southern shore of Michigan's Upper Peninsula through the Straits of Mackinac to Green Bay, Wisconsin, and then through the entire loop of Lake Michigan. Returning to the Straits of Mackinac, the regionalization continues south along the west shore of Lake Huron, to the St. Clair River, Lake St. Clair, the Detroit River, Lake Erie, the Niagara River, Lake Ontario, and finally to the head of the St. Lawrence River.

In all, 77 stretches of coastline have been delimited for the Great Lakes and their connecting rivers (Maps I-V). For each stretch, a brief description of upland topography, shoreline configuration, and relevant nearshore features is presented first, as these generate the characteristic contexts for wetland development. The definition and description of stretches was based on the following sources:

1. **published natural divisions maps and descriptions** for Minnesota, Wisconsin, and Michigan (Albert 1995; Hole and Germain 1994), Illinois (Schwegman 1973), Indiana (Homoya 1997), and New York (Reschke 1990);

2. **bedrock geology maps and texts** for the Lake Superior region of Minnesota, Wisconsin, and Michigan (Morey et al. 1982), Minnesota (Olsen and Mossler 1982), Michigan (Dorr and Eschman 1981), and New York (Van Diver 1985);

3. **glacial geomorphology** of the Lake Superior region (Clayton 1984; Farrand et al. 1984), Minnesota (Hobbs and Goebel 1982), Northern and Southern Michigan (Farrand and Bell 1982a, 1982b), the Illinois-Indiana coast (Chrzastowski et al. 1994), and Lake Erie (Herdendorf 1989);

4. **soils maps** for Minnesota (Dept. of Soil Science 1977, 1981; Anderson and Grigal 1984), Wisconsin (Hole 1968, 1976), and county soil surveys for Michigan;

5. **topographic maps**, including the USGS 7.5" series for all of the U.S. Great Lakes shoreline;

6. **shoreline descriptions**, including (a) detailed, reach-by-reach shoreline descriptions of lower Michigan and part of the Lake Superior shoreline (Humphrys et al. 1958; Humphrys 1958), the Illinois-Indiana coast (Chrzastowski et al. 1994), and Lakes Erie and Ontario (Herdendorf 1975); (b) reach-by-reach maps generated under the U.S. Army Corps of Engineers (n.d.) Great Lakes/St. Lawrence River shoreline classification; and

(c) more generalized characterizations provided by the Great Lake Basin Commission (1975) and the IJC Levels Reference Study (1993);

7. **ecological profiles** (including descriptions of land use and water quality) for St. Marys River (Duffy et al. 1987; Liston et al. 1986); the Detroit River (Manny et al. 1988), Lake St. Clair (Herdendorf et al. 1986; Edsall et al. 1988), the St. Clair River (Edsall et al. 1988), and western Lake Erie (Herdendorf 1987);

8. **natural vegetation maps** for the Michigan shoreline (Veatch 1953; Raphael 1987; Comer and Albert 1997) and Lake Erie (Gordon 1966);

9. **inventories of natural communities of the Great Lakes shoreline**, including coastal marshes (Albert et al. 1987, 1988, 1989; Geis and Key 1977), Lake Erie estuaries (Herdendorf 1987, 1990, 1992), dune-and-swale complexes (Comer and Albert 1991, 1993), and bedrock communities of Michigan (Albert et al. 1997); and

10. **field visits by Heritage Program personnel**, including MNFI, the Minnesota Natural Heritage Program, the Wisconsin Natural Heritage Program, and New York Natural Heritage Program.

Each stretch of shoreline so defined is then linked to the comprehensive Great Lakes coastal wetland survey conducted by the U.S. Fish and Wildlife Service (Herdendorf et al. 1981a-1981f). This survey identified and mapped all wetlands greater than 1 acre in size that occur wholly or partially within 1000 feet of the Great Lakes shoreline (Fig. 31). Not all the wetlands so identified are directly influenced by Great Lakes water levels (they may be at elevations well above the lake), while some wetlands further inland are not included that are in fact linked to and influenced by the Great Lakes via connecting water ways. Further, the inventory provides only limited information on wetland characteristics, such as whether the vegetation is wooded, partially wooded, or non-wooded, and whether the wetland is primarily riverine, palustrine, or lacustrine in its hydrology. With these limitations in mind, however, the USFWS wetland inventory provides a very useful registry of wetland locations from which key coastal marshes for each stretch can be identified.

Finally, characteristic wetland sites are listed for each stretch, which are included within the MNFI data base. Descriptions of individual sites along Michigan's shores can be found in Albert et al. (1987, 1988, 1989). Descriptions of non-Michigan marsh sites sampled by MNFI are included in Appendix I to this report.

Figure 31. Criteria used by the U.S. Fish and Wildlife Service for inclusion of wetlands in their Great Lakes coastal wetland inventory (from Herdendorf et al. 1981).

I. LAKE SUPERIOR

1.	Isle Royale	exposed volcanic bedrock shoreline
2.	International Border to Split Rock Point	exposed bedrock shoreline
3.	Split Rock Point to Duluth	steep clay bluffs
4.	Duluth (MN) to Superior (WI)	St. Louis River drainage
5.	Superior to Port Wing	low till shoreline bluffs
6.	Port Wing to Bayfield to Washburn	steep till shoreline bluffs
7.	Apostle Islands	low sandstone cliff and till bluff
8.	Washburn to Marble Point	flat, clay lakeplain
9.	Marble Point (WI) to Union Bay (MI)	bedrock or till bluffs
10.	Union Bay to Misery Bay/Rockhouse Point	narrow sand beach on clay lakeplain
11.	Rockhouse Pt. to Portage Lake Ship Canal West	sandstone cliffs
12.	Portage Lake Ship Canal	ground moraine and deltaic deposits
13.	Portage Lake Ship Canal West to Gratiot River	sand and gravel beach over sandstone
14.	Gratiot River to Bete Grise	basalt bedrock shoreline
15.	Bete Grise to Little Traverse Bay	sand lakeplain
16.	Little Traverse Bay to Huron River Point	sandstone cliff and till bluff
17.	Huron River Point to Marquette	sandstone cliff and granitic points
18.	Marquette to Marquette/Alger county line	sand lakeplain
19.	Marquette/Alger county line to Grand Portal	sandstone cliff
20.	Grand Portal to Sable Creek (Alger Co.)	sand bluff
21.	Sable Creek to Vermillion	dry sand lakeplain
22.	Vermillion to Whitefish Point to St. Marys River	poorly drained sand lakeplain

II. ST. MARYS RIVER

23.	Lake Superior to St. Marys River Rapids	exposed shoreline
24.	St. Marys River Rapids to Raber Point	clay lakeplain

Map I: Shoreline divisions of Lake Superior. Base map showing wetland locations from Herdendorf et al. (1981a); not all wetlands shown are directly influenced by Lake Superior water levels.

III. LAKE HURON

25.	Drummond Island	limestone/dolomite bedrock shoreline
26.	Potagannissing Bay to St. Vital Point	marly shoreline
27.	St. Vital Point to Albany Island	sand lakeplain
28.	Albany Island to Search Bay, & Les Cheneaux Is.	drumlinized ground moraine
29.	Search Bay to Poupard Bay	sandy shoreline on marly substrates
54.	Cross Village to Lighthouse Point (Lake Huron)	calcareous glacial lakeplain
55.	Lighthouse Point to Rogers City (Presque Isle Co.)	sand lakeplain
56.	Rogers City to Squaw Bay (Alpena Co.)	cobble beach and marly embayments
57.	Squaw Bay to Point Lookout (Arenac Co.)	sandy lakeplain
58.	Saginaw Bay (Point Lookout to Port Austin)	clay lakeplain
59.	Port Austin to Port Huron	low shale or clay bluffs

Map II: Shoreline divisions of Lake Huron, St. Clair River, Lake St. Clair and Detroit River. Base map showing wetland locations from Herdendorf et al. (1981a); not all wetlands shown are directly influenced by Great Lakes water levels.

IV. ST. CLAIR RIVER

60. St. Clair River — lacustrine clays

V. LAKE ST. CLAIR

61. Lake St. Clair — clay lakeplain

VI. DETROIT RIVER

62. Detroit River — clay lakeplain

Map III: Shoreline divisions of Lake Michigan. Base map showing wetland locations from Herdendorf et al. (1981a); not all wetlands shown are directly influenced by Great Lakes water levels.

III. LAKE MICHIGAN

30. Poupard Bay/Gros Cap to Thompson
31. Thompson to Valentine Creek
32. Valentine Creek to Ogontz River
33. Ogontz River to Squaw Point
34. Squaw Point to Ford River
35. Ford River to Menominee River (MI/WI line)
36. Menominee River to eastern Green Bay
37. W. shore of Door Peninsula to Washington Is.
38. Northern tip of Door Peninsula to Algoma
39. Algoma to Sheboygan
40. Sheboygan to Port Washington
41. Port Washington to Kenosha
42. Kenosha (WI) to North Chicago (IL)
43. North Chicago to Winnetka
44. Winnetka (IL) to Gary (IN)
45. Gary (IN) to Nordhouse Dunes (MI)
46. Nordhouse Dunes to Frankfort
47. Frankfort to east edge of Good Harbor Bay
48. E. Good Harbor Bay to Northport Point
49. Northport Point to Yuba (Grand Traverse Co.)
50. Yuba to South Point/Charlevoix
51. South Point to Petoskey (Little Traverse Bay)
52. Petoskey to Cross Village
53. Beaver Island Group
54. Cross Village to Lighthouse Point (Lake Huron)

30. sand lakeplain
31. limestone bedrock shoreline
32. sand lakeplain & loamy ground moraine
33. sand over limestone bedrock
34. well-drained outwash & sand lakeplain
35. poorly drained sand lakeplain
36. wet, nearly level lakeplain
37. steep till bluff
38. sand over low bedrock plain
39. clayey till plain
40. sand beach and dune
41. glacial till bluffs
42. beach-ridge plain
43. morainic bluff coast
44. lacustrine plain
45. steep dunes and sandy bluffs
46. moraine and till bluffs
47. sand lakeplain
48. drumlin field
49. cobble shoreline
50. sand lakeplain
51. cobble beach & low bedrock cliff
52. moraine bluffs
53. sand lakeplain
54. calcareous glacial lakeplain

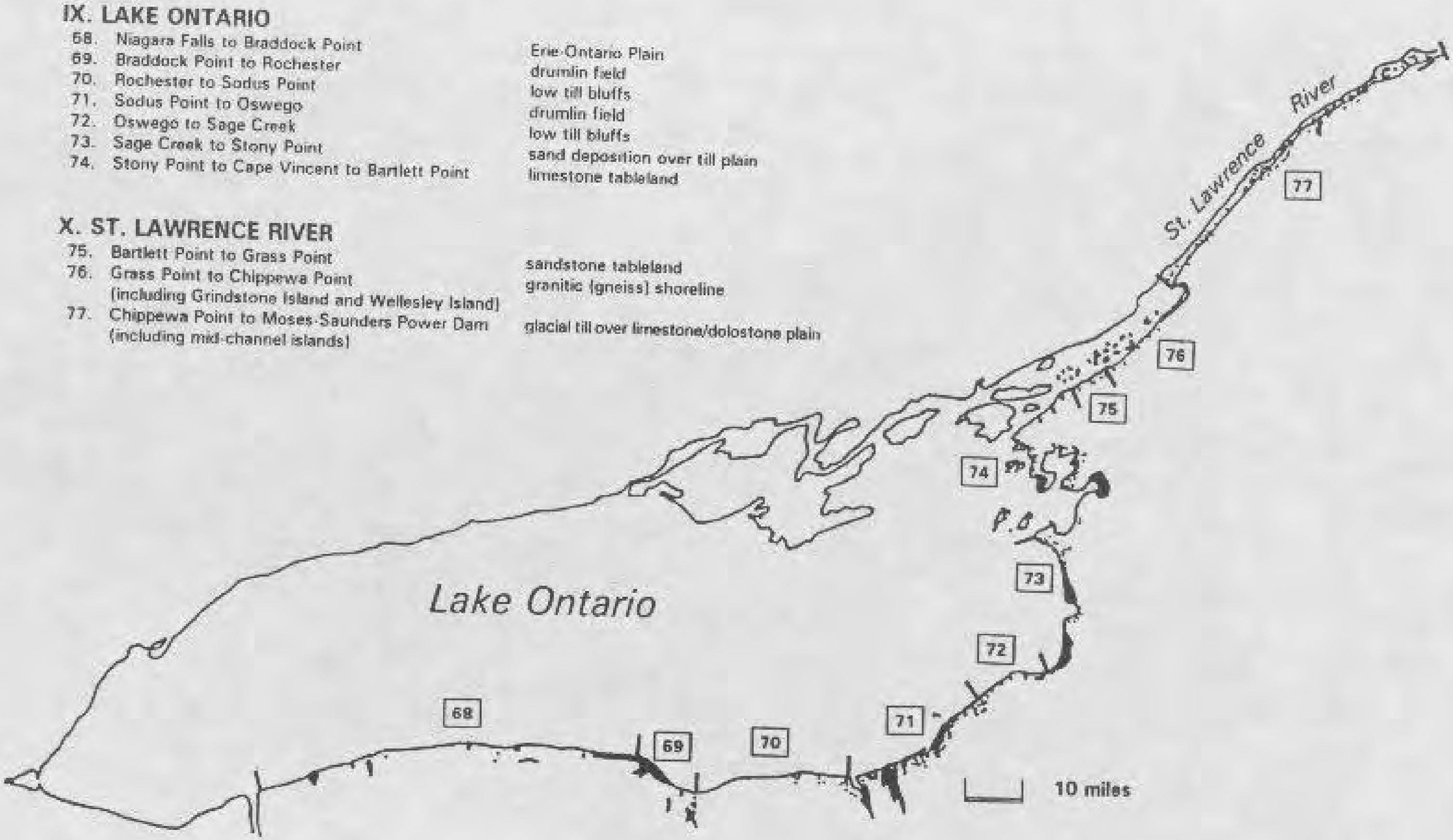
VII. LAKE ERIE

63.	Detroit River (MI) to Port Clinton (OH)	clay lakeplain
64.	Port Clinton to Marble Head (including the Erie Islands)	low bedrock bluffs
65.	Marble Head to Vermillion (including Sandusky Bay)	clay lakeplain
66.	Vermillion (OH) to Niagara River (NY)	Erie-Ontario Plain

VIII. NIAGARA RIVER

67.	Niagara River	low till bluffs over calcareous bedrock

Map IV: Shoreline divisions of Lake Erie and Niagara River. Base map showing wetland locations from Herdendorf et al. (1981a); not all wetlands shown are directly influenced by Great Lakes water levels.



Map V: Shoreline divisions of Lake Ontario and the St. Lawrence River. Base map showing wetland locations from Herdendorf et al. (1981a); not all wetlands shown are directly influenced by Great Lakes water levels.

I. LAKE SUPERIOR:

Lake Superior is the largest, deepest, and coldest of the Great Lakes. The lake itself is characterized as oligotrophic, with low levels of nutrients, little plant life, high levels of dissolved oxygen, and a long retention period. Along the shoreline, coastal wetland development is constrained by large areas of bedrock at or near the surface, shallow (generally acidic) soils, and a northerly climate.

Bedrock composition is an important determinant of wetland distribution and type along Lake Superior. Granitic and metamorphosed sedimentary rocks form the northern Minnesota and Canadian shorelines, while sedimentary rock occurs along most of the shoreline of Wisconsin and the Upper Peninsula of Michigan. Extensive exposures of volcanic rock and conglomerates derived from volcanic rock line the northwestern shore of the Keweenaw Peninsula and much of Isle Royale. Soils derived from these bedrock types are heavily leached and generally acidic.

Shorelines vary from steep rock cliffs through low-lying clay and gravel bluffs which preclude development of major wetlands, to more sheltered embayments and stream mouths. Many of the lake's tributaries have extended deep-water estuaries or extensive shallows at their mouths, offering excellent shallow-water habitat for wetland development.

The climate of the Lake Superior region is a product of its northern latitude, and is characterized by short growing season and extreme low winter temperatures; both continental and lake-influenced sections of shoreline are found (Albert 1995). This northern climate is reflected in the more boreal nature of the wetlands, which are typically rich in bog or poor fen species, including Sphagnum mosses and low shrubs such as sweet gale (*Myrica gale*), leatherleaf (*Chamaedaphne calyculata*), and bog rosemary (*Andromeda glaucophylla*).

Lake Superior is the purest of the lakes, owing in part to the small population within its drainage basin. Lake Superior has the lowest concentrations of suspended solids, dissolved solids, and organic materials of all the Great Lakes; dissolved solids remain less than half of that seen in the other lakes. Although the lake is relatively clean, point source pollution locally affects the shoreline environment. Seven Areas of Concern (AOCs) have been identified by the U.S. and Canadian governments under the 1978 Great Lakes Water Quality Agreement and the 1987 Protocol (SOLEC 1997). AOCs are defined as severely degraded geographic areas where beneficial uses (activities dependent on the chemical, physical, and biological integrity of the water) are threatened or impaired. On the U.S. side, these AOCs are the St. Louis Bay/St. Louis River (Duluth-Superior), Torch Lake (Houghton), and Deer Lake-Carp Creek (Marquette); Canadian AOCs include Thunder Bay, Nipigon Bay, Jackfish Bay, and Peninsula Harbor.

1. Isle Royale: exposed volcanic bedrock shoreline. Rugged volcanic bedrock dominates the shoreline creating very narrow, linear embayments, stream valleys, and inland lakes and wetlands. Most of the bedrock is steeply tilted basalt, but a small section of sandstone and volcanic conglomerate is found along the SW portion of the island extending from Maloney Bay to Cumberland Point.

Wetlands: Although the island has more than 480 km of shoreline, there are few large coastal wetlands. The USFWS coastal wetland inventory conducted by Herdendorf et al. (1981f:790-796) identified 29 wetlands within 1000' of the Isle Royale shoreline (LS-320 - LS-348), ranging in size from 5 to 335 acres. The majority of these are associated with basaltic shoreline (LS-320 - LS-342), while a few (LS-343 - LS-348) occur on sandstone or conglomerate. However, no information is given on the proximity of these wetlands to the shore or their elevation relative to Lake Superior, making it difficult to determine from this inventory which wetlands are influenced by Lake Superior's water level.

MNFI surveys conducted during the summer of 1997 divide the wetlands of Isle Royale into three distinct types (Will MacKinnon, pers. comm. 10/97):

1. narrow and deep embayments of the basaltic shoreline, with small, partially wooded wetlands at the head of the bay, often extending inland along tributary streams;

2. barrier-beach "lagoons" found on sandstone or conglomerate bedrock. These tend to have steep barriers (up to 2 m high) of cobble or gravel with some sand, often with water seeping through their face; some enclose an open lagoon (e.g. Feldman Lake), but most support swamp. Examples include LS-320, and LS-344 - LS-346, plus two additional wetlands (Feldman Lake and The Head) not inventoried by Herdendorf et al. (1981f);

3. perched or isolated wetlands 3-65 m above the Lake Superior shoreline and not influenced by Lake Superior.

In all cases, emergent and submergent marsh components are very minor; some wetlands contain a wet meadow zone, but most consist of shrub swamp dominated by alder, or treed swamp dominated by black spruce or northern white-cedar.

2. International Border to Split Rock Point (Lake Co., MN): exposed bedrock shoreline along North Shore Highlands. This area forms a strongly sloping boundary between the interior high moraines and Lake Superior. The shoreline is rugged and consists of exposed basaltic bedrock with localized areas of sand (Subsection X.9, Albert 1995:229). The topography rises steeply to the interior; there, glacial drift is thin and bedrock is at or near the surface (Olsen and Mossler 1982). Where present, the soils are reddish brown, strongly acidic loamy till (Dept. of Soil Science 1981:24). Many fast flowing streams cut through the region as they flow toward Lake Superior.

Wetlands: Coastal wetlands are small and restricted to localized areas of sand accumulation. Herdendorf et al. (1981f:778-780) identify 7 coastal wetlands (LS-313 - LS-319) along this stretch, ranging from 1 to 25 acres in size. Five of these are clustered at the Paradise Beach area, north of Grand Marais, MN (Dept. of Soil Science 1981). These small wetlands occupy depressions behind the sand beach and are partially wooded.

3. Split Rock Point to Duluth: steep clay bluffs (North Shore Highlands [Subsection X.9, Albert 1995]; Nemadji-Duluth Lacustrine Plain, clayey [Dept. of Soil Science 1981]). Clay lakeplain (lake modified till) forms a broad band of reddish-brown, calcareous sediments along the Lake Superior shoreline (Clayton 1984). The till is exposed as steep clay bluffs along the shore, which alternate with rocky points of exposed bedrock. Inland, the topography rises steeply to the interior highlands formed by the flat-to-rolling clay plain. Numerous short streams, 15-25 km long, lead directly from the highland interior to the shores of Lake Superior through deeply incised ravines; most of the streams have water falls near the shoreline (Wright 1972). ***Wetlands:*** No coastal wetland development.

4. Duluth, MN to Superior, WI (St. Louis, Superior, and Allouez bays): St. Louis River drainage. The Nemadji-Duluth Lacustrine Plain continues through this stretch (Dept. of Soil Science 1977). The region is predominantly a flat plain of reddish-brown clays (53%) and sands (34%) that sits about 130 m above the level of Lake Superior. The plain became deeply dissected by the St. Louis River and its tributaries when the glacial lake water levels dropped following the retreat of last the glacier. A subsequent rise in Lake Superior to present levels has partially submerged the river valleys, creating a series of lacustrine estuaries within steep-sided ravines. The St. Louis River estuary is a widely-recognized example of a buried river mouth (Lee Clayton, pers. comm.). Dominant longshore currents, carrying sediments from further east, deposited a series of sand spits over 15 km long across the mouths of the St. Louis, Nemadji, and Allouez rivers, creating the St. Louis Bay, Superior Bay, and Allouez Bay lagoons. Organic deposits 1-2 m thick developed behind the barrier, and are still present within Allouez Bay; underlying soils are clay. In general, the St. Louis, Superior, and Allouez bays have been heavily modified for the construction of harbors and docks, as have the main channels of the St. Louis and Nemadji rivers.

Wetlands: Formerly there were extensive wetlands behind the barriers as evidenced by remnant organic soils. Large areas of wetland remain in the upper estuarine reaches of the St. Louis and Pokegama rivers. Herdendorf et al. (1981f:710-711) identify 37 wetlands (LS-276 - LS-312) in this stretch. Eleven of these (the Minnesota Point, Superior City, Nemadji River wetland complexes) are on artificial fill. The larger non-wooded wetlands remaining in more natural contexts include Allouez Bay (LS-276, 365 acres), Mud Lake along the St. Louis River (LS-298, 290 acres), Pokegama River (LS-310, 235 acres), and Oliver (LS-296, 170 acres); others range from 2 to 40 acres in size.

MNFI sampled two wetlands in this stretch: Pokegama River and Fond du Lac (adjacent to the St. Louis River) (see Appendix I for site descriptions). Both sites are considered lacustrine estuaries.

5. Superior to Port Wing, WI: low till shoreline bluffs. Lake-modified glacial till continues along this stretch of Lake Superior, and is exposed as low bluffs (ca. 8 m high) of reddish clayey sediments belonging to the Miller Creek Formation (Clayton 1984). Inland, the topography is flat to undulating, at least in part reflecting its wave-washed origins. Steeply dissected, narrow streams (with ravine slopes of 10-15%) cut across the Superior lowland; many are intermittent in flow.

Wetlands: The narrow streams generally have sand bars at their mouths, forming from the eastern side, which partially block and protect their outlets. Small herbaceous wetlands (ranging in size from 2 to 70 acres) have formed behind protective sand bars at the mouths of several streams, including the Amnicon, Middle, Poplar, and Bois Brule rivers (LS-269 - LS-273; Herdendorf et al. 1981f:711).

6. Port Wing to Bayfield to Washburn, WI: steep till shoreline bluffs. East of Port Wing and the mouth of the Flag River the character of the coastline changes dramatically. Sediments remain lake-modified clayey till, but the reddish bluffs rise much higher along this stretch (from 15 m up to 200 m above the lake at Bayfield), and the shoreline configuration becomes more complex. Most streams are small and flow through deeply dissected ravines; many are intermittent.

Wetlands: Predominant east-to-west surface currents have trapped sand in the steep east-facing embayments, creating barrier beaches behind which lagoons have formed; many are fed by small streams. Typical lagoon soils are muck or peat over sand. Some of these lagoons appear to be part of larger dune and swale complexes. Herdendorf et al. (1981f:587, 619) identify 11 wetlands along this stretch (LS-228, LS-258 - LS-261, and LS-263 - LS-268). All are characteristic barrier-beach lagoon wetlands, including Bark Bay (LS-266, 680 acres), Siskewit Bay (LS-263/LS-265, 250 acres), Sand Bay (LS-261, 235 acres), Raspberry Bay (LS-259, 140 acres), and the Sioux River bay (LS-228, 202 acres) (Herdendorf et al. 1981f:587, 619). MNFI marsh sampling included transects at Bark Bay, Siskewit Bay, and Raspberry Bay (see Appendix I for site descriptions).

7. Apostle Islands, WI: low sandstone cliff and till bluff. The Apostle Islands are a group of 22 islands with 175 miles (280 km) of shoreline, lying to the NE of the Bayfield Peninsula. The shoreline is characterized by stretches of low sandstone cliff, slumping shore bluffs of clayey till, and a diversity of sand scapes, including sand and gravel beaches, sand spits, and tombolos.

Wetlands: The coastal wetland inventory of Herdendorf et al. (1981f:619) identified 30 wetlands (LS-229 - LS-257, and LS-262) on the Apostle Islands. These wetlands include substantial barrier-beach lagoon wetlands in east-facing embayments (e.g. Bog Lake [LS-232] and Big Bay Lagoon [LS-234] on Madeline Island, and Presque Isle [LS-238] on Stockton Island), as well as smaller wetlands perched along the bluffline above the lake. MNFI sampling included a transect through the barrier-beach lagoon on Stockton Island (see Appendix I for site description).

8. Washburn to Marble Point, WI: flat, clay lakeplain. South of Washburn (near Bono Creek), the shoreline levels out. Low bluffs of lake-modified clayey till line the west shore of Chequamegon Bay, while the eastern shoreline is flat. Very low, flat topography continues around Chequamegon Point to Marble Point.

Wetlands: Two major deltaic systems occur on this flat lakeplain. The first is formed by the confluence of North Fish Creek, South Fish Creek, and Whittlesby Creek at the head of Chequamegon Bay. The second, larger delta is formed by the White and Bad rivers, along with several smaller creeks, as these feed into the area known as the Kakagon Sloughs and Honest John Lake. In both cases, the larger streams appear to have cut their channels during an earlier low-water stage of Lake Superior. Post-glacial uplift and/or rise in lake level has subsequently lowered the gradient, reduced stream velocity, and caused the streams to meander widely, filling their valley floors with sandy deposits. Deltas have formed where these flows enter the lake, trapping deep accumulations of organics.

At Kakagon Slough/Honest John Lake, nearshore currents have transported sands northwest along the coast, creating a stretch of barrier beaches and sand spits along the shore, ending in the long spit of Chequamegon Point. The barriers and spits enclose a series of lagoons (including Honest John Lake), further impede water flow, and protect deep organic soils from erosion by the lake. The result is a large wetland complex containing a variety of wetland habitats, including estuarine river channels, deltaic oxbows and meanders, and barrier-beach lagoons.

Herdendorf et al. (1981f:587) identify two main wetland complexes along this stretch: Chequamegon comprising Kakagon Slough/Honest John Lake (LS-221, 9510 acres), and Fish Creek at the head of Chequamegon Bay (LS-227, 780 acres). MNFI sampling placed transects in Kakagon Slough, Bad River Slough, and Honest John Lake, as well as across a sand-spit swale enclosed by Chequamegon Point (see Appendix I for site descriptions).

Elsewhere along this flat shoreline, small streams flow to the lake through straight, dissected channels; most are intermittent. Some have very small wetlands (< 15 acres in size) at their mouths formed behind barrier beaches or sand spits (LS-222 - LS-226).

9. Marble Point, WI to Union Bay, MI: bedrock or till bluffs. East of Marble Point, Wisconsin the shoreline rises steeply. Sheer bedrock cliffs rim the shoreline near the Wisconsin/Michigan border. Further east, the shoreline consists of a narrow beach or terrace of bedrock slabs and cobble, backed by sheer bluffs up to 20 m high (Humphrys 1958). The bluffs are generally of sandstone/shale with a cap of reworked lacustrine clay, although short stretches of till bluff are found near Little Girls Point and the Black River. Low relic sand bars occur on the uplands. Streams have low bluffs, straight valleys, and are intermittent, with no wetland development at their mouths.

Wetlands: There is no wetland development along this stretch of Lake Superior shoreline. The single wetland identified by Herdendorf et al. (1981f:496) for this stretch is at Graveyard Creek (LS-220), a wooded stream-side site situated on the high bluff well above the water's edge and not influenced by Lake Superior.

10. Union Bay to Misery Bay/Rockhouse Point: narrow sand beach on clay lakeplain. The shoreline here is very smooth and regular, consisting of a narrow (6-15 m wide) beach of sand and gravel, backed by low (1-6 m), steep bluffs (Humphrys 1958). Sandstone bedrock is exposed in a few places, and sandstone slabs may be found. Inland, relic beach-ridge-and-swale complexes are encountered, consisting of three or four parallel sand bars (10-35 m wide and 5-15 m high). The intervening swales are occupied by poor fen/bog herbaceous communities or swamp forest.

Between Union Bay and Ontonagon, numerous small, often intermittent streams cut straight, shallow channels to the lake. The littoral currents are sufficiently strong to keep barrier bars erected across the mouths of these entering streams except during flood stage (Humphrys 1958). For most of the year, the water dams up in the stream mouth until it overflows the bar and/or cuts a temporary channel for itself. These barriers always form from the west side and close to the east, reflecting the flow of dominant longshore currents.

Between Ontonagan and Rockhouse Point, the sand beach widens. Dune formation is evident at the mouths of the larger rivers, where littoral currents are confounded by river flows, causing both flows to drop part of their sediment load. These dune features are subject to wind erosion.

Wetlands: Partially open coastal wetlands are found at the mouths of the Flintsteel River (LS-217 and LS-218), the Firesteel River (LS-214), and East Sleeping River (Herdendorf et al. 1981f:496). An extensive dune and swale complex (500 acres in size) stretches along the shore northeast of Ontonagon to the mouths of the Flintsteel and Firesteel rivers, and 400-500 m inland (Comer and Albert 1993:81-83). Shore dunes here are low (0.5-2.0 m), and wet swales were encountered up to 200 m inland from the shore. The acidic, saturated soils (pH 4.23-4.67) support bog-like vegetation.

11. Rockhouse Point to Portage Lake Ship Canal West: sandstone cliffs. Low, wave-cut cliffs of Freda sandstone (2-15 m high) rim this section of shoreline. A bedrock shelf extends out into Lake Superior less than a meter below the lake surface; a veneer of sand may accumulate on this shelf. A few small streams cut narrow gorges through the sandstone to enter Lake Superior, but have no associated wetlands. The Great Lakes Basin Commission (1975) has classified this stretch of shoreline as non-erodible high bluff.

Wetlands: Herdendorf et al. (1981f:496) report a single small, herbaceous wetland (LS-212) inland along the Salmon Trout River at Redridge. This wetland is not under the influence of Great Lakes water levels.

12. Portage Lake Ship Canal: ground moraine and deltaic deposits. The Portage Lake Ship Canal cuts across the Keweenaw Peninsula through an area characterized by broad ridges of sandy till or ground moraine (the Gay Sub-subsection, IX.7.1, Albert 1995). The main areas of wetland development are found along the Portage River and within Portage Lake, whose water levels are directly connected to and controlled by the Lake Superior.

Wetlands: Wetland habitats are estuarine, and include old meander loops of the Portage River, and a large delta at the south end of Portage Lake formed by the inflowing Sturgeon and Snake rivers. Extensive wetlands are also found where the Portage River connects to Torch Lake; water levels here are also under Great Lakes control, even though the wetlands are over 20 km inland. Herdendorf et al. (1981f:394) identified 15 wetlands (LS-156 - LS-170) inland along Portage River or belonging to the Portage Lake complex. The largest include the Sturgeon River-Snake River Delta wetland (LS-158, 8155 acres) and the Torch Lake wetland (LS-167, 1180 acres); both contain herbaceous wetland communities. MNFI Great Lakes marsh sampling included transects across an oxbow of the Portage River and on the delta of the Sturgeon River (Albert et al. 1987).

13. Portage Lake Ship Canal West to Gratiot River: sand and gravel beach over sandstone. This short stretch features a combination of sand and gravel beach, including low dunes, with very localized exposures of sandstone bedrock. The Great Lakes Basin Commission (1975) classifies this stretch as erodible low bluff in the west, and non-erodible low bluff in the east. Numerous small, often intermittent streams cut straight, shallow channels to the lake.

Wetlands: The sandy/gravelly substrates generally preclude wetland development along the lake, even in the mouths of entering streams. Herdendorf et al. (1981f:496) identify 12 wetlands along this stretch (LS-200-LS-211); all are wooded and/or situated well above Lake Superior's influence.

14. Gratiot River to Bete Grise, including Manitou Island: basalt bedrock shoreline. Volcanic bedrock (basalt) predominates, with intervening stretches of coarse gravel and cobble beach. The bedrock occurs as steep ridges (45° slope) of basalt and conglomerate (Albert et al. 1997). The Great Lakes Shoreline Commission (1975) classifies most of this stretch as non-erodible high bluff.

Wetlands: There are no herbaceous wetlands of ecological significance in this stretch. Although Herdendorf et al. (1981f:394, 496) identify 18 wetlands along this stretch (LS-182 - LS-199), only The Marshes (LS-192), a 640-acre wetland west of Eagle Harbor, is classified as a non-wooded wetland site adjacent to the lake. The Marshes are situated on a localized area of sand lakeplain; the site appears to be an old embayment now separated from the lake by a gravel bar. However, Highway 26 now runs along the bar, and the hydrology of the wetland has been altered by this road construction. Elsewhere along this stretch, narrow shrub or treed swamps occupy swales between gravel bars in the cobble beaches. Big Bay (LS-282) is the largest example (325 acres) adjacent to the lake; this site consists of a steep gravel bar backed by swamp. Other swamps are perched above the bluff-line, and not influenced by Lake Superior.

15. Bete Grise to Little Traverse Bay: sand lakeplain. Most of this stretch of sand lakeplain extending along the eastern shore of the Keweenaw Peninsula is classified as low sand dune (Great Lakes Basin Commission 1975) and is characterized by major dune and swale complexes (Comer and Albert 1993). Broad embayments up to 5 km in length contain dune ridges and swales extending inland for more than 2 km. The dunes are low (0.5-2 m in height); lakeside swales are typically wooded, but may contain herbaceous communities (either poor fen/bog or marsh).

Wetlands: In the inventory by Herdendorf et al. (1981f), eight wetlands are identified for this stretch (LS-174 - LS-181). All are dune and swale features described in greater detail by Comer and Albert (1993:77-81), including the large dune and swale complexes at Oliver Bay/Point Isabell (950 acres), Grand Traverse Bay (3500 acres), and Little Traverse Bay/Mud Lake Creek (575 acres); of these, only the Little Traverse Bay complex contains Great Lakes marsh. Lac la Belle is a barred lacustrine estuary, whose open waters are separated from Lake Superior by a series of wooded dunes and swales, the lower portions of which contain poor fen or bog. Finally, other shoreline features without wetlands include very localized exposures of sandstone and cobble beach.

16. Little Traverse Bay to Huron River Point (Marquette County): sandstone cliff and till bluff. South of Little Traverse Bay, the Lake Superior shoreline features a mix of steep till bluffs and sandstone cliff of the Jacobsville formation (5-20 m high); major sandstone exposures are found north of Jacobsville, Pt. Abbaye, and Huron River. Cliff faces are often unstable, producing low talus slopes at the cliff base (Albert et al. 1997).

Wetlands: Coastal wetlands in this stretch are associated with areas of sand accumulation. Significant wetland sites include the sand-spit embayments just north of Assinins (LS-154), along Sand Point (LS-153), and at Lightfoot Bay (LS-148), as well as the tombolo site of Pequaming (LS-151). An area of sand lakeplain is found near L'Anse at the head of Keweenaw Bay (LS-152); several creeks cross the lakeplain and their meandering channels create an extensive wetland with numerous oxbows and abandoned channels. This wetland appears to have been degraded by U.S. Highway 41 which runs right along the shore. MNFI sampling of Great Lakes marshes included the tombolo site at Pequaming (Albert et al. 1987).

17. Huron River Point to Marquette: sandstone cliff and granitic points. This very irregular stretch of Lake Superior coastline is formed by bedrock cliffs of sandstone with isolated headlands of granitic and basaltic bedrock. Sand carried by nearshore transport has created a series of dune and swale complexes along the coast; most of these complexes are high and dry. In some of the deeper embayments, however, barrier beaches have created small lakes or lagoons, including Pine Lake, Conway Lake, Lake Independence, and Saux Head Lake.

Wetlands: The USFWS inventory (Herdendorf et al. 1981f:250-251) identifies 16 wetlands along this stretch (LS-130 - LS-145); most are perched above the lake along the cliffline. Large coastal wetlands are found adjacent to embayments at Salmon Trout River (LS-141, 1480 acres), Big Bay/Squaw Beach (LS-139, 245 acres), and Middle Bay (LS-130, 225 acres). The Pine River (LS-144, 35 acres) and Iron River (LS-137, 95 acres) wetlands occupy small buried river mouths protected by sand spits. MNFI sampling included Lake Independence, a barrier-beach lagoon site inland from Big Bay/Squaw Beach (Albert et al. 1989).

18. Marquette to Marquette/Alger County line: sand lakeplain. Marquette Bay is formed within a small area of sand lakeplain. Large dune and swale complexes are characteristic of this stretch, but lakeside swales are generally dry. Wet swales are encountered fairly far inland (0.5 km).

Wetlands: Herdendorf et al. (1981f:250) identify only two wetlands along this stretch (LS-128 and LS-129). LS-128 is a dune and swale complex situated above the lake; the Marquette State Prison Area wetland (LS-129) is a small (17-acre) buried-river mouth site at the mouth of the Carp River, which contains herbaceous wetland vegetation.

19. Marquette/Alger County line to Grand Portal, including Grand Island: sandstone cliff. Major exposures of sandstone cliff are found along the mainland and off-shore islands. The cliffs are fairly low (1-10 m) west of Munising, and fairly high (20-60 m) east of Munising. Localized areas of coastal wetlands occur in association with sand-accumulation features.

Wetlands: The USFWS wetland inventory (Herdendorf et al. 1981f:250) identify 21 wetlands along this stretch (LS-107 - LS-127), but only three are directly associated with and influenced by Lake Superior's waters. These include the barred lacustrine estuaries at the mouths of the Laughing Whitefish River (LS-124, 65 acres) and the Au Train River (LS-119, 205 acres), as well as the barrier-beach lagoon at Powell Point (LS-115, 535 acres), all of which contain herbaceous wetland vegetation. MNFI sampling included the barred lacustrine estuary site at Au Train (Albert et al. 1987), and the tombolo on Grand Island (Albert et al. 1989), a site not inventoried by Herdendorf et al. (1981f).

20. Grand Portal to Sable Creek (Alger County): sand bluff. Steep, almost vertical sand bluffs rise 30-65 m above the lake; large dunes (over 35 m high) are found just east of Au Sable Point at Grand Sable Dunes. Very localized exposures of sandstone cliff occur at Au Sable Point.

Wetlands: No coastal wetland development occurs along this stretch. The Great Lakes wetland survey by Herdendorf et al. (1981f:250) identifies 6 wetlands along this stretch (LS-101 - LS-106). However, all are located along the bluffline above Lake Superior.

21. Sable Creek to Vermillion: dry sand lakeplain. The shoreline is largely characterized by sand beach, rising to extensive areas of dry dune and swale complexes. A 12-mile stretch of parabolic dunes occurs near the Two Hearted River. Wetlands are associated with sand spits and barrier bars. At Grand Marais, a sand spit protects West Bay, while another has completely enclosed East Bay, creating a barrier-beach lagoon at the mouth of the Sucker River. Inland lagoons along this stretch include Randolph Lake, Blind Sucker Flooding, Cranberry Lake, Muskallonge Lake, Mud Lake, Browns Lake, and Twomile Lake; all are the product of an earlier high-lake level era and are situated well above the current level of Lake Superior.

Wetlands: The USFWS wetland inventory (Herdendorf et al. 1981f:250, 183) maps 9 wetlands along this stretch (LS-092 - LS-100). Of these, the Grand Marais/Sucker River site (LS-099, 266 acres) is directly associated with Lake Superior and contains herbaceous wetland vegetation.

22. Vermillion to Whitefish Point to St. Marys River: poorly drained sand lakeplain. Wet dune and swale complexes predominate along this long stretch of sand lakeplain; the ridges support upland conifers, while poor fen/bog is found in the swales. These poorly drained areas are separated by small areas of dry sand beach or dry dune and swale complexes. Broad areas of sand spit form Whitefish Point and have enclosed small lagoons.

Wetlands: The USFWS wetland inventory identified 15 wetlands (LS-077 - LS-091) along this stretch (Herdendorf et al. 1981f:183). The largest are extensive wooded dune and swale complexes at Weathershog Creek (LS-091, 750 acres), Whitefish Bay (LS-085, 1442 acres), the Tahquamenon River outlet (LS-085, 2545 acres), and both West Tahquamenon Bay (LS-084, 1110 acres), and South Tahquamenon Bay (LS-083, 1200 acres). The remaining wetlands are smaller dune and swale sites, ranging from 8 to 230 acres in size. Few of these sites contain herbaceous wetland vegetation.

II. ST. MARYS RIVER

The St. Marys River, the single outlet channel from Lake Superior, flows 112 km to connect to Lake Huron. Although the river bed and the rapids have been modified to accommodate commercial navigation and for hydroelectric generation, the St. Marys River retains more of its biological integrity than does any other Great Lakes connecting channel (Duffy et al. 1987; Edwards et al. 1989; Shimizu and Finch 1988).

Hydrologically, the river can be divided into three stretches (Duffy et al. 1987):

(1) the **upper stretch** (22.5 km long) from Lake Superior to the St. Marys Rapids decreases in width rapidly and is characterized by sandy or rock shores, with emergent wetlands only in protected areas.

(2) the **rapids** is a 1.2 km long stretch over which the river drops 6.1 m; substrates are boulders and exposed bedrock.

(3) the **lower stretch** extending from the foot of the rapids to De Tour Passage at Lake Huron has a very irregular shoreline and contains four large islands (Sugar, Neebish, St. Joseph, and Drummond), as well as more than 100 smaller islands. The western (American) shore of the river consists largely of flat clay lakeplain, and is bordered by

extensive areas of emergent wetland; Jaworski and Raphael (1978) report 4,848 ha of coastal wetlands in Chippewa County.

Water entering St. Marys River from Lake Superior is exceptionally clear; however, the lower stretch of the river can be turbid due to clay substrate. Turbidity is least pronounced along the main channel, and is higher in off-channel water in wider reaches of the river (Liston et al. 1986); western Munuscong Lake and the SW shore of Neebish Island are especially turbid. This turbidity limits submersed aquatic plant establishment and growth. The entire River has been declared an AOC because of elevated concentrations of contaminants in the water and localized contaminants in the sediments; these impacts are especially heavy along the Canadian shore, downstream of Sault Ste. Marie, Ontario to Little Lake St. George (SOLEC 1997).

The St. Marys is subject to the same three scales of water level fluctuations experienced by the Great Lakes, including short-term, seasonal, and long-term. Seasonal fluctuations average about 0.3 m over the year; long-term fluctuations have a range of 1.2 m in the upper stretch and 1.5 m in the lower stretch. Short-term fluctuations results from wind tides, sudden changes in barometric pressure, and seiches. In addition, the wake from passing ships creates water level fluctuations up to 0.7 m; amplitude and impact of ship wake varies depending on site location and protectedness.

23. St. Marys River (Lake Superior to the Rapids): exposed shoreline. Sandy or rock shores, and strong current characterize this stretch. Emergent wetlands are found only in protected areas. ***Wetlands:*** Herdendorf et al. (1981f:150-151) identify only 6 wetlands in this stretch (LS-071 - LS-076); all are dominated by swamp forest. The largest is at Isaac Walton Bay (LS-071, 185 acres).

24. St. Marys River Rapids to Raber Point/Carlton Creek: clay lakeplain. Most of the lower stretch of St. Marys River (including Sugar Island and Neebish Island) consists of gently sloping, poorly drained clay substrates which support extensive wetlands. Stands of emergent vegetation are particularly well-developed where wind and waves are not a prominent feature of the shore-zone environment, and may extend uninterrupted for 3-5 km along the shoreline in protected sites.

Wetlands: Overall, Herdendorf et al. (1981f:4-5, 150-151) identify 28 wetlands (LS-043 - LS-070) all directly associated with the St. Marys. The shores of Sugar Island support almost continuous wetlands, including the large (815 acre) Baie de Wasai marsh. Embayments on Neebish Island and within Munuscong Lake range up to 1300-1600 acres in area. MNFI field workers sampled extensively along the lower St. Marys, with transects at Baie de Wasai, Hog Island, Whipple Point, Hursley, Shingle Bay, Sugar Island, Churchville Point, Sand Island, Gogomain River, Kemps Point, Munuscong River, and Roach Point (Albert et al. 1987).

Emergent zone vegetation along the lower St. Marys is very consistently dominated by *Scirpus acutus*, *Sparganium eurycarpum*, and *Eleocharis smallii*, which form relatively long-lived clones (Liston et al. 1986). Submersed zones are dominated by the charaphytes *Chara globularis* and *Nitella flexilis*, along with the quillwort *Isoetes riparia*. These three species tend to carpet bottom sediments forming extensive meadows, punctuated by widely scattered clusters of pondweed (generally *Potamogeton richardsonii*).

III. LAKES MICHIGAN/HURON

Lake Michigan and Lake Huron are connected through the Straits of Mackinac, and are regarded as one lake hydrologically. In addition, they share similar glacial history and climatic regime.

Lake Michigan: The basin occupied by Lake Michigan features a diversity of glacial landforms and associated soil types that determine coastal wetland distribution. The northern shore contains long stretches of sand lakeplain broken by areas of limestone bedrock exposures, while till bluff predominates along much of the western shore. The eastern shore of Lake Michigan features a long expanse of high sand dunes, one of the most impressive natural shore types of the entire Great Lakes; significant wetlands along this shore are large estuarine features extending inland along drowned river channels.

Given the lake's long north-south axis, climate plays a major role in determining the community composition of the various wetland habitats (Dodge and Kavetsky 1995). The north-south gradient is pronounced enough that northern Lake Michigan is often grouped with Lake Superior, while the southern, more temperate end of the lake has more similarities with Lakes Erie and Ontario.

The north-south gradient also determines impairment and habitat loss. The south, with its concentration of agriculture and urban areas, has generally higher levels of nutrients and toxic chemicals than the north, along with greater loss of shoreline habitat (Dodge and Kavetsky 1995). In the north, Green Bay has been most seriously affected, with high nutrient and PCB levels. Overall, surface waters of Lake Michigan have higher burdens of heavy metals than any of the other Great Lakes.

The Lake Michigan basin has 10 Areas of Concern (AOC), more than any other lake (Thorp et al. 1996). AOCs within Lake Michigan include Manistique River, Menominee River, Fox River/Southern Green Bay, Sheboygan River, Milwaukee Estuary, Waukegan Harbor, Grand Calumet River, Kalamazoo River, Muskegon Lake, and White Lake.

Lake Huron: The second largest of the Great Lakes (after Superior), Lake Huron also features a mix of bedrock and glaciated landforms. Rocky shores associated with the Precambrian shield cover the northern and eastern (Canadian) shores, while limestone underlies the Drummond Island - Manitoulin Island group; glacial deposits of till, gravel, and sand predominate further south. Wetland habitats are correspondingly diverse, and include sheltered bays and river mouths, as well as sand transport features.

The climatic gradient observed in Lake Michigan holds for Lake Huron as well. Northern Lake Huron shares a boreal floristic component with Lake Superior, while south of Saginaw Bay, the climate becomes more temperate and similar to that of Lakes Erie and Ontario.

Virtually all of Lake Huron's shoreline is classed as oligotrophic (having little or no nutrients). Lake Huron is the least developed of the Great Lakes, next to Lake Superior; however, pollution can be severe in waters adjacent to urban areas. Along the U.S. shoreline of the lake, Saginaw Bay has been identified as an AOC; two other sites are similarly identified along the Canadian shoreline (SOLEC 1997).

25. Drummond Island: limestone/dolomite bedrock shoreline. Horizontally bedded limestone or dolomite is exposed along or near the shoreline of Drummond Island as pavement lakeshore or low cliff, interspersed with stretches of locally derived cobbles (Albert et al. 1997:9). Soils are stony and calcareous. In general, the broad expanse of shoreline bedrock supports little or no plants, the result of both severe wave action and ice abrasion. Very poorly developed marshes are found in some of the more protected embayments along the south shore; a few larger marshes are found along the north-western shore.

Wetlands: Herdendorf et al. (1981e:4-5) identify 49 wetlands along the Drummond Island shoreline (LS-001 - LS-037 and LH-186 - LH-197). Most are quite small (< 10 acres); however, there are large marshes in Grand Marais Lake, a protected embayment along the north shore of the island (LS-023, 170 acres), and at Paw Point/Scott Bay (LS-032, 450 acres). MNFI sampling included transects at Paw Point/Scott Bay (Albert et al. 1987), and Big Shoal Cove (Albert et al. 1989).

26. Potagannissing Bay and DeTour Passage to St. Vital Point: marly shoreline. South of Raber Point on the lower St. Marys River, a thin cap of marly sand or clay covers the limestone bedrock. Portions of the shoreline have limestone cobble beach. Wetlands form a narrow fringe along the shoreline, with some marly swales further inland.

Wetlands: The USFWS wetland inventory identifies 9 small wetlands (LS-041, LS-042, LH-179 - LH-185) in this stretch; all are adjacent to the lake (Herdendorf 1981f:4; Herdendorf 1981d:681). Only Sweets Point (LS-041, 8 acres) and St. Vital Bay (LH-179 - LH-182, 28 acres) contain herbaceous vegetation zones. Comer and Albert (1991, 1993) report on the wooded dune and swale complex in St. Vital Bay.

27. St. Vital Point to Albany Island: sand lakeplain. Long stretches of curving shoreline with sand deposition characterize this segment. Sandy beaches and low dune features are common; wetlands are restricted to wooded dune and swale complexes that range from very poorly drained to dry. ***Wetlands:*** No coastal wetlands were inventoried in this stretch by the USFWS (Herdendorf et al. 1981d).

28. Albany Island to Search Bay, including Les Cheneaux Islands: drumlinized ground moraine. Glacial deposition and subsequent modification of till created the complex shoreline of the Les Cheneaux Islands, which are drumlinized ground moraine features. Embayments here typically display a long and narrow shape, with a NW-SE orientation paralleling the drumlin fields of northern Lower Michigan (Farrand and Bell 1982b).

Wetlands: Within the protection of these deep embayments, organic soils have developed that support broad, extensive marshes with both submergent and emergent zones. In contrast, the outer shoreline consists of either sand or gravel/cobble beach; a few of the more protected outer embayments have small wetlands on exposed marly clay. These marshes have only poorly developed emergent zones and no submergent vegetation; the marly flats, however, support herbaceous wetlands with characteristic calciphiles.

Herdendorf et al. (1981d:585) identify 35 coastal wetlands in this stretch; most are adjacent to the lake. Wetlands situated within the deep, protected embayments which contain wide emergent marsh and wet meadow zones are represented by Steele Creek (LH-146, 375 acres), Prentiss Bay (LH-174, 90 acres), and Mackinac Bay (LH-149/LH-150, 60+ acres) on the mainland, as well as Duck Bay on Marquette Island (LH-152, 60 acres). In contrast, the wetlands at Voight Bay (LH-157, 90 acres) and Peck Bay (LH-153, 17 acres) on Marquette

Island represent the outer, more exposed embayments characterized by marly soils. The remaining sites are small (generally <50 acres), but many contain herbaceous wetland vegetation. MNFI sampling included transects at Mismer Bay (LH-147) and Mackinac Bay (LH-149) on the mainland (Albert et al. 1987), and at Voight Bay, Duck Bay, and Peck Bay on Marquette Island (Albert et al. 1989).

29. Search Bay (Mackinac County) to Poupard Bay: open sandy shoreline on limestone or marly clays. This section consists of a low lacustrine plain formed by the south-facing slope of the Niagara Cuesta and includes several islands (Big St. Martin, St. Martin, Mackinac, and Round islands). Limestone bedrock is at or near the surface here, and only thin sand deposits overlie the bedrock or clay.

Wetlands: Sand accumulation along the shoreline has created large areas of low dunes and swales; northern white cedar dominates the ridges while calciphiles are common in the swales. Emergent marsh is rare except along the NE shoreline of St. Martins Bay and Point La Barbe. Calcareous coastal wetlands are associated with several of the points where marly clays are exposed, including Grosse Point, Rabbit Back Point, St. Martin Island, Big St. Martin Island, and St. Martin Point. Inland, large wetlands are common in low areas of the plain.

The USFWS coastal wetland inventory identifies 17 wetland sites along this stretch, including 3 sites on Bois Blanc Island (LH-128 - LH-130; Herdendorf 1981e:512), 6 sites along the Lake Huron mainland shore (LH-138 - LH-143; Herdendorf 1981e:585), and 8 sites on the Lake Michigan mainland shore and nearshore islands (LM-410 - LM-417; Herdendorf et al. 1981d:1369). The largest sites are the extensive wooded dune and swale complexes at St. Martin Bay (LH-140) and Horseshoe Bay (LH-138). Small herbaceous wetlands are reported for St. Martin Bay, St. Martin Point, Big St. Martin Island, and St. Martin Island.

MNFI marsh sampling included a transect at St. Martin Bay (Albert et al. 1989), and field visits to the Charles wetland, Big St. Martin Island, St. Martin Island. The wooded dune and swale survey included Horseshoe Bay (Comer and Albert 1991, 1993).

30. Poupard Bay/Gros Cap to Thompson (Schoolcraft County): sand lakeplain. Beginning just north of Gros Cap, this stretch features open, exposed sandy shoreline broken by areas of sand beach and low coastal dunes. Limestone bedrock or cobble are locally exposed or near the surface at many of the points (including Pt. Epoufette, Scott Point, Hughes Point, Seul Choix Point, Manistique Point, Stony Point, and Pt. aux Barques).

Wetlands: Small coastal wetlands on marly substrates are often associated with the bedrock points, while dune and swale complexes are characteristic of the reaches of sandy shoreline. The USFWS wetland inventory maps 63 wetlands along this stretch (LM-347 - LM-409; Herdendorf 1981e:1272, 1369). Most consist of swamp forest associated either with large beach ridge and swale complexes (as at Paquin Creek and Mattix Creek), or with isolated small swales separated from Lake Michigan by low dunes or broad sandy beach. At Pointe aux Chenes, however, the coastal beach ridges contain swales with open water and extensive areas of marsh vegetation (LM-409, 2949 acres). A few barrier beach lagoons also occur along this stretch; Indian Lake (LM-347) is a former embayment now closed off by a sand and gravel barrier which support marsh vegetation. Marly wetlands are represented between Epoufette Bay, Point Epoufette, Kenyon Bay, and West Harbor (LM-400/404; 91 acres), where a nearly continuous wetland complex parallels the shoreline for 2 to 3 miles. These sites consist largely of emergent vegetation in shallow water, underlain by dolomite.

The MNFI marsh survey sampled the marly coastal marshes at Epoufette Bay and Kenyon Bay (Albert et al. 1989). MNFI's wooded dune and swale survey examined complexes at Pointe aux Chenes, Epoufette Bay, Big Knob, Crow River mouth, Scott Point, Seiners Point, Gulliver Lake Dunes, and Thompson (Comer and Albert 1991, 1993).

31. Thompson to Valentine Creek (Garden Peninsula): limestone bedrock shoreline. Bedrock of the Garden Peninsula tilts downward 8-12 m/km (40-60 feet/mile) toward the east. As a result of this tilt, the eastern shore of the peninsula consists of bedrock pavement sloping gradually into Lake Michigan, while low bedrock cliffs are exposed along the western edge of the peninsula and at Point Detour in the southeast (Albert et al. 1997:32). A talus of limestone boulders and cobbles at the base of these cliffs precludes wetland development along much of the southern and western portions of the Garden Peninsula. Along the gently sloping eastern side of the Garden Peninsula, however, herbaceous wetland sites are found in very shallow, marly lagoons or bedrock flats behind low beach ridges of limestone gravel. At Portage Bay, several small lagoons occur within an isolated sandy dune and swale complex.

Wetlands: Herdendorf et al. (1981e:1108-1109) identify 15 wetlands on this stretch of the Garden Peninsula (LM-332 - LM-346). The largest coastal wetlands include the wooded dune and swale complex at Portage Bay (LM-339/LM-340, 903 acres) and the marly ponds at Sucker Lake (LM-337, 292 acres). The Portage Bay site was sampled in MNFI's wooded dune and swale survey (Comer and Albert 1991, 1993).

32. Valentine Creek to Ogontz River: sand lakeplain, including areas of loamy ground moraine. This flat stretch of shoreline is characterized by extensive areas of low, poorly drained dune and swale complexes. Both the dunes and swales are forested with swamp conifers (including cedar, black spruce, and tamarack).

Wetlands: Coastal marshes are restricted to the deltaic deposits of both the Little Fishdam River and the Sturgeon River located within a larger wooded dune and swale complexes. In the wetland inventory conducted by Herdendorf et al. (1981e:1108), four large wetlands are identified for this stretch (LM-328 - LM-331). These include the extensive wooded dune and swale complexes at Ogontz Bay (LM-328, 1740 acres), Upper Big Bay de Noc (LM-330, 9331 acres), and on the delta of the Sturgeon River (LM-329, 6697). MNFI sampled herbaceous wetlands within the Sturgeon River delta (Indian Point wetland), and a narrow emergent marsh along the Little Fishdam River as in enters Big Bay de Noc (Albert et al. 1987).

33. Ogontz River to Squaw Point (west side of Stonington Peninsula): limestone bedrock with sand accumulation. This stretch is similar to the Garden Peninsula in that the underlying bedrock slopes gently downward toward the east. As a result of this tilt, the eastern shore of the peninsula slopes gradually down into Lake Michigan, while low bedrock cliffs are exposed along the western edge of the peninsula. However, bedrock is found at or near the surface along the eastern side only north of St. Vital Point and on St. Vital Island. South of St. Vital Point (between Martin Bay and Peninsula Point), greater sand accumulation obscures the underlying limestone pavement and creates a variety of sand features, including beach ridge and swale complexes, sand beaches, and sand spits.

Wetlands: Coastal wetlands associated with the limestone include narrow marly marsh, while dune and swale features are found within the area of sand accumulation. Sites along the western side of the peninsula in this stretch are situated above the lake inland of low limestone cliffs.

Herdendorf et al. (1981e:1108) map 17 wetlands along this stretch (LM-311 - LM-327). Narrow marly marsh is found in sites LM-325/327, while wooded dune and swale features are found in sites LM-315 - LM-322. The largest of these is the Granskog Creek/Chippewa Point wetland (LM-318/319; 729 acres), which also contains emergent marsh behind a sand spit. The MNFI marsh survey sampled the emergent marsh at Chippewa Point (Albert et al. 1987).

34. Squaw Point to Ford River: well-drained outwash and sand lakeplain. Beginning just south of Squaw Point, limestone bedrock topography is replaced by outwash. This stretch is flat, sandy, and generally well drained, with some typical sand accumulation features. Small areas of dune and swale features are found along the eastern shore of Little Bay de Noc and near the Ford River south of Escanaba, but these are typically wooded. At Portage Creek, abundant sandy sediments in an area of greater protection from wave action has led to the formation of a barrier-beach lagoon which supports fairly extensive wetlands. Elsewhere, well developed herbaceous wetlands are restricted to river deltas, although a fringe of open emergent marsh occurs along much of the shoreline.

Wetlands: The USFWS wetland inventory identifies 12 coastal wetlands along this stretch (LM-299 - LM-310; Herdendorf et al. 1981e:1108). Herbaceous wetland sites include the deltas of the Rapid River (LM-307, 496 acres), the Days River (LM-305, 58 acres), the Whitefish River (LM-308/310, 97 acres), and the Ford River (LM-297, 97 acres). The largest herbaceous wetland site is the lagoon and emergent marsh protected by a barrier beach at Portage Marsh (LM-299, 1302 acres), while a small emergent marsh is found between sand bars at Escanaba City (LM-300, 49 acres). The remaining wetland sites are generally swamp forest, including the wooded dune and swale complex inland along the Ford River (LM-298, 292 acres). The MNFI coastal marsh survey sampled the delta of the Rapid River (Albert et al. 1987).

35. Ford River to Menominee River (MI/WI state line): poorly drained sand lakeplain. South of the Ford River is a stretch of relatively straight, flat shoreline of fine sands and some loamy ground moraine. This stretch is largely poorly drained along the shoreline with swamp forest down to the water's edge; much of the interior is also poorly drained and covered by large inland wetlands.

Wetlands: Owing to its exposure to Lake Michigan, herbaceous coastal wetlands along this stretch are small and largely restricted to the mouths of creeks and rivers (e.g. the Cedar River and Deer Creek). The coastal wetland inventory by Herdendorf et al. (1981e:1044) identifies 10 wetlands along this stretch of coastline (LM-287 - LM-296). The mouths of the Cedar River (LM-290) and Deer Creek (LM-291) contain small herbaceous wetlands, although these sites are largely swamp forest. Other wetlands include several small sites raised above the lake level.

36. Menominee River to eastern Green Bay: wet, nearly level lakeplain. Poorly drained organic (Menominee-Pensaukee) and mineral (Pensaukee-Green Bay) soils on flat lakeplain characterize this stretch; the shoreline itself is typified at "flat, low, sandy, and poorly drained" (Herdendorf et al. 1981e). Owing to the low gradient, fluctuations in Lake Michigan's water level considerably alter the size of coastal wetlands (Harris et al. 1977), with substantial portions of sandy beach exposed during low water. The waters of Lower Green Bay are heavily polluted due to numerous industrial discharges to the Fox River; nearshore waters are hard and generally turbid. Seiche activity within the bay can cause nutrient- and silt-laden waters to inundate coastal wetlands.

Wetlands: Extensive marshes are found on deltas formed by the Peshtigo and Oconto rivers, which feature numerous oxbow lakes and abandoned channels. Previously extensive marshes at the mouths of Menominee River, Duck Creek, and Fox River have been highly disturbed by urban development. Numerous small marshes occur where sand spits have created narrow, protected embayments (as at Seagull Bar, Little Tail Point, Long Tail Point, and Grassy Island), or behind sand bars at the mouths of smaller creeks (as at Little Suamico).

The USFWS wetland inventory identified 31 wetlands in this stretch (LM-256A - LM-286; Herdendorf et al. 1981e:904). The largest wetland sites are the deltas of the Peshtigo River (LM-284, 5040 acres) and the Oconto River (LM-283; 9370 acres), both of which contain herbaceous as well as swamp vegetation. Sand-spit embayment sites associated with Little Tail Point (LM-274/275), Long Tail Point (LM-270/273), and Grassy Island (LM-262/264, LM-269) contain smaller marshes, ranging from 1 to 200 acres in size. Several formerly significant marshes at the head of Green Bay (Atkinson Marsh and Whitney Slough) have been heavily modified by urban development and industrial pollution.

Detailed topographic cross-sections and vegetation data exist for Oconto Marsh (Herdendorf et al. 1981a). The MNFI marsh survey included transects at Peshtigo River, Oconto River, Little Tail Point, and Dead Horse Bay (see Appendix I for site descriptions).

37. Eastern side of Green Bay (western shore of Door Peninsula) to Washington Island: steep till bluff and limestone cliff. The western side of the Door Peninsula is formed by the elevated edge of the Niagaran Cuesta, and the landscape slopes gently downward to the east. As a result, the shoreline here is primarily steep bluffs of loamy till up to 60 m high with local exposures of limestone bedrock cliffs (at Peninsula State Park). Below the bluffs, low sand and gravel spits or bars at the mouths of tributary streams protect small wetlands from the lake, or create barrier-beach lagoons within embayments, as on the tip of Washington Island (Coffee Swamp, Big Marsh, Little Marsh).

Wetlands: Herdendorf et al. (1981e:682-683) identify 43 wetlands along this stretch (LM-214 - LM-256); of these, 14 are found on the islands (LM-214 - LM-225, LM-230/231). Most of these small sites are adjacent to the lake and/or influenced by Lake Michigan, although a few lie along the bluffline. Herbaceous coastal wetlands are found behind spits or bars within Tennison Bay (LM-233, 60 acres), Juddville Bay (LM-234, 80 acres), Sawyer Harbor (LM-244, 3 acres), Little Sturgeon Bay (LM-310/311, 315 acres), and several embayments of Washington Island. Coffee Swamp (LM-224, 165 acres) on Washington Island is a calcareous bog (pH 8.4), formed within a barrier-beach lagoon.

38. Northern tip of Door Peninsula to Algoma: sand over low bedrock plain. The complex coastline of this stretch lies on a low plain with thin, loamy soils over limestone/dolomite bedrock. In the north, exposed bedrock headlands alternate with deeply incised embayments. Barrier beaches of sand and gravel have formed across the embayments, enclosing lagoons or small lakes such as Mud Lake and Europe Lake. In the south, coastal dunes overlie the bedrock, and the shoreline becomes less convoluted. Extensive low dunes and barrier beaches across former embayments separate a series of wetland swales and lagoons from Lake Michigan (including Kangaroo Lake, Hibbard Creek, and Clark Lake). The barrier beach at Kangaroo Lake is formed by dunes 6.5 m high, while at Clark Lake the barrier beach rises to roughly 15 m high. All the lagoons along this stretch have marly bottoms with little submersed vegetation other than the charaphytes; emergent and shoreline macrophytes include calciphiles.

The Niagaran Escarpment underlying the Door Peninsula is broken in several places by lowlands occupying old glacial melt-water channels. These include the Mink River drainage, Baileys Harbor/Ephraim Swamp, and the Sturgeon Bay gap. The Mink River wetland cuts across the northern tip of the Door Peninsula for a distance of approximately 4 miles. The northern (Green Bay) extent of this channel contains discontinuous wetlands separated by upland forests. Further south, the wetland is partially drained by the Mink River, a spring-fed system whose waters are highly alkaline from the dissolving limestone (Keough 1987, 1990). The mouth of the Mink River as it flows into Rowley Bay is estuarine, and is subject to regular flow reversals caused by Lake Michigan wind tides.

Baileys Harbor/Ephraim Swamp is a wetland corridor that almost bisects the peninsula. This large wetland is separated from Green Bay by a high bluff line, and from Lake Michigan by a line of low coastal beach ridges. Much of the interior consists of parallel beach ridges and swales which support swamp conifers. The Sturgeon Bay gap represents the preglacial course of the Menominee River, deepened somewhat by glacial sculpture, and submerged beneath the waters of Lake Michigan.

Wetlands: The USFWS wetland inventory identifies 11 wetlands along this stretch. The largest sites are situated along the low wetland corridors: Mink River/Rowleys Bay (LM-207/208; 540 acres), Baileys Harbor/Ephraim Swamp (LM-202, 5050 acres), and Sturgeon Bay (LM-194/195, 700 acres); both the Mink River and Baileys Harbor sites contain small areas of herbaceous wetland although the sites are dominated by swamp forest. The barrier-beach lagoon sites (Mud Lake, Europe Lake [LM-212/213], Kangaroo Lake [LM-200/201], and Clark Lake [LM-197]) are similarly dominated by swamp forest, although both wet meadow and emergent marsh are reported from Mud Lake. MNFI marsh sampling included transects at Mud Lake and the Mink River estuary (see Appendix I for site descriptions). The Mink River estuary has been studied in detail (see Harris et al. 1977; Keough 1986, 1987, 1990).

39. Algoma to Sheboygan: clayey till plain. High bluffs of clayey reddish till (up to 40 m high) distinguish this stretch of Lake Michigan. Localized areas of narrow sand beach occur below the bluffs, and small streams have cut steep ravines to the lake. Coastal wetlands are largely associated with riverine contexts. The delta of the Twin Rivers has created an extensive area of wetland with numerous meanders; the lower channel of West Twin River is estuarine. Elsewhere, estuarine wetlands are found at the mouth of the Kewaunee River (where marsh extends 7 km inland), as well as at the Sheboygan and Pigeon rivers (1 km of marsh). Other major river mouths have been heavily modified by urbanization.

Wetlands: The USFWS wetland inventory maps 8 wetlands in this stretch (LM-185 - LM-192; Herdendorf et al. 1981e:593). The largest marsh site is the Kewaunee River estuary (LM-191, 360 acres). Other marsh sites are less than 15 acres in size. A large area of wet dunes and swales (LM-185; 1490 acres) extends almost 8 km north of Twin Rivers but the complex is above the level of Lake Michigan. The MNFI marsh survey included a transect at West Twin River (see Appendix I for site description).

40. Sheboygan to Port Washington: sand beach and dune. South of Sheboygan, a short stretch of broad sand beach with areas of low dune fronts the till bluff. Much of the shoreline is lined with cottages.

Wetlands: The USFWS wetland inventory identifies a single wetland along this stretch (LM-184; Herdendorf et al. 1981e:593). This wetland is situated on the broad upland till plain, 18 m above the level of Lake Michigan.

41. Port Washington to Kenosha: glacial till bluffs. Just north of Port Washington the shoreline rises, and steep bluffs of glacial till (up to 30 m in height) again line the shore. The high bluffs normally have narrow sand beaches and few wetlands. Streams flow directly to the lake through steep ravines, and have no marsh vegetation at their mouths. Near Milwaukee, this section crosses a major climatic boundary, with the north experiencing shorter a growing season and lower growing season temperatures than experienced to the south (Albert 1995).

Wetlands: Herdendorf et al. (1981e:593) identify 9 wetlands in this stretch (LM-175 - LM-183). All are situated along the bluffline well above the lake, except for a 1-acre marsh located in a ravine at the bluff base (LM-175).

42. Kenosha (WI) to North Chicago (IL): beach-ridge plain. In southern Wisconsin and northern Illinois, the Lake Michigan shoreline consists of a coastal lowland of curvilinear beach ridges with superimposed low-lying dunes and interdunal coastal wetlands (swales) (Chrzastowski et al. 1994). The plain is a sand body that has migrated southward by littoral transport processes through the late Holocene. Portions of this stretch are preserved in a natural or near-natural setting in the north and south units of Illinois Beach State Park; along its southern reach, the plain has been substantially modified by industrial and port development.

Wetlands: The USFWS coastal wetland inventory identified only two wetlands in this stretch (LM-173 and LM-174). Both belong to the Illinois Beach State Park and total 2906 acres (Herdendorf et al. 1981e:545).

43. North Chicago to Winnetka: morainic bluff coast. A bluff coast eroding into morainic topography extends southward from North Chicago for a distance of 25 km (Chrzastowski et al. 1994). Bluffs of gray-brown glacial till and glacial lacustrine sediments average about 22 m in height above mean lake level, but decrease in height to about 11 m near the southern end of this stretch. Cutting the bluffs between Waukegan and Winnetka are more than 30 V-shaped ravines eroded by intermittent streams draining the interior moraines. Residential landuse dominates the bluff; aerial photographs dating to 1990 document the presence of 232 groins along this stretch. ***Wetlands:*** The USFWS coastal wetland inventory identified no coastal wetlands along this stretch.

44. Winnetka (IL) to Gary (IN): lacustrine plain. This stretch consists of a lakeward-sloping glacial till plain on which coastal and offshore deposits from glacial and recent high-lake phases have been superimposed (Chrzastowski et al. 1994). Several major rivers (including the Chicago and Grand Calumet) and streams flow into Lake Michigan across this plain. In the natural setting, beach deposits typically formed bars across the mouths of these streams, which were breached only in times of peak stream flow. However, most of this stretch has been degraded by shoreline development, and natural drainage patterns have been significantly altered by channel modifications, canals, and flow diversions.

Wetlands: Herdendorf et al. (1981e:545) identify 36 wetlands along this stretch of Lake Michigan (LM-137 - LM-172), ranging from 3 to 135 acres in size. These small wetlands were probably once part of a single extensive wetland that has been divided and radically altered by industrial and urban development.

45. Gary (IN) to Nordhouse Dunes (north of Ludington, MI): steep dunes and sandy bluffs. Sand accretion along the southeastern shore of Lake Michigan begins building dune features east of Gary, Indiana (Chrzastowski et al. 1994; Homoya 1997:158). Beyond that heavily urbanized area, this scenic stretch of Lake Michigan is characterized by long curving reaches of sand beach (3-30 m wide) below stabilized dunes and erosion-cut sandy bluffs (10-35 m high). Inland, the high dunes form a series of sand hills (up to 80 m high) parallel to the shoreline and up to several kilometers in width. Localized areas of dune over till, with gravel accumulation along the beach, are also found (Humphrys et al. 1958a-1958f). Inland, the landscape consists of flat lakeplain and gently sloping moraine.

Wetlands: All of the major rivers along this stretch (including the Galien, St. Joseph, Paw Paw, Kalamazoo, Grand, Muskegon, Stony, Pentwater, and Big Sable) have lacustrine estuaries at their mouths. Most are partially to largely barred by longshore sand transport, and many have artificially maintained channels to Lake Michigan. These estuarine systems can extend for a considerable distance inland (up to 17 miles along the Pere Marquette), where the rivers occupy linear depressions through interior glacial moraines and sand lakeplain. Soils are typically muck, mucky peat, and/or peat over sand. Vegetation includes both swamp forest and herbaceous zones.

The USFWS wetland inventory identifies 54 wetlands in this stretch (LM-083 - LM-136). Most are inland wetlands connected to Lake Michigan via the buried river mouth estuaries. However, this inventory does not include wetlands associated with the Kalamazoo River and Grand River estuaries. Other wetland sites include small swales isolated from Lake Michigan, usually perched well above the lake level (e.g. LM-115, LM-120, LM-121, LM-126). MNFI marsh sampling included transects within the estuaries of the Galien, Paw Paw, Kalamazoo, Grand (Pottawatomi and S. Lloyd sites), Muskegon, White, Pentwater, Pere Marquette, and Big Sable rivers, as well as Stoney Creek (Albert et al. 1988, 1989).

This stretch crosses a major climatic boundary (Albert et al. 1986; Albert 1995). The southern portion, from Indiana to just north of the White River, falls within Southern Lower Michigan, and enjoys a more southern climate moderated by Lake Michigan. In contrast, the stretch north of the White River belongs to the Northern Lower Michigan climatic division, which experiences a shorter growing season (141 vs. 157 days), a lower growing season temperature (17.2 vs. 18.7), and lower growing season heat sum (2300 vs. 2560) (Albert et al. 1986:11).

46. Nordhouse Dunes to Frankfort: moraine and till bluffs. Steep bluffs of clayey till face the shoreline where the upland moraine has been cut by the lake (Humphrys et al. 1958g-1958i). Near the southern end, clay bluffs rise directly from the lake to a height of 65 m. Further north, a narrow gravel beach lines the shore below bluffs of sandy or gravelly till that range from quite low (2 m) to high (60 m); the upland is rolling morainic topography.

Wetlands: As in the preceding stretch, the major rivers have lacustrine estuaries at their mouths which provide the dominant coastal wetland sites. Examples include the Manistee and Betsie rivers, as well as Portage Lake and Arcadia Lake; Lower Herring Lake is a completely barred lagoon within an old embayment.

The USFWS wetland inventory maps 9 wetlands along this stretch (LM-074 - LM-082; Herdendorf 1981e:166, 257). The largest is associated with the estuarine meanders of the Manistee River (LM-080, 9156 acres) which extend more than 14 miles inland. Other estuarine sites include Little Manistee River (LM-081, 243 acres), Betsie River (LM-074, 380 acres), Bar Lake (LM-077, 973 acres), and Arcadia Lake (LM-075, 380 acres). All these sites contain substantial areas of herbaceous wetland, in addition to swamp forest.

Topographic cross-sections and vegetation data for the Betsie River wetlands are presented in Herdendorf et al. (1981a). MNFI marsh sampling included transects in the estuaries of the Betsie and Manistee rivers, and within Bar Lake (Albert et al. 1989).

47. Frankfort to east edge of Good Harbor Bay: sand lakeplain. North of Frankfort, sand features again predominate, including low dunes (1-3 m), high dunes (at Sleeping Bear), sand bluff, and low foredunes below high bluff (65 m) of sand and clay drift (Humphrys et al. 1958i, 1985j). The stretch includes four islands (North and South Manitou, and North and South Fox islands). The western edges of all the islands contain large areas of perched sand dune and the greater part of each island consists of either dunes or other lacustrine physiographic features.

Wetlands: Longshore sand transport is a primary factor determining wetland formation. Coastal wetlands include the partially barred estuary at Platte River, the barrier-beach lagoons at North Bar and South Bar lakes, the bay mouth bar and low dunes at Otter Creek, and the dune and swale complex at Glen Harbor. Herdendorf et al. (1981e:166) identify only 6 wetlands in this stretch (LM-037 - LM-042); all are on raised sites above the lake. However, there appears to be a gap in coverage between Betsie River and Port Oneida; significant coastal wetlands in this stretch are listed above.

48. East edge of Good Harbor Bay to Northport Point (Leelanau Peninsula): drumlin field. Stretches of broader gravel and sand beach (up to 20 m wide) alternate with narrow gravel beach backed by gravelly till bluff (12-24 m high) (Humphrys et al. 1958k). Upland topography consists of a till plain with drumlin features. ***Wetlands:*** No coastal wetland development.

49. Northport Point to Yuba (Grand Traverse Co.): cobble shoreline. A narrow beach (3-7 m wide) of sand, gravel, cobble, and glacial erratics below a low (3-8 m) bluff of sandy glacial till (Humphrys et al. 1958k). In places, upland vegetation extends down to the water line. The larger embayments (Bowars Harbor, Old Mission Harbor, Traverse City) trap sand, creating substantial areas of sand beach.

Wetlands: No significant coastal wetland development occurs in this stretch. The USFWS wetland inventory maps 10 wetlands along this stretch (LM-027 - LM-036; Herdendorf et al. 1981e:66). Most are situated on raised sites above the lake, except for two partially wooded wetlands in the Traverse City area (LM-027/028). However, both are now separated from Lake Michigan by a road.

50. Yuba to South Point/Charlevoix: sand lakeplain. The sand lakeplain along this stretch extends inland 200-670 m creating flat, nearly level topography (Humphrys et al. 1958l). A gravel belt of rounded pebbles occurs along the water line, and is backed by sand beach 7-20 m wide. Inland, a low bluff fronts a hilly till plain with many drumlins features. No significant coastal wetlands.

Wetlands: Herdendorf et al. (1981e:66) identify 13 wetlands along this stretch (LM-014 - LM-026). All occupy inland sites slightly raised above Lake Michigan.

51. South Point to Petoskey (Little Traverse Bay): cobble beach and low bedrock cliff. A narrow beach of gravel, cobble, and transverse limestone outcrop characterizes this stretch. Some reaches have steep, but low limestone bedrock cliffs (3-7 m) behind the beach. ***Wetlands:*** No coastal wetland development.

52. Petoskey to Cross Village: moraine bluffs. Steep morainic bluffs (15-35 m high) sit 100-165 m back from the shore and are fronted by sandy beach and low foredune (Humphrys et al. 1958n). ***Wetlands:*** No significant coastal wetland development occurs within this stretch. The USFWS wetland inventory identifies a single wetland along this stretch (LM-013) which occupies a raised site above Lake Michigan.

53. Beaver Island Group: sand lakeplain. This group of five islands consists of sand lakeplain; the shores are characterized by sandy beach, with areas of both low dune and high dune. Coastal wetlands are associated with small sand bar or dune and swale features.

Wetlands: The USFWS wetland inventory lists 31 wetlands for this island group (LM-043 - LM-073; Herdendorf et al. 1981e:166). Small herbaceous wetlands are reported on Beaver Island at Looney Point (LM-044), Little Sandy Bay (LM-045), and French Bay (LM-050), on High Island (LM-056/057), on Hog Island (LM-065 - LM-067), and on Garden Island at Jensen Harbor (LM-072) and Northcutt Bay (LM-073). All occur within partially wooded sites ranging from 20 to 100 acres in size.

54. Cross Village (Lake Michigan) to Mackinac City (Lake Huron) to Lighthouse Point (Cheboygan Co.): calcareous glacial lakeplain. This stretch features fairly low, flat lakeplain with calcareous soils, ranging from marly sands to clays, but includes sections of gravel beach or dunes. Limestone bedrock is near the surface along this stretch, and exposed bedrock and cobble beaches are common. Bois Blanc, Round, and Mackinac Islands are limestone/dolomite bedrock and cobble, with a thin veneer of marly sand or clay.

Wetlands: Wetland sites on the mainland include large embayments (e.g. Cecil Bay and Duncan Bay), and wooded dune and swale complexes. Waugoshance Point is a long spit of sand and cobbles with extensive emergent vegetation along the southern shore; sand movement along the northern shore has enclosed several shallow lagoons with emergent vegetation. Most wetlands have marly substrates.

The USFWS coastal wetland inventory identified 29 wetlands along this stretch (LM-001 - LM-012 and LH-121 - LH-137; Herdendorf et al. 1981e:3, 1981d:512). Many of the wetlands occupy raised sites or are heavily wooded. However, large herbaceous wetlands are listed for the Cheboygan/Duncan Bay area (LH-121 - LH-127), with smaller areas of herbaceous wetland at Cecil Bay (LM-006, 10 acres), Waugoshance Point (LM-010, 10 acres), and Cadottes Point (LH-132, 15 acres). MNFI marsh sampling included transects at Waugoshance Point and Duncan Bay (the Cheboygan wetland sites) (Albert et al. 1989). The wooded dune and swale survey included Sturgeon Bay, Big Stone Bay, and Trails End Bay (Comer and Albert 1993).

55. Lighthouse Point to Rogers City (Presque Isle Co.): sand lakeplain. A narrow band of flat, sandy lake plain extends along this stretch of Lake Huron. Shoreline topography is a series of beach ridges and adjacent wet depressions, locally extending several kilometers inland. These dune and swale complexes are well developed at Grass Bay east of Cheboygan and along Hammond Bay. Near the present lake shore, the depressions are typically poorly drained and sometimes ponded. Farther inland, the depressions become better drained; in some places they are excessively drained, as are adjacent beach ridges. Sand dunes, low foredunes, sand spits, and beach ridges line much of the shoreline.

Wetlands: Herdendorf et al. (1981d:512) identify 12 coastal wetlands along this stretch of Lake Huron (LH-109 - LH-120). All are classed as palustrine and appear to occupy sites above or inland from the shoreline. MNFI's survey of wooded dune and swale complexes included Hammond Bay and Grass Bay (Comer and Albert 1993).

56. Rogers City (Presque Isle Co.) to Squaw Bay (Alpena Co.): limestone cobble beach and marly embayments. Narrow beach (2-7 m wide) of limestone gravel, cobbles, and boulders; on the upland, bedrock is at or near the surface with a thin cap of sand (Humphrys et al. 1958p). Areas of marly shoreline also occur, usually within embayments. Major wetland sites occur within these embayments and are characterized by marly substrates (including El Cajon Bay, Misery Bay, Squaw Bay, and Whitefish Bay).

Wetlands: The USFWS coastal wetland inventory map 42 sites for this stretch of Lake Huron (LH-067 - LH-108; Herdendorf et al. 1981d:324, 426, 512). Most of the embayments contain herbaceous vegetation within partially wooded wetlands, with the largest including Misery Bay (LH-081, 1885 acres), Squaw Bay (LH-068, 777 acres), South Alpena (LH-069, 385 acres), Thompsons Harbor (LH-106, 240 acres), and Whitefish Bay (LH-074, 180 acres). The MNFI marsh survey included transects along the marly shores of El Cajon Bay, Squaw Bay, and Whitefish Bay, and within the estuary of the Bell River at False Presque Isle (Albert et al. 1989). Foul weather prevented sampling at Misery Bay, although this may well be one of the finest marsh sites in the Lower Peninsula. The dune and swale portion of this site was sampled, as was Squaw Bay (Comer and Albert 1993).

57. Squaw Bay to Point Lookout (Arenac Co.): sandy lakeplain. South of Squaw Bay, the shoreline consists of a flat coastal lake plain with small dune features and sand spits. Long stretches of wooded dune and swale features extend along the shoreline between Ossineke (Alpena Co.) and Alcona (Alcona Co.), and from the Iosco/Arenac county line to Point Lookout, with numerous smaller wooded dune and swale complexes in between. Shallow barrier-beach lagoons are found at Devils Lake (Alpena Co.), Cedar Lake (Alcona Co.), and Grass Lake, Lake Solitude, and Tawas Lake (Iosco Co.) which contain emergent marsh; all of these are associated with dune and swale complexes and are primarily wooded sites.

Wetlands: Herdendorf et al. (1981d:197, 324) list 8 wetlands within this stretch (LH-059 - LH-066). Only the Tawas Point (LH-064) and Au Sable Point (LH-065) wetlands are listed as containing significant areas of herbaceous wetland. MNFI's wooded dune and swale survey included wetlands at Lake Solitude (Tawas Point), Black River, Negwegon State Park, and Point Lookout (Comer and Albert 1993).

58. Saginaw Bay (Point Lookout to Port Austin): clay lakeplain. Saginaw is a highly eutrophic embayment of Lake Huron. The bay receives waste discharge and runoff from an area of 20,720 km^2 and from over 1.2 million people, primarily through the Saginaw River drainage system (Schumacher 1980; Jude and Pappas 1992). Conditions in the western sector are strongly affected by inputs from the Saginaw River; water quality gradually improves toward Lake Huron.

Saginaw Bay is formed by a flat glacial lakeplain that slopes gently into Lake Huron. The bay is very shallow with a thin veneer of sand over clay; Wildfowl Bay Islands are sand spits anchored on limestone bedrock. The shoreline of Saginaw Bay is an intricate mixture of sand and clay lakeplain along which low beach ridges and sand dunes alternate with organic-rich clays.

In the early 1800s, a broad band of wet prairie and marsh lined much of the Bay, with swamp forests extending inland from the coast. Extensive marsh also surrounded the Wildfowl Bay islands. The open coastal wetlands became still broader on the deltaic deposits of several major rivers, including the Quanicassee, Saginaw, Pine, Rifle, and Au Gres rivers; wet prairie and marsh extended up to 5 km inland along the Quanicassee and Saginaw rivers. Early surveyors commented on the abundance and diversity of waterfowl in the coastal wetlands. Beginning in the 1850s, extensive drainage of the lakeplain converted most wetland areas into agricultural lands to within 0.5 km from the shoreline. Sedimentation from agricultural run-off has further degraded the remaining fringe of wetlands, although not as severely as in Lake Erie. Submergent vegetation has been particularly affected by increased turbidity and siltation.

Wetlands: Present day wetlands are greatly reduced both in distribution and size relative to presettlement times, with the largest remaining marshes being along the Quanicassee and Saginaw River rivers. Extensive wetlands persist surrounding the Wildfowl Bay Islands, and an almost continuous band of marsh extends along the southeastern shore from Bay City to Bay Port where small lagoons are common in depressions between the modern beach and older beach ridges. Along the western shore, marshes are less prevalent and narrower, being concentrated at river mouths and small protected embayments behind sand spits (e.g. Pinconning and Nayanquing Point).

The USFWS coastal wetland inventory lists 21 wetlands for this stretch (LH-038 - LM-058; Herdendorf et al. 1981d:110, 197). However, three wetland areas are quite extensive and stretch along large portions of the bay: East Saginaw Bay wetland (LH-049, 16,730 acres), Nayanquing Point (LH-057, 2135 acres), and West Saginaw Bay wetland (LH-058). Smaller but significant herbaceous wetlands are listed for Linwood (LH-056, 85 acres), Tobico Marsh (LH-054/055, 650 acres), Lagoon Beach (LH-053, 37 acres), Aplin Beach (LH-052, 97 acres), Windy Point/Saginaw River (LH-051, 30 acres), and Wildfowl Bay (LH-046, 317 acres).

Topographic cross-sections and vegetation data exist for Tobico Marsh, and several other shoreline locations within Saginaw Bay (Herdendorf et al. 1981a). The MNFI marsh survey sampled wetlands at Pine River, Saganing River, Wigwam Bay, Pinconning, Nayanquing Point, Tobico, Coryeon Point, Wildfowl Bay, and Wildfowl Bay Islands (Albert et al. 1988). The wooded dune and swale survey examined Wildfowl Bay, Albert Sleeper State Park, and Port Crescent (Comer and Albert 1993).

Saginaw Bay falls on the Tension Zone between Northern and Southern Lower Michigan. Compared to more northern regions, southern Lower Michigan is warmer throughout the year. Because the growing season is longer and less variable in length, there is less danger of damage to plants from late spring or early fall freezes (Albert et al. 1986:7).

59. Port Austin (near the tip of the Thumb) to Port Huron: low shale or clay bluffs. This stretch of shoreline is characterized by lacustrine clays and water-worked tills belonging to the Sandusky Lake Plain (Albert 1995, VI.5.1); along much of the shoreline, there are low bluffs (less than 10 m high) of fine textured soil or shale bedrock, which preclude extensive wetland development. Most of the streams are small and flow through deeply incised ravines, which similarly do not support wetlands. However, several small embayments contain narrow zones of marsh, and some narrow areas of wooded dune and swale are found at the southern end (between Lakeport and Port Huron). Much of this shoreline now has residential development.

Wetlands: The comprehensive coastal wetland survey by Herdendorf et al. lists 18 wetland sites along this stretch of Lake Huron (LH-020 - LH-037; 1981d:110). Significant areas of herbaceous wetland are found at the Gore Township wetland (LH-031, 167 acres), Hardwood Point (LH-029, 195 acres), St. Margaret Mission (LH-028, 75 acres), Purdy Bay (LH-024, 65 acres) and Whiskey Bay (LH-032, 40 acres). MNFI marsh sampling included transects at Whiskey Bay and Hardwood Point (Albert et al. 1988), while the dune and swale survey examined Pointe aux Barques and Harbor Beach (Comer and Albert 1993).

IV. ST. CLAIR RIVER

The St. Clair River flows south approximately 64 km from Lake Huron to Lake St. Clair where it forms an extensive delta. The river is located on the international border between the U.S. (Michigan) and Canada (Ontario), and is a major shipping channel. Navigation-related dredging at the head of the St. Clair River has lowered the levels of Lakes Michigan and Huron 0.27 m (1 foot) (Derecki 1985).

The upper St. Clair River is heavily industrialized. Ontario's "chemical valley" utilizes much of the upper riverine shoreline, and sediment contamination is high on the Canadian side (Shimizu and Finch 1988); pollutants on the Michigan side were generally low or very localized. The entire St. Clair River has been declared an AOC, due to the levels of toxic substances in the water, contaminated sediments, impaired benthos, and bacterial contamination (SOLEC 1997).

60. St. Clair River: lacustrine clays. The St. Clair River flows through glacial moraine and lake plain topography, and has cut its channel in the lake clays. The entrenchment of the river in clay sediments may account for the straightness of the river and the lack of typical floodplain features, such as meanders and oxbow lakes (Edsall et al. 1988:30). In turn, this lack of shoreline complexity, along with the fast current, the depth of the river, and wave forces generated by the passage of large commercial vessels, limits wetland development along the river.

Wetlands: The USFWS wetland inventory lists only 5 wetlands along the St. Clair River (LH-015 - LH-019, Herdendorf et al. 1981d:4). Three of these (Point aux Tremble [LH-015, 60 acres], Point aux Chenes [LH-016, 27 acres], and Russell Island [LM-017, 20 acres]) are small channel side wetlands with herbaceous vegetation located along North Channel just above the St. Clair River delta, while the remaining two sites are not directly connected to the river. However, more recent inventories (Herdendorf et al. 1986; Edsall et al. 1988:70) list several additional sites along the main channel of the St. Clair River, including the estuaries of the Belle and Pine rivers (Fig. 2; after Edsall et al. 1988:70).

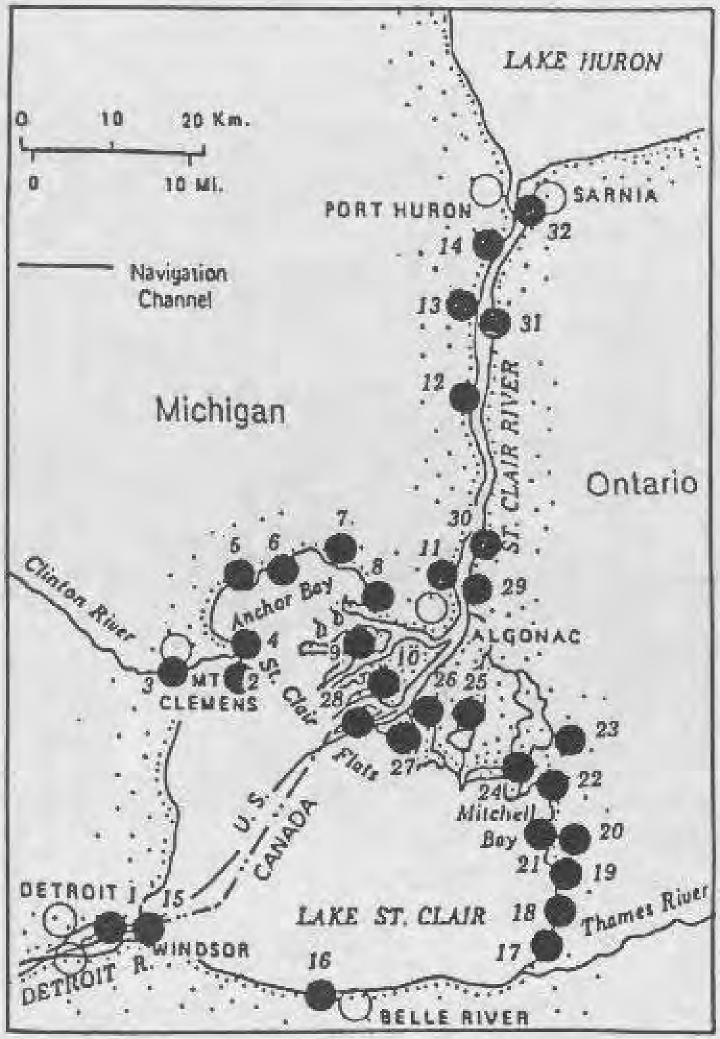
V. LAKE ST. CLAIR

Lake St. Clair is a relatively small, shallow lake with a natural maximum depth of 6.5 m, excluding an artificially maintained ship channel (Edsall et al. 1988). Although not considered as one of the Great Lakes, it is an important link along the Great Lakes chain. Almost all flow (98%) entering Lake St. Clair comes from the St. Clair River, with concomitant influx of contaminated water and sediments. Along the western side of the lake, the tributary Clinton River has been designated an AOC (SOLEC 1997).

61. Lake St. Clair: clay lakeplain. The entire U.S. shoreline of Lake St. Clair consists of flat, clay lakeplain formed by glacial Lake Maumee, 10,000-14,000 years ago (Herdendorf 1989). The lakeplain is characterized by slopes of less than 1%; wet loamy and clayey soils are prevalent. Major tributary rivers include the Clinton, the St. Clair (flowing from Lake Huron to Lake St. Clair), and the Detroit River (connecting Lake St. Clair to Lake Erie). The most significant wetland feature is the Lake St. Clair Delta, commonly known as the "St. Clair flats", the largest freshwater delta in the world. Smaller coastal wetlands exist within the estuaries of tributary streams.

At the time of European contact, Lake St. Clair shoreline was originally bordered by extensive swamp forests, wet prairies, and wet meadows. Shallow water areas contained a nearly continuous band of emergent marsh, while deeper water supported large beds of *Vallisneria americana*, an important food for migrating waterfowl.

The lake-moderated climate and productive loamy soils resulted in early and intensive agricultural development. In 1873, Lake St. Clair contained an estimated 18,000 acres of wetlands; one hundred years later, only 5000 acres remained (Jaworski and Raphael 1976; Raphael 1987). In the mid-1970s, the only significant area of intact wetlands was within the interdistributary basins of the St. Clair River delta and a small portion of the Clinton River delta. Since that time, the Clinton River marsh has been developed for residences and boat harbors, while almost continuous urban development now lines the shoreline of St. Clair River, further reducing the area of coastal wetlands.



MICHIGAN

Wayne County

1. Belle Isle

Macomb County

2. Black Creek
3. Clinton River Estuary
4. Belvidere Bay
5. Salt River Estuary

St. Clair County

6. Marsac Point
7. Swan Creek Estuary
8. St. John's Marsh
9. Dickinson Island
10. Harsens Island
11. Belle River Estuary
12. Pine River Estuary
13. Marysville
14. Port Huron

ONTARIO

Essex County

15. Peach Island
16. Ruscom River
17. Thames River Estuary

Kent County

18. Bradley Marsh
19. Big Point Marsh
20. Tacky Marsh
21. Mitchell Point Marsh
22. Mitchell Bay
23. Wallaceburg

Lambton County

24. St. Anne Island
25. Walpole Island
26. Squirrel Island
27. Bassett Island
28. Seaway Island
29. Port Lambton
30. Fawn Island
31. Stag Island
32. Sarnia

Figure 32. Coastal wetlands of the St. Clair system (from Edsall et al. 1988:70).

Wetlands: Herdendorf et al. (1981d:4) list 7 wetland sites within Lake St. Clair (LH-008 - LH-104). Extensive herbaceous wetlands (totalling 8060 acres) are concentrated within the St. Clair River delta flats, including Bouvier Bay (LH-012), Dickenson Island (LH-013), and Harsens Island (LH-014). A second area of herbaceous wetland is associated with the Clinton River delta (LH-008/009, 585 acres). Small coastal wetlands include the Swan Creek estuary (LH-011, 77 acres) and Salt River estuary (Edsall et al. (1988:70; Fig. 2).

Topographic cross-sections and vegetation data for Dickenson Island and Harsens Island are presented in Herdendorf et al. (1981a). The MNFI marsh survey included transects within the St. Clair River delta and the Clinton River delta (Albert et al. 1988).

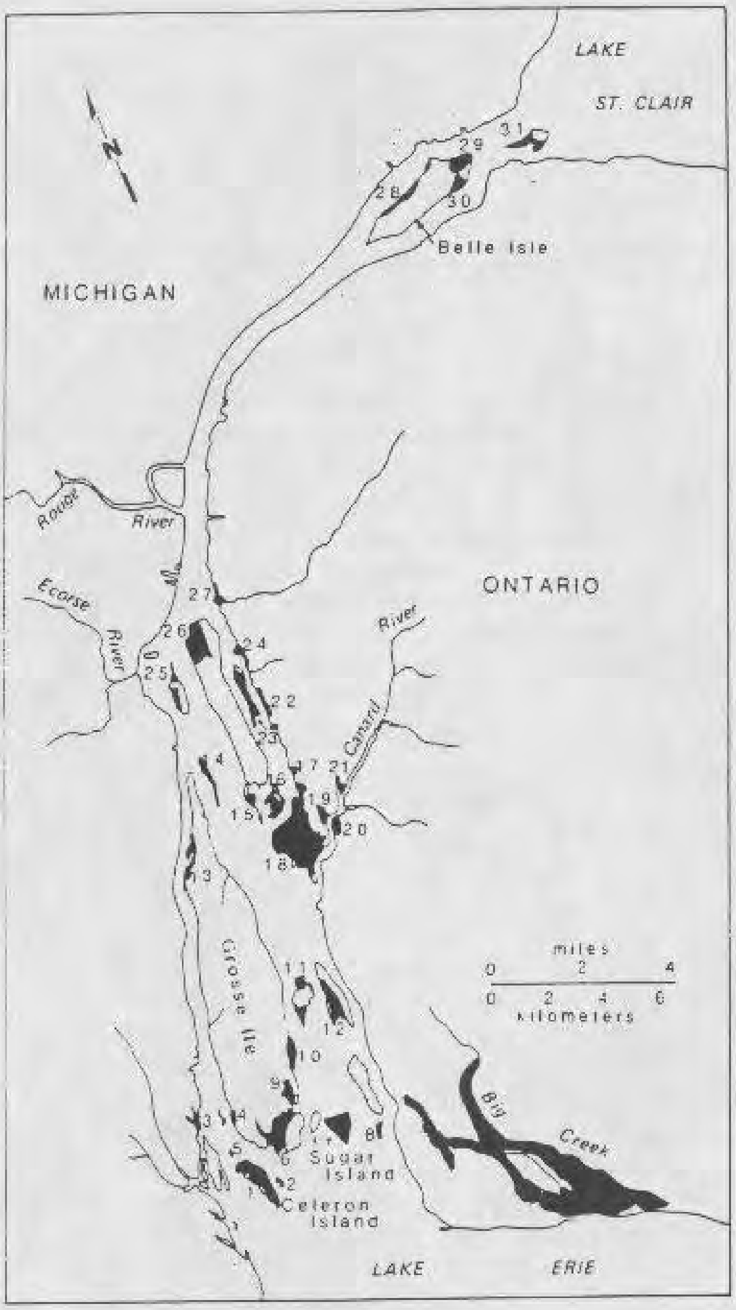
VI. DETROIT RIVER

The Detroit River constitutes a 51 km-long channel connecting Lakes St. Clair and Erie; an international boundary divides the river about equally between Michigan and Ontario. As part of the Great Lakes-St. Lawrence seaway, the Detroit River has been dredged since 1969 to maintain a channel depth of 27 feet (8.23 m); prior water depths averaged 6.0 to 7.6 m. Commercial ship traffic is heavy on the river, as Detroit is the busiest port in the Great Lakes.

The river is characterized by intensively developed shorelines and tributary drainage basins, and suffers from heavy industrial discharges, urban runoff, and sewage overflows. As a result, sediments in the Detroit River are heavily polluted with hazardous and toxic substances compared to other connecting channels. Manny et al. (1988) divide the river into upper and lower subsystems based on the health of the macrozoobenthic communities. The upper subsystem, upstream of the Rouge River/Zug Island, is considered normal and healthy, while the lower subsystem below the Rouge River is severely impacted by polluted. The Detroit River as a whole has been identified as an AOC (SOLEC 1997).

62. Detroit River: clay lakeplain. The Detroit River flows primarily through flat clay lakebed and waterlaid moraine overlain with lacustrine clays (Manny et al. 1988: Fig. 3). At the time of European contact, coastal wetlands and large submersed macrophyte beds were nearly continuous along its low, clayey shores. At present, wetland and aquatic communities exist as 31 small, isolated remnants (Manny et al. 1988:19, see Fig. 3); most of these are submersed macrophytes owing to the destruction of shoreline habitat formerly occupied by wet meadow and shrub swamp communities. On the Michigan side, the most functional wetlands appear to be Celaron Island, Gibraltar Bay (at the southern end of Grosse Ile), Belle Isle, Stony Island, and the eastern shore of Grosse Ile (Manny et al. 1988:21); most are dominated by cattails (Herdendorf 1992:544). Wetlands on the Ontario side (east of Fighting Island and at the mouth of Canard River) exhibit better sediment and water quality, and are biologically more diverse (Manny et al. 1988:9).

Wetlands: The USFWS wetland inventory lists only 7 coastal wetlands along this stretch (LH-001 - LH-007; Herdendorf et al. 1981d:4); all have some herbaceous vegetation. These include Round Island (LH-001, 30 acres), Trenton Channel on Grosse Ile (LH-002, 45 acres), Elba Island (LH-003, 80 acres), Calf Island (LH-004, 7 acres), Stony Island (LH-005, 65 acres), No. 2 Drain (LH-006, 110 acres), and Grassy Island (LH-007, 48 acres).



No.	Wetland type	Area (ha)
1	EM/AQ	87.28
2	AQ	7.27
3	EM/AQ	25.46
4	EM/AQ	14.55
5	EM/AQ	7.27
6	EM/AQ	87.28
7	AQ	72.73
8	AQ	25.46
9	AQ	21.82
10	EM/AQ	36.37
11	EM/AQ	43.64
12	AQ	50.91
13	EM/AQ	43.64
14	AQ	29.09
15	AQ	14.55
16	EM/AQ	43.64
17	EM/AQ	14.55
18	EM	247.30
19	EM	18.04
20	SS/EM	25.46
21	SS/EM	14.55
22	EM	29.09
23	EM/AQ	58.19
24	EM	29.09
25	SS/EM/AQ	43.64
26	FO/SS	101.83
27	EM	29.09
28	EM/AQ	43.64
29	AQ	43.64
30	EM/AQ	29.09
31	FO/SS/EM	43.64
	Total	1,381.80

[a] Wetland type: EM = Emergent Marsh,
AQ = Submersed Macrophyte,
FO = Forested,
SS = Shrub-Scrub.

Figure 33. Distribution of wetlands and large submersed macrophyte beds in the Detroit River, July, 1982 (from Manny et al. 1988:20).

VII. LAKE ERIE

Lake Erie is the smallest of the Great Lakes in water volume, as well as the most shallow. The lake can be divided into three basins: western, central, and eastern. The western basin, separated by a line of islands and shoals extending from Cedar Point, Ohio to Pelee Point, Ontario, is the smallest of the basins, with water depths of only 7-10 m. The central and eastern basins (divided by a submarine ridge near Erie, Pennsylvania) are substantially deeper, with water depths of up to 26 m and 64 m, respectively (Herdendorf and Krieger 1989).

Lake-modified glacial till is the primary landform bordering Lake Erie on the U.S. side. Much of shoreline around the western basin consists of flat, clay glacial lakeplain; further east, the shore is composed of limited beach area at the foot of bluffs cut from clayey tills. Although the lakeplain formerly supported extensive marsh and wet prairie communities, the predominant remaining wetlands are the lacustrine estuaries formed at the mouths of rivers drowned by the post-glacial rise in lake level (i.e. buried river mouths).

Lake Erie is the most southern of the Great Lakes, and its more moderate climate is marked by the appearance of a distinctively southern floristic component. In addition, the shallow waters of Lake Erie respond rapidly to the annual thermal heating and cooling cycle, creating a distinct growing season environment. However, its E-W orientation parallel to the prevailing storm track makes Lake Erie very susceptible to the passage of storms. Lake Erie is noted for its severe storms, intense wave attach, and rapid water level changes (Herdendorf and Krieger 1989).

Lake Erie is also exposed to the greatest stress from both urbanization and agricultural development. Turbidity and excessive suspended solids are significant stressors to coastal wetlands of Lake Erie (Herdendorf 1987, 1992; Jude and Pappas 1992). Over the last century, erosion and "stirring" of fine shoreline sediments through agriculture, the dredging, diking, and drainage of many large wetlands, shoreline modification, and the introduction of carp have caused the nearshore waters of Lake Erie to become turbid.

The waters of western Lake Erie are more turbid than elsewhere due to large sediment loads from the Detroit, Maumee, Portage, and Sandusky rivers, and the resuspension of silt and clay from the relatively shallow bottom by wind action. Flow from the Detroit River controls local circulation patterns, retarding the dispersion of sediment-laden waters from the Maumee River and Michigan streams, and resulting in high concentrations of contaminants along the western shore (Herdendorf and Krieger 1989:14). Identified AOCs include the Rouge River, River Raisin, Maumee River, Black River, Cuyahoga River, Ashtabula River, Presque Isle Bay, Buffalo River, and Niagara River, New York (SOLEC 1997).

63. Detroit River to Port Clinton, OH: clay lakeplain. The Maumee Lakeplain bordering Lake St. Clair continues south around western Lake Erie. Shoreline characteristics are similar: poorly drained sand and clay lacustrine deposits, with slopes of less than 1%.

The low, clay shore fronts the great "Black Swamp" area reported by early land surveyors, famous for its immense white oaks and infamous for its standing water, clinging mud, mosquitoes, and malaria (Gordon 1966; Herdendorf 1989:20; Campbell 1995). The shoreline, in its natural state, consisted of a marsh area protected by low barrier beaches and numerous estuarine river mouths; wetlands extended several miles inland from the coast

(Herdendorf 1989:55). Early explorers mention vast expanses of wet prairie along the western Lake Erie shore. For example, in 1815 Samuel Brown described an area "ninety miles long and two to ten wide, extending from the mouth of the Portage" nearly to Detroit, containing grass "higher than our heads and as thick as a mat confined together by a species of pea vine". Near the mouth of the Toussaint River the prairie grass was "about seven feet high and so thick that it would easily sustain one's hat - in some places a cat could have walked on its surface." Writing in 1837, John D. Riddell mentions the "Grand Maumee Prairie" beside Lake Erie extending from the Maumee River to the headwaters of the Portage (cited in Campbell 1995:100).

Today, earthen and rock dikes protect much of the shore, severely limiting natural wetland distribution (Herdendorf 1989:20). However, submergent and emergent wetlands surround the islands at the mouth of the Detroit River (Herdendorf 1989:51). More characteristic are the lacustrine estuaries at the mouths of most tributary streams and rivers. Most of the rivers entering western Lake Erie have wide mouths, indicative of coastal drowning due to rising lake levels or downwarping of the landscape (Herdendorf et al. 1981a:152). In Michigan, estuarine wetlands are found at Otter Creek, River Raison, Sandy Creek, Stony Creek, and Swan Creek. In Ohio, the Ottawa River, Maumee River, Crane Creek, Turtle Creek, Toussaint River, Lacarpe Creek, and Portage River have estuarine wetlands (Brant and Herdendorf 1972; Herdendorf 1989:56). Many of these, however, have been severely modified by dredging and rip-rapping for commercial and/or recreational boat traffic.

Wetlands: The USFWS coastal wetland inventory maps 40 wetlands along this stretch (LE-069 - LE-096 in Michigan, and LE-057 - LE-068 in Ohio; Herdendorf et al. 1981c:242, 311). These include extensive areas of diked wetlands at North Maumee Bay (LE-069 - LE-076, 1419 acres), Cedar Point (LE-065, 1591 acres), and Magee Marsh/Ottawa Wildlife Refuge (LE-062/063, 3730 acres). Most of the remaining sites mapped are estuarine, including Otter Creek (LE-079, 165 acres), River Raisin (LE-082/083, 134 acres), Sandy Creek (LE-084/085, 50 acres), Stony Creek (LE-086/087, 26 acres), and Swan Creek (LE-090, 306 acres) in Michigan, as well as the Toussaint River (LE-060, 2600 acres) and Otter Creek (LE-067, 70 acres) in Ohio.

The MNFI marsh survey sampled the estuaries at Swan Creek and Otter Creek in Michigan, as well as Erie Marsh and Pt. Mouillee on the Detroit River delta (Albert et al. 1988). Herdendorf et al. (1981a) provide detailed geomorphic and vegetation information for the Erie Marsh/Woodtick Peninsula site in Michigan, and for the Toussaint River estuary in Ohio.

64. Port Clinton to Catawba Island to Marble Head (including the Erie Islands): low bedrock bluffs. Bedrock is locally exposed in the low limestone and dolomite bluffs of Catawba Island and Marble Head (Herdendorf 1975). The Lake Erie Islands are also rockbound, with small stretches of sand and gravel beach; wave and current action is generally strong.

Wetlands: The east shore of Catawba Island (actually a rocky peninsula) contains three major embayments (West Harbor, Middle Harbor, and East Harbor) protected by a nearly continuous barrier beach. These natural harbors contain rather complete zones of emergent, floating-leaved, and submergent plants (Herdendorf 1992:546), owing to the protection of the barrier beach. Herdendorf et al. (1981:218) record three herbaceous wetlands in East Harbor (LE-051 - LE-053) totalling 15.5 acres.

Small pockets of wetlands are also found on most of the larger island in western Lake Erie (Herdendorf 1992), most in the form of barrier-beach lagoons occupying depressions between the shoreline and sand spits or barrier bars built by along shore currents. Some of the more prominent ones include Carp Pond on Kelleys Island (LE-050, 17 acres), Terwilliger's Pond on South Bass Island, Middle Bass Island (LE-054, 17 acres), and Manila Bay/Smith's Pond and Fox's Marsh on North Bass Island (LE-055/ LE-056, 39 acres) (Herdendorf 1992:545; Herdendorf et al. 1981:218).

65. Marble Head to Vermillion, including Sandusky Bay: clay lakeplain. This stretch is a continuation of the low, clay shoreline found further west (see Unit 61). Shoreline characteristics are similar: poorly drained sand and clay lacustrine deposits, with slopes of less than 1%. In its natural state, the shoreline consisted of a marsh area protected by low barrier beaches and numerous estuarine river mouths; wetlands extended several miles inland from the coast (Herdendorf 1989:55). Today, earthen and rock dikes protect much of the shore, severely limiting natural wetland distribution. Lacustrine estuaries and tributary deltas are the predominant wetland types along this stretch.

Wetlands: A major wetland feature in this stretch is Sandusky Bay. The mouth of Sandusky Bay is a area of convergence of opposing littoral currents; as a result, the bay mouth is protected by two sand spits. Bay Point Spit, projecting south from Marblehead, results from erosion of the low limestone shore of Marblehead. Cedar Point, extending NW from near Huron, is a 15-20 ft high sand spit formed through the westerly movement of sand eroded from till and lacustrine bluffs to the east. These spits protect extensive wetlands throughout the bay.

One of the largest concentrations of wetlands on Lake Erie is found at the head of Sandusky Bay, along the estuarine lower reaches and deltaic deposits formed by the Sandusky River, Muddy Creek, Pickerel Creek, and [Port Clinton] Creek (Herdendorf 1989:54). Herdendorf et al. (1981c:124) identify eight wetlands associated with inner Sandusky Bay (LE-040 - LE-047) totalling over 4200 acres; all have been extensively modified through diking and rip-rap.

A second complex of wetlands within Sandusky Bay are those enclosed by Cedar Point. Nine marsh sites (LE-131 - LE-039), which were probably part of the same original marsh, are found where several small streams (Plum Brook, Hemming Ditch, and Pipe Creek) flow into the narrow embayment between Cedar Point and the mainland shore. The stream mouths all contain estuarine wetlands with emergent marsh. Emergent marsh also occurs along the outer edge of Cedar Point (LE-028 - LE-030).

East of Sandusky Bay, characteristic wetland sites are found in lacustrine estuaries, where tributary streams and rivers enter Lake Erie, including the mouths of the Huron River (LE-027) and Old Woman Creek (LE-026) (Brant and Herdendorf 1972; Herdendorf 1989:56).

The Old Woman Creek estuary and a large portion of its drainage basin have been designated as a National Estuarine Research Reserve. As a result, the site has been intensively studied and reported in the literature (e.g. Herdendorf 1990; Matisoff and Eaker 1992; Heath 1992; Klarer and Miller 1992). MNFI marsh sampling included transects at Sheldon Marsh, Huron River estuary, and Old Woman Creek estuary (see Appendix I for site descriptions).

66. Vermillion, OH to Niagara River, NY: low bluffs of glacial till (Erie-Ontario Plain). Just west of Vermillion, the shoreline characteristics of Lake Erie change abruptly; the low marshy backshore typical to the west disappears and is replaced by low bluffs of glacial till, lacustrine sediments, and black shale (Herdendorf 1989:54). In Ohio, these bluffs rise from 3 m near Vermilion to 20 m at Ashtabula, while in Pennsylvania, the bluffs rise as high as 30 m. At the base of these bluffs, narrow shingle beaches have formed; few sand beaches occur.

Wetlands: Wetland development along this reach is largely limited to the estuarine mouths of tributaries (LE-020 - LE-025; Herdendorf et al. 1981c:61). The largest wetland occurs at Mentor marsh (over 700 acres), in the abandoned valley and delta of the Grand River which now enters Lake Erie several kilometers east of the marsh. Old meanders contain 7-20 m of organic accumulations, and provide a very protected marsh environment. However, portions of the marsh have been dredged, and marsh vegetation is low diversity, with cattails and giant bulrush predominating. Much smaller estuarine marshes are found at the mouths of Beaver Creek (protected by a barrier beach; 9 acres), Ashtabula River (6.5 acres), and Conneaut Creek (2.5 acres).

One other notable wetland complex in this stretch occurs at Presque Isle Peninsula, a 25 km-long sand spit which encloses Erie Harbor. Formed by the deposition of sand and gravel eroded from bluffs further west, the shifting construction of this spit has created numerous shallow lagoons where wetlands have developed (Kormondy 1969, 1984). At the NE end of peninsula, beach ridges up to 2 m in height have enclosed an embayment formerly open to lake creating a large lagoon (LE-013; 281 acres). Smaller elongate beach ponds parallel the former or present shoreline along the length of the sand spit (LE-014 - LE-016; 13-65 acres). Sheltered by Presque Isle peninsula, several small herbaceous wetlands (LE-010 - LE-012) persist on the mainland shore within the city of Erie, along the narrow lacustrine plain backed by steep bluffs of the Portage escarpment. MNFI sampling included transects at Thompson's Harbor and The Lagoons near the eastern end of Presque Isle (see Appendix I for site descriptions).

Other small, wooded wetlands reported for this stretch (LE-017 - LE-019) are situated 15-20 m above the lake along the bluff line and are not influenced by Great Lakes water levels.

VIII. NIAGARA RIVER

The Niagara River flows northerly from Lake Erie at Buffalo, New York, to Lake Ontario, at Niagara-on-the-Lake, Ontario, forming part of the international boundary between the United States and Canada. Over the river's 58 km course, it drops almost 100 m in elevation; about half of this (56 m) occurs as the river cascades over the Niagara Escarpment at Niagara Falls, which separate the upper and lower reaches of the river (Edwards et al. 1989). Rapids precede the falls for 11 km, before the river is divided by Goat Island into Horseshoe Falls on the Canadian side and the American Falls on the U.S. side. The fast flow of the river has precluded the wetland development along many reaches of the river.

The Niagara River had been declared an AOC as a result of excessive toxic chemicals in the water, sediment contamination, fish edibility restrictions, the incidence of tumors in fish, degraded benthos, and elevated phosphorus levels (SOLEC 1997). Pollution of the river is primarily from an industrial complex along the New York shoreline, sewage treatment plants, and urban and agricultural development along tributaries.

67. Niagara River: low till bluffs over dolomite/limestone bedrock. The river flows over hard dolomitic limestone of Silurian age underlain by softer shales and sandstone; serious erosion of the fall line has taken place within recent times. The shoreline is typically low and marshy shore, bordered by low bluffs rarely greater than 7 m in height; thin glacial soil overlie the carbonate-rich bedrock.

Wetlands: Several small wetlands have formed along the Niagara River, particularly on Grand Island; many are at the mouths of small tributary streams. Herdendorf et al. (1981c:3) record nine sites along this stretch (LE-001 - LE-009); all but one (LE-007) lie at the river's edge. Six sites have primarily herbaceous wetland vegetation (LE-001, 004, 005, and 006 on Grand Island, LE-008 on New York shore, and LE-009 on Motor Island); other sites are primarily wooded. The largest wetland along this stretch is the herbaceous community at Buckthorn Island (LE-001, 250 acres); the remaining herbaceous sites range from 10 to 25 acres. There are also extensive submerged beds in the Niagara River.

IX. LAKE ONTARIO

Lake Ontario is the smallest of the Great Lakes in surface area, although it has the largest drainage basin. It is significantly deeper and colder than Lake Erie, although the two share a similar growing-season climate and perimeter air-temperature regime. Water levels in the lake are controlled by dams and locks in the St. Lawrence River, and natural fluctuations in lake level have been dampened significantly since 1959.

Along the U.S. side, Lake Ontario is bordered by low glacial till bluffs belonging to the Erie-Ontario and Eastern Ontario plains. As a result, most of Lake Ontario's shoreline (85%) is characterized by regular (nearly linear) shorelines sloping rapidly into deep waters (Whillans 1980) which preclude extensive wetland development. Wetlands are most abundant along the eastern end of the lake owing to sand accumulation in the form of barrier beaches. Dominant wetland types include barrier-beach lagoons and partially barred lacustrine estuaries. Exotic species (including purple loosestrife, eurasian water-milfoil, and frog-bit) are common.

High sediment loads and excess turbidity have been noted as stressors in several coastal wetlands (SOLEC 1997). Turbidity problems are compounded by excess nutrients (eutrophication), with consequent degradation of the aquatic habitat (Dodge and Kavetsky 1995). Most of the sheltered nearshore waters have been strongly affected by cultural eutrophication since the 1940s, leading to nuisance algae blooms, with a concomitant decrease in water clarity and reduced abundance of submergent macrophytes. Toxic chemicals also impair habitat quality, especially in harbors and river mouths. Seven AOCs have been identified on Lake Ontario (SOLEC 1997). Along the U.S. shoreline these include Eighteen Mile Creek, Rochester Embayment, and Oswego River.

68. Niagara Falls east to Braddock Point (just west of Rochester, NY): low bluffs of glacial till (Erie-Ontario Plain). The shoreline of western Lake Ontario is a continuation of the preceding unit bordering eastern Lake Erie. Here, till plain (ground moraine) deposits over shale bedrock result in narrow shingle beaches, backed by low bluffs 3-20 m high. Some deeply incised streams cut through the bluffs, but these often flow directly over bedrock near the lake and are quite shallow.

Wetlands: Few significant wetlands occur along this portion of coast. Herdendorf et al. (1981b:1099) identify 21 small wetland areas along this stretch (LO-292 - LO-312). The largest are river mouth sites at Sandy Harbor (LO-302, 75 acres) and Brush Creek (LO-294, 80 acres). The remaining sites are all less than 50 acres in size.

69. Braddock Point to Rochester: drumlin field. A small field of N-S oriented drumlins are truncated by Lake Ontario (for details on geomorphological processes see Unit 71). Barrier-beaches across intervening embayments have created a series of lagoons at Cranberry Pond, Long Pond, Buck Pond, and Round Pond. Braddock Bay is a partially barred lacustrine estuary between drumlin features at mouths of Buttonwood and Salmon Creeks; the embayment south of Payne Beach appears to be a buried inlet between drumlins as well. All of these wetlands are crossed by or are adjacent to the 4-lane Lake Ontario State Parkway.

Wetlands: The USFWS wetland inventory identifies 6 herbaceous wetlands in this short stretch (LO-286 - LO-291; Herdendorf et al. 1981b:1099). These include the wetlands mentioned above: Payne Beach area (LO-291, 125 acres), Braddock Bay (LO-290, 392 acres), Cranberry Pond (LO-289, 200 acres), Buck Pond (LO-288, 355 acres), and Round Pond (LO-287, 225 acres).

70. Rochester to Sodus Point: low till bluffs. Shore bluffs of unconsolidated glacial sediments ranging in height from 3 to 15 m stretch continuously along this reach (Herdendorf 1975). There are no significant wetlands along this stretch, with the exception of Irondequoit Bay, a lacustrine estuary just east of Rochester. The estuary is bordered by very steep bluffs (50-60 m high) and probably occupies an old glacial melt-water channel.

Wetlands: Herdendorf et al. (1981b:926, 1099) identify 5 coastal wetlands in this stretch (LO-281 - LO-285). The only site of significant size is the Irondequoit Bay wetland (LO-285, 165 acres); the remainder are very small herbaceous sites 3-8 acres in size.

71. Sodus Point to Oswego: drumlin field. This stretch of shoreline includes one of the largest and most striking drumlin fields in the world. The drumlins are generally aligned N-S and are variable in height. Molded under massive glacial ice and later eroded by rising lake levels, the drumlin fields create a unique coastline consisting of truncated drumlin features separated by low-lying plains or depressions. Along the shoreline, undulating bluffs rise from near lake level between drumlins to over 50 m on the drumlin crests.

Drumlin material eroded by the lake has been transported along the coast to form small sandspits or barrier beaches (generally less than 3 m high) across the mouths of most inter-drumlin depressions, creating a series of shallow lagoons or partially barred embayments parallel to the coast. The lagoons are typically fed by small streams draining off the drumlin field and are characterized by deep organic deposits accumulated over the last several thousand years. Long and linear wetlands may extend several kilometers inland along the streams.

Wetlands: This stretch of Lake Ontario shoreline contains 34 wetlands (LO-247 - LO-280) as mapped by Herdendorf et al. (1981b:925-926). The major sites listed are the barrier-beach lagoons at Root Swamp (LO-279, 180 acres), East Bay (LO-277, 1253 acres), Beaver Creek (LO-174, 405 acres), Port Bay (LO-273, 414 acres), Desbrough Park (LO-271, 181 acres), Red Creek (LO-267, 344 acres), Black Creek (LO-264, 508 acres), and Sterling Creek (LO-257, 906 acres). Other wetlands include smaller areas of herbaceous wetland within partially barred embayments, such as Little Sodus and Blind Sodus bays, as well as river mouth sites (generally less than 100 acres), containing both woody and herbaceous vegetation. The MNFI marsh survey sampled the wetlands at East Bay and Black Creek in Wayne County, and at Sterling Creek in Cayuga County (see Appendix I for site descriptions).

72. Oswego to Sage Creek: low till bluffs. Low, resistant shore bluffs composed of glacial till overlying bedrock at or near lake level comprise much of this stretch (Herdendorf 1975:62). Drumlin features are visible on the interior uplands. Small wetlands are found at the mouths of Otter Branch, Catfish Creek, Little Salmon River, and Sage Creek, where sand bars have partially dammed stream flow creating barred lacustrine estuaries. Butterfly Swamp is a barrier-beach lagoon formed within a small embayment.

Wetlands: The USFWS wetland inventory maps 20 wetlands along this stretch (LO-227 - LO-246; Herdendorf et al. 1981b:764, 925). The largest site is the barrier-beach lagoon wetland at Butterfly Swamp (LO-231/231, 406 acres), followed by smaller herbaceous wetlands at Little Salmon River (LO-230, 65 acres), Sage Creek (LO-227, 50 acres), Catfish Creek (LO-233, 20 acres), and Otter Branch (LO-235, 20 acres). The remaining sites are less than 10 acres in size.

73. Sage Creek to Stony Point: sand deposition over till plain. Just east of Sage Creek, the shoreline evens out along a north-south oriented section of lakeshore. This stretch is underlain by rolling till plain; however, predominant wind and water currents have led to the accumulation of sands at this eastern-most end of Lake Ontario (Herdendorf 1975; Steadman 1997). The result is a low shoreline characterized by numerous embayments with barrier beaches and sand dunes rising up to 30 m above the lake. The barrier beaches create a string of lagoons including Deer Creek, South Pond, North Pond, Cranberry Pond, North and South Colwell Ponds, Goose Pond, Floodwood Pond, Lakeview Pond, and Black Pond, all connected by extensive wetlands. The lagoons are generally shallow, and most are fed by small streams. The larger lagoons extend inland up to 3 km, and are bordered by drumlin features of the till plain. Barred lacustrine estuaries are found at the mouths of Grindstone Creek and Salmon River.

Sand starvation is a potential threat to wetlands of this area (Steadman 1997). Cobbles now dominate the southern third of what was once a continuous sand beach; some experts argue that the cobbles are being exposed in place as a result of diminished sand supply.

Wetlands: The USFWS wetland inventory breaks out 24 separate wetlands along this stretch (LO-203 - LO-226), almost all of which contain herbaceous wetland vegetation (Herdendorf et al. 1981b:763-764). The largest lagoon site is identified as South Pond of Deer Creek (LO-222, 1348 acres); however, no acreage is given for the Lakeview Pond complex, which may be larger. The estuarine wetlands at Salmon River (LO-224, 75 acres) and Grindstone Creek (LO-225, 65 acres) are considerably smaller. The MNFI marsh survey included transects at Deer Creek in Owego County, and at Lakeview Pond and South Colwell Pond in Jefferson County (see Appendix I for site descriptions). Maps and descriptions of vegetation zonation are provided for the marshes at Cranberry Pond, Sandy Creek, Lakeview Pond, Southwick Beach, Little Stony Creek, Black Pond, Stony Creek, Ray Bay, Campbell, Sherwin Bay, and Guffin Bay by Geis and Kee (1977).

74. Stony Point to Cape Vincent to Bartlett Point: limestone tableland. This stretch of complex coastline consists of a tableland developed on limestone and dolostone of the Black River-Trenton group, and includes several offshore islands (Galloo, Stony, Association, Grenadier, and Fox). The shoreline appears as a low, flat plain that slopes gently to the SW, with local exposures of limestone bedrock ledges (as at Pillar Point and Cape Vincent). Streams flowing from the interior are slightly entrenched, and the lake shoreline is deeply indented with bays as a result of the drowning of the lower valleys of these streams (Van Diver 1985:296). These estuarine river mouth embayments and stream channels (including Black River, Perch River, and Kents Creek) provide the context for extensive wetland development reaching several kilometers inland.

Other wetland contexts include protected embayments, such as Chaumont Bay (enclosed by Point Peninsula) and along the eastern sides of Grenadier and Fox islands, which are rimmed with marsh vegetation. In contrast, along the exposed shoreline of Point Peninsula, sand and gravel transport has enclosed several barrier-beach lagoons, including Point Peninsula Marsh and Little Fox Creek marsh, as well as several other very small examples. Finally, shoals between the islands and the mainland are sites for submergent and ephemeral emergent vegetation.

Wetlands: The USFWS wetland inventory maps 64 coastal wetlands along this mainland stretch, and on Grenadier, Fox, Galloo, Stony, Calf, and Association islands (LO-139 - LO-202; Herdendorf et al. 1981b:472, 597-598, 763). The largest wetlands are estuarine sites associated with buried river mouth embayments at Black River/Muskalonge Bay (LO-188, 528 acres), Perch River bay (LO-187, 250 acres), and Mud Bay Marsh at Kents Creek (LO-149, 233 acres). Other significant sites include the barrier-beach lagoons at Point Peninsula marsh (LO-168, 330 acres) and Wilson Bay marsh (LO-147, 170 acres). Examples of protected embayment sites include the Chaumont Bay marshes (LO-171/172; 150 acres) and Fox Island (LO-156, 80 acres). The remaining sites are generally small (less than 50 acres).

The MNFI marsh survey included transects along the Black River (Dexter Marsh), and at the Point Peninsula barrier-beach lagoon (see Appendix I for site descriptions). Geis and Kee (1977) provide detailed maps of vegetation zonation for the estuary at Kents Creek, for the embayment site at Long Carry Marsh, and for the barrier-beach lagoons at Little Fox Creek, Point Peninsula Marsh, Point Peninsula Isthmus, Wilson Bay, and Fuller Bay.

X. ST. LAWRENCE RIVER

The St. Lawrence River is the outlet for Lake Ontario; from its origin near Wolfe Island/Cape Vincent, it flows northeast between the United States and Canada for 182 km before entering the Province of Quebec on its way to its outlet in the Gulf of St. Lawrence. Over this course, the St. Lawrence River drops about 74 meters, with roughly one-third of this descent occurring along the New York/Ontario border. Based on limnological characteristics, the St. Lawrence can be divided into three reaches:

1. the **upper reach** between Cape Vincent and Chippewa Point has numerous islands, expansive bays, and shoals; this reach is most influenced by Lake Ontario and is essentially an extension of the lake;

2. **the middle reach** between Chippewa Point and Red Mills Rapids is narrow and has few islands or shoals, except for several large islands in the stretch between Ogdensburg, NY and Cardinal, Ontario;

3. **the lower reach,** now known as Lake St. Lawrence, is highly modified through inundation following construction of the Moses-Saunders Dam (Edwards et al. 1989:242).

Water quality of the St. Lawrence River reflects that of upstream Lake Ontario and is generally good. However, localized areas of sediment contamination exist at Ogdensburg Harbor and Chimney Bay (Edwards et al. 1989:244-245). Contaminants include oil and grease, lead, nickel, and mercury. The section of the St. Lawrence River downstream of Massena, New York and Cornwall, Ontario has been declared an AOC (SOLEC 1997).

75. Bartlett Point to Grass Point: sandstone tableland. This short section consists of a gently sloping, flat tableland developed on durable Potsdam sandstone. The sandstone is visible as ledges along much of the shore (Van Diver 1985:296).

Wetlands: Herdendorf et al. (1981b:472) identify 11 wetlands associated with the sandstone (LO-116 - LO-126). All are non-wooded and most are adjacent to the shoreline. The largest wetland site is French Creek Marsh (LO-125, 630 acres), which extends 8 kilometers inland along the entrenched channel. Other small marshes are found within embayments, with the largest being Blind Bay (LO-120, 80 acres). Geis and Kee (1977) provide maps and descriptions of vegetation zones for the marshes at both French Creek and Blind Bay.

76. Grass Point to Chippewa Bay (including Grindstone Island and Wellesley Island): granitic (gneiss) shoreline. The Thousand Islands and adjacent mainland shore are the surface expression of the Frontenac Arch, where overlying limestone and sandstone formations have been removed by glacial scouring to reveal the irregular surface of the underlying Precambrian granitic rock. The bedrock of the islands and of the mainland shore from Grass Point to Chippewa Bay is mostly pink, massive rock of granitic composition, called Alexandria Bay gneiss, or Thousand Islands gneiss, but darker, syenitic, and banded gneisses also occur. Most of the exposures are smoothly rounded, even polished by scouring ice. The islands themselves are elongated parallel to the river (Van Diver 1985:295-296).

Small streams or rivers occupy apparent pre-glacial valleys cut through rounded bedrock knobs and ridges which have been partially filled in by outwash deposits to form fairly broad, flat basins. Extensive wetlands (up to 1 km wide) line the lower reaches of the streams for several kilometers inland as they flow through the basins; a narrow delta has formed at the mouth of some basins. In addition, the complex shoreline of both the mainland and the islands has numerous small embayments which support localized areas of marsh along the St. Lawrence channel.

Wetlands: The USFWS wetland inventory maps 72 wetlands in this stretch, including Grindstone Island (LO-127 - LO-138), Wellesley Island (LO-095 - LO-138), and the mainland shoreline (LO-067 - LO-094) (Herdendorf et al. 1981b:236, 356, 472). Along the mainland, extensive marshes are found at the mouths and along the lower reaches of Cranberry Creek (LO-085, 375 acres), Crooked Creek (LO-080, 850 acres), and Chippewa Creek (LO-072, 680 acres). Embayment sites along the mainland shore include Grass Point Bay (LO-094), Moore Landing (LO-092), Swan Bay (LO-091), Point Vivian Bay (LO-090), Sheephead (LO-069), and Blind Bay (LO-067), all of which range from 30-70 acres in size.

On Grindstone Island, somewhat larger embayment sites are found at Delaney Bay (LO-129, 200 acres), Aunt Janes Bay (LO-130, 100 acres), and McCrae Bay (LO-132, 175 acres). The largest embayment sites on Wellesley Island are Barnett Marsh (LO-101, 175 acres), Eel Bay (LO-105, 170 acres), Westminster Marsh (LO-097, 150 acres), and the Rift area (LO-110, 120 acres). Both islands contain numerous smaller embayment marsh sites as well.

Detailed vegetation zonation maps for the larger marsh sites on both the mainland and island shorelines are presented in Geis and Kee (1977). The MNFI marsh survey included transects at Flynn Bay and Delaney Bay on Grindstone Island, at Barnett marsh on Wellesley Island, and at Cranberry Creek, Chippewa Creek, and Crooked Creek on the mainland shore (see Appendix for site descriptions).

77. Chippewa Point to Moses-Saunders Power Dam, including mid-channel islands: glacial till over limestone/dolostone plain. Beyond Chippewa Point the St. Lawrence River channel narrows as it flows through a low till plain. Inland, the topography consists of gently rolling morrainic ridges over bedrock; the clay-rich soils are generally poorly drained. Wetland sites along the St. Lawrence are found at the mouths of slightly entrenched streams and in small stream-side embayments.

The construction of the Moses-Saunders Power Dam on the St. Lawrence near Massena and the subsequent flooding of the river has introduced profound changes in the shoreline and islands between Red Mills and Massena. Entrenched stream mouths have been drowned by the rising level of the St. Lawrence River, and embayments now reach far upstream into the side valleys. Many of the islands east of Red Mills have sawtooth shorelines that result from the flooding of low moraine ridges or small drumlins fields. The effects of flooding diminish to the SW and are negligible upstream of Ogdensburg (Van Diver 1985:289).

Wetlands: The USFWS coastal wetland inventory identifies 66 wetlands in this final stretch (LO-001 - LO-066; Herdendorf et al. 1981b:3, 62, 142). Of these, only 13 wetland sites (LO-054 - LO-066) are situated upstream of Red Mills, and above the flooding effects of the Moses-Saunders Power Dam. Overall, very few sites are located adjacent to the river. Small shoreline marshes are found in the vicinity of Ogdensburg (LO-056, 43 acres), Tibbits Creek (LO-054, 20 acres), Brown Church Bay (LO-046, 27 acres), Whitehouse Bay (LO-043, 45 acres), River Road (LO-042, 40 acres), and Croil Island (LO-024, 30 acres).

PART III

GREAT LAKES COASTAL WETLAND VEGETATION ANALYSES

METHODS

This classification of coastal wetlands characterizes variability among marshes in terms of specific vegetative zones (Fig. 3). Moving from deeper water to the shore, these zones are (1) the **Submergent Marsh** containing submergent and/or floating vegetation; (2) the **Emergent Marsh** typically dominated by bulrushes, cat-tails, and other emergent species; and (3) a narrow but diverse **Shoreline Zone** containing emergent, submergent, and floating species. The Shoreline Zone is narrow enough that it was not generally mapped as a distinct unit, but was treated as part of the Emergent Marsh zone. Inland from the shore three additional zones can be identified: (4) a sedge-and-grass dominated **Herbaceous Zone**; (5) **Shrub Swamp**; and (6) **Swamp Forest**. Not all zones are present or well-developed in every marsh.

In order to provide baseline data on both the biotic and abiotic components of selected coastal wetlands, sampling transects were established to include the full range of vegetation zones present, extending from the upland boundary lakeward to water depths of approximately 2 m. At 10-20 m intervals along the transect, the cover value for each species present was recorded, along with data on substrate, organics, and water depth. The cover value for each species present was recorded on a 5-point scale: 1 = 1-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, and 5 = 81-100%, while a value of .25 was used to indicate species presence within a meter of the plot. For this study, species cover values have been summed by vegetation zone and their mean cover values computed, in order to generalize species behavior throughout the zone as a whole. These data were then integrated with regional information on bedrock characteristics, glacial landform, soils, topography, shoreline configuration, and water quality.

The present study concentrates on patterns of species co-occurrence and distribution in three of the marsh zones: Emergent Marsh, Herbaceous (Wet Meadow), and Shrub Swamp. Data for these analyses were taken along 130 transects representing 102 marshes sampled in the field (Figs. 34-38).[1] Species within the vegetation zones were not separated into physiognomic classes; thus, species generally classed as "emergent" may be found across both the emergent and herbaceous zones, while woody species may occur in both the herbaceous and shrub-swamp zones.

The vegetative analyses had two specific goals: first, to define groups of marshes with similar species composition that represent distinct marsh types; and second, to clarify the site factors controlling species distribution and hence the occurrence of the different marsh types. The identification of distinctive patterns of species co-occurrence relied heavily on TWINSPAN or Two-Way Indicator Species Analysis. TWINSPAN is a polythetic divisive method of classification of samples based on the differential occurrence or abundance of one or more indicator species (Hill 1979). A key attribute of the approach is the identification of these differential "indicator" species, i.e. species with clear ecological preferences, so that the presence of the species can be used to identify particular site conditions. The program first ordinates the samples and then uses this ordination to obtain a classification of the species according to their ecological preferences. The two classifications are then presented together in an ordered two-way table that expresses the species' relations across a gradient defined by the ordering of the samples. The resulting ordered table is not simply an ordination, rather the arrangement displays the significant features of the data by grouping similar samples together and similar species together.

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[1] Transects excluded from the study typically had high levels of human disturbance.

The dual classification of samples and species proceeds from several steps. TWINSPAN begins by ordinating the samples based on all species using reciprocal averaging (Hill 1973). The program then identifies differential species that are preferential to one end or the other of this ordination; the samples are then ordinated again based on these differential species to obtain the "refined" ordination. Finally, the refined ordination of samples is subdivided to identify similar groups of samples, and the most strongly preferential species or "indicator species" associated with each subdivision are identified.

TWINSPAN is appropriate as a preliminary investigative tool because, relative to other ordination techniques, the method can handle a fairly sparse data matrix resulting from high beta diversity (sample set heterogeneity)[2] and because the initial ordination of samples through reciprocal averaging side-steps the issue of multivariate normality which underlies the success of linear ordination techniques (such as principal components analysis). The disadvantage of TWINSPAN is that it is constrained to a very reduced-dimensional space such that the method works best, as an ordination, when the community data represent one broad environmental gradient. For all TWINSPAN analyses, the default program values were utilized except for pseudo-species cut values (see Table 7). Species codes are listed in Appendix II.

Site factors determining species distribution were assessed through a variety of methods. Key aspects of spatial or geographic patterning were identified through regional plots of species density. Species preferences for specific types of substrate and shoreline configuration were clarified through tables, descriptive statistics, and bar plots, where appropriate.

Species patterns as summarized by TWINSPAN are presented for each of the three marsh zones separately. For identification of marsh transects included in each analysis, see Tables 8 and 9. The concluding discussion section synthesizes these results into a single vegetative classification.

Table 7
Pseudo-Species Cut Values used in TWINSPAN

Pseudo-Species Code	Mean Cover Value Code	Mean Cover Value (%)
-	0.0	absent
1	> 0.0 and < .5	< 10%
2	> .5 and < 1.0	11-20%
3	> 1.0 and < 2.0	21-40%
4	> 2.0 and < 3.0	40-60%
5	> 3.0 and ≤ 5.0	60-100%

[2]When beta diversity is high, some samples have few or no species in common with other samples, resulting in a large number of zero values in the data matrix.

Table 8
Michigan Marsh Transects Included in Vegetation Study

Marsh and Transect[a]	Aquatic Context/ Lake	Marsh Site Type	Vegetation Zones Present		
			Emergent	Wet Meadow	Shrub Swamp
Au Train, A & B	Lake Superior	Lacustrine estuary	●	●	●
Baie de Wasai, A	St. Marys River	Channel-side embayment	●	●	
Baie de Wasai, C	St. Marys River	Channel-side embayment	●	●	
Bar Lake	Lake Michigan	Barrier-beach Lagoon	●		●
Betsie River	Lake Michigan	Lacustrine estuary	●	●	
Big Sable River	Lake Michigan	Lacustrine estuary	●		●
Big Shoal Cove	Lake Huron	Coastal bay, protected	●	●	
Carp-Pine River, A & B	Lake Huron	Coastal bay, open	●	●	●
Cheboygan, A	Lake Huron	Coastal bay, protected	●		●
Cheboygan, B	Lake Huron	Coastal bay, protected		●	
Cheboygan, C	Lake Huron	Coastal bay, protected	●	●	●
Chippewa Point	Lake Michigan	Coastal bay, open		●	
Churchville/Hay, A	St. Marys River	Channel-side wetland	●	●	
Churchville/Hay, B	St. Marys River	Channel-side wetland	●		
Clinton River	Lake St. Clair	Tributary delta	●	●	
Coryeon Point, A	Saginaw Bay	Coastal bay, open	●	●	
Duck Bay	Lake Huron	Coastal bay, protected	●	●	

Marsh and Transect*	Aquatic Context/ Lake	Marsh Site Type	Vegetation Zones Present		
			Emergent	Wet Meadow	Shrub Swamp
El Cajon	Lake Huron	Coastal bay, protected	●	●	
Epoufette	Lake Michigan	Coastal bay, open	●	●	●
Erie Marsh	Lake Erie	Coastal bay, protected	●	●	
False Presque Isle	Lake Michigan	Lacustrine estuary	●	●	
Galien River	Lake Michigan	Lacustrine estuary	●	●	
Gogomain River, A	St. Marys River	Channel-side embayment	●	●	
Gogomain River, D	St. Marys River	Channel-side embayment	●	●	
Grand Island	Lake Superior	Tombolo with swale	●	●	
Hardwood Point	Saginaw Bay	Coastal bay, open	●	●	
Hog Island, A	St. Marys River	Channel-side wetland		●	●
Hog Island, B	St. Marys River	Channel-side wetland	●	●	
Hursley Creek, A	St. Marys River	Channel-side wetland	●		●
Hursley Creek, B	St. Marys River	Channel-side wetland	●	●	●
Independence	Lake Superior	Barrier-beach Lagoon			●
Indian Point, A	Lake Michigan	Coastal bay, open			●
Indian Point, B	Lake Michigan	Coastal bay, open	●	●	
Kalamazoo River, A	Lake Michigan	Lacustrine estuary	●	●	
Kalamazoo River, D	Lake Michigan	Lacustrine estuary	●	●	
Kemps Point	St. Marys River	Channel-side wetland	●	●	

Marsh and Transect[a]	Aquatic Context/ Lake	Marsh Site Type	Vegetation Zones Present		
			Emergent	Wet Meadow	Shrub Swamp
Kenyon Bay	Lake Michigan	Coastal bay, open	●	●	
Lac la Belle, A	Lake Superior	Lacustrine estuary	●	●	●
Little Fishdam River	Lake Michigan	Coastal bay, open	●	●	
Mackinac Bay	Lake Huron	Coastal bay, protected	●	●	
Mismer Bay	Lake Huron	Coastal bay, open	●	●	
Munuscong River, A & B	St. Marys River	Channel-side embayment	●	●	
Muskegon River, B	Lake Michigan	Lacustrine estuary	●		
Otter Creek	Lake Erie	Lacustrine estuary		●	
Pawpaw River, B	Lake Michigan	Lacustrine estuary		●	
Peck Bay	Lake Huron	Coastal bay, protected	●	●	
Pentwater	Lake Michigan	Lacustrine estuary	●	●	
Pequaming	Lake Superior	Tombolo with swale		●	●
Pinconning, A	Saginaw Bay	Coastal bay, protected	●	●	
Pinconning, B	Saginaw Bay	Coastal bay, open	●		
Pine River, A	Saginaw Bay	Coastal bay, open	●	●	
Portage River	Lake Superior	Lacustrine estuary/delta		●	
Pottawattomi	Lake Michigan	Lacustrine estuary	●	●	●
Point Mouillee	Lake Erie	Tributary delta	●	●	
Roach Point, A & B	St. Marys River	Channel-side embayment	●	●	

Marsh and Transect[a]	Aquatic Context/ Lake	Marsh Site Type	Vegetation Zones Present		
			Emergent	Wet Meadow	Shrub Swamp
S. Lloyd Island	Lake Michigan	Lacustrine estuary	●		
Saganing River	Saginaw Bay	Coastal bay, open	●		●
Sand Island	St. Marys River	Channel-side wetland	●	●	●
Scott Bay	Lake Huron	Coastal bay, open	●	●	
Shingle Bay, B	St. Marys River	Channel-side embayment	●	●	
Shingle Bay, C	St. Marys River	Channel-side embayment	●	●	
Squaw Bay	Lake Huron	Coastal bay, open	●		
St. Clair River	St. Clair River	Connecting channel delta	●	●	
St. Martin Point, A	Lake Huron	Coastal bay, open	●	●	
Stony Creek	Lake Michigan	Lacustrine estuary		●	
Sturgeon River, A & C	Lake Superior	Tributary delta	●		●
Sugar Island, A	St. Marys River	Channel-side wetland	●	●	●
Sugar Island, B	St. Marys River	Channel-side embayment	●	●	
Swan Creek	Lake Erie	Lacustrine estuary	●	●	
Tobico, A	Saginaw Bay	Barrier-beach Lagoon	●	●	
Voight Bay	Lake Huron	Coastal bay, protected	●	●	
Waugoshance	Lake Michigan	Coastal bay, open	●	●	
Whipple Point, A	St. Marys River	Channel-side wetland	●	●	
Whipple Point, B	St. Marys River	Channel-side wetland	●	●	

Marsh and Transect[a]	Aquatic Context/ Lake	Marsh Site Type	Vegetation Zones Present		
			Emergent	Wet Meadow	Shrub Swamp
Whiskey Harbor	Saginaw Bay	Coastal bay, open	●	●	
White River, A	Lake Michigan	Lacustrine estuary		●	●
White River, B	Lake Michigan	Lacustrine estuary	●	●	
Wigwam Bay, A	Saginaw Bay	Tributary delta	●	●	
Wildfowl Bay	Saginaw Bay	Coastal bay, protected	●	●	
Wildfowl Bay Islands, A	Saginaw Bay	Coastal bay, protected	●	●	
Wildfowl Bay Islands, B	Saginaw Bay	Coastal bay, protected	●	●	
Wildfowl Bay Islands, E	Saginaw Bay	Coastal bay, protected	●	●	

[a]Transects are specified only for those cases where multiple transects were placed in a marsh.

Table 9
Marsh Transects from Other Great Lakes States Included in Vegetation Study

Marsh and Transect[a]	Aquatic Context/ Lake	Marsh Site Type	Vegetation Zones Present		
			Emergent/ Submergent	Herbaceous	Shrub Swamp
Minnesota Sites					
Fond du Lac, A	Lake Superior	Lacustrine estuary	●	●	●
Fond du Lac, B	Lake Superior	Lacustrine estuary	●	●	
Wisconsin Sites					
Bad River, A	Lake Superior	Barrier-beach lagoon	●		
Bad River, B	Lake Superior	Barrier-beach lagoon	●	●	●
Bad River Mouth	Lake Superior	Lacustrine estuary	●	●	
Bark Bay, A	Lake Superior	Barrier-beach lagoon	●	●	
Bark Bay, B	Lake Superior	Barrier-beach lagoon			●
Dead Horse Bay	Green Bay	Sand-spit embayment	●	●	
Honest John, A	Lake Superior	Barrier-beach lagoon	●	●	●
Honest John, B	Lake Superior	Barrier-beach lagoon			●
Kakagon, A & B	Lake Superior	Lacustrine estuary	●	●	●
Little Tail Pt.	Green Bay	Sand-spit embayment	●	●	
Long Island	Lake Superior	Sand-spit swale	●	●	
Mink River, A	Door Penin.	Lacustrine estuary	●	●	
Mink River, B	Door Penin.	Tributary delta	●	●	

Marsh and Transect[a]	Aquatic Context/ Lake	Marsh Site Type	Vegetation Zones Present		
			Emergent/ Submergent	Herbaceous	Shrub Swamp
Mud Lake	Door Penin.	Barrier-beach lagoon	●	●	
Oconto River	Green Bay	Tributary delta	●	●	
Peshtigo River	Green Bay	Tributary delta	●	●	
Pokegama River, A	Lake Superior	Lacustrine estuary	●	●	
Pokegama River, B	Lake Superior	Lacustrine estuary	●	●	
Raspberry Bay, A	Lake Superior	Barrier-beach lagoon		●	●
Raspberry Bay, B	Lake Superior	Lacustrine estuary	●	●	
Siskewit Bay	Lake Superior	Barrier-beach lagoon	●	●	●
Stockton Island	Lake Superior	Barrier-beach lagoon	●	●	
West Twin River, A	L. Michigan	Lacustrine estuary		●	●
West Twin River, B	L. Michigan	Lacustrine estuary		●	
Ohio Sites					
Huron River	Lake Erie	Lacustrine estuary	●	●	
Old Woman Creek	Lake Erie	Lacustrine estuary	●		
Sheldon Marsh	Lake Erie	Barrier-beach lagoon		●	
Pennsylvania Sites					
Presque Isle	Lake Erie	Sand-spit swale	●	●	
Thompson Harbor	Lake Erie	Sand-spit swale	●	●	●

Marsh and Transect[a]	Aquatic Context/ Lake	Marsh Site Type	Vegetation Zones Present		
			Emergent/ Submergent	Herbaceous	Shrub Swamp
New York Sites					
Barnett Marsh	St. Lawrence	Lacustrine estuary	●	●	
Black Creek, A	Lake Ontario	Barrier-beach lagoon			●
Black Creek, B	Lake Ontario	Barrier-beach lagoon	●		●
Chippewa Creek, A	St. Lawrence	Tributary delta	●	●	
Chippewa Creek, B	St. Lawrence	Lacustrine estuary	●	●	
S. Colwell	Lake Ontario	Barrier-beach lagoon	●	●	
Cranberry Creek	St. Lawrence	Lacustrine estuary	●	●	
Crooked Cr., A&B	St. Lawrence	Lacustrine estuary	●	●	
Crooked Creek Bay	St. Lawrence	Lacustrine estuary	●	●	
Deer Creek, A&B	Lake Ontario	Barrier-beach lagoon	●	●	●
Delaney Bay	St. Lawrence	Lacustrine estuary	●	●	
Dexter Marsh	Lake Ontario	Tributary delta	●	●	
East Bay	Lake Ontario	Barrier-beach lagoon	●		●
Flynn Bay, C	St. Lawrence	Lacustrine estuary	●	●	
Lakeview Pond	Lake Ontario	Barrier-beach lagoon	●	●	
Pt. Peninsula Marsh	Lake Ontario	Barrier-beach lagoon		●	●
Sterling Creek	Lake Ontario	Barrier-beach lagoon	●	●	●

[a]Transects are specified only for those cases where multiple transects were placed in a marsh.

Figure 34. Identification and location of Lake Superior and St. Marys River coastal wetlands included in vegetation analysis. Base map showing wetland locations from Herdendorf et al. (1981a); not all wetlands mapped by Herdendorf et al. are directly influenced by Lake Superior water levels.

Figure 35. Identification and location of coastal wetlands from Lake Huron, St. Clair River, Lake St. Clair, and Detroit River included in vegetation analysis. Base map showing wetland locations from Herdendorf et al. (1981a).

Figure 36. Identification and location of Lake Michigan coastal wetlands included in vegetation analysis. Base map showing wetland locations from Herdendorf et al. (1981a).

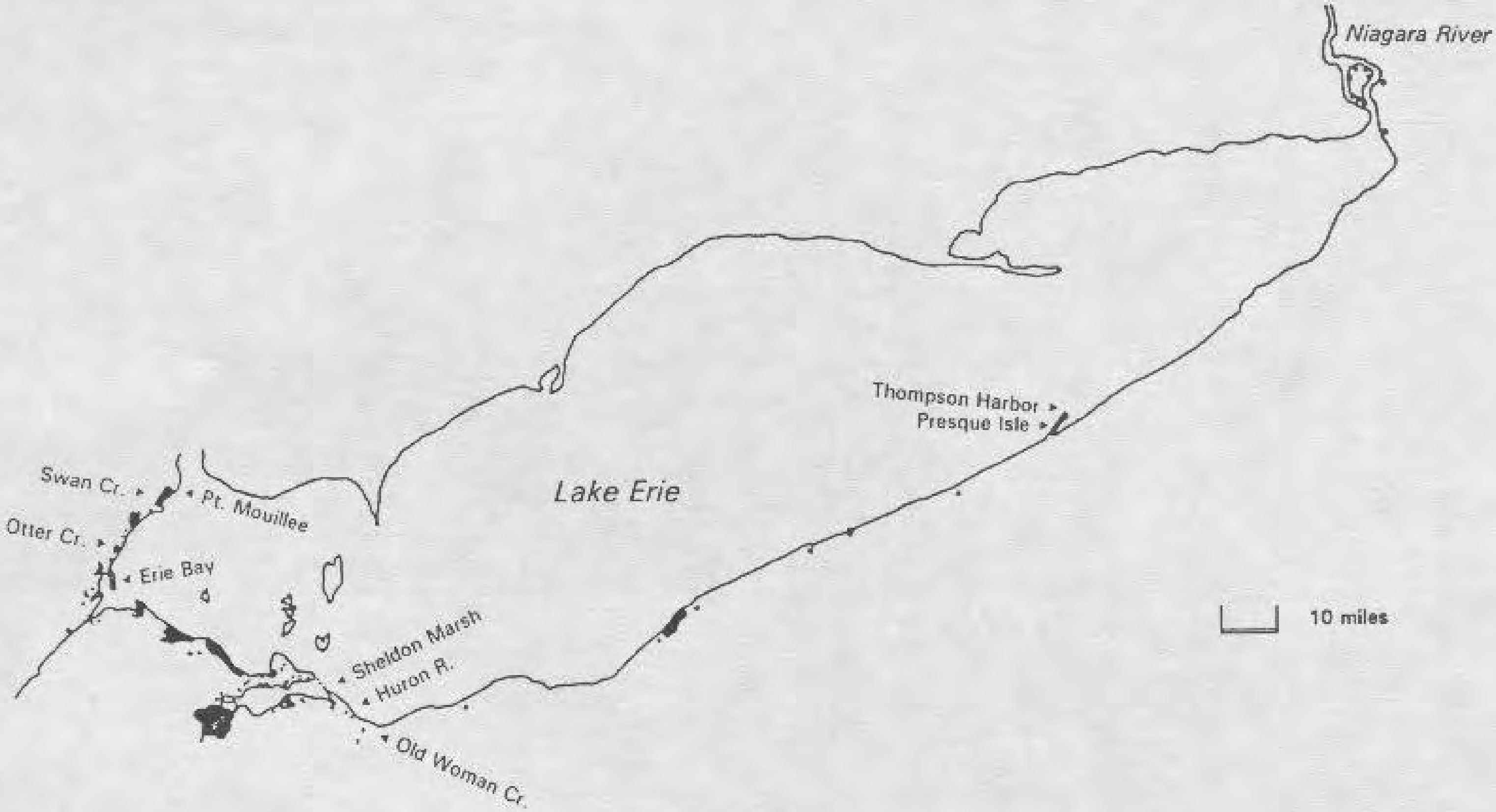

Figure 37. **Identification and location of Lake Erie coastal wetlands included in vegetation analysis.** Base map showing wetland locations from Herdendorf et al. (1981a).

Figure 38. Identification and location of Lake Ontario and St. Lawrence River coastal wetlands included in vegetation analysis. Base map showing wetland locations from Herdendorf et al. (1981a).

RESULTS

A. Emergent Marsh

Emergent marsh was encountered along 111 transects (85%) representing 93 marshes (91% of sample). Emergent marsh zones are well represented in all marsh site types for which we have adequate sample sizes, but are least common in association with barrier-beach lagoon sites (Table 10).

Table 10
Distribution of Emergent Marsh Zones by Marsh Site Type

Site Type	Emergent Marsh Zone				
	Absent		Present		Total
	#	%	#	%	
Coastal Embayment					
Open	2	12.5	14	87.5	16
Protected	1	7.7	22	92.3	13
Barrier-beach Lagoon	8	33.3	16	66.7	24
Sand-spit					
Embayment	0	0.0	5	100.0	5
Swale	0	0.0	4	100.0	5
Connecting Channel					
Channel-side wetland	0	0.0	12	100.0	12
Channel-side Embayment	1	12.5	7	87.5	8
Delta	0	0.0	10	100.0	10
Lacustrine Estuary	7	18.4	31	81.6	38
Total	19	14.6	111	85.4	130

A total of 257 species was recorded along these transects; however, 99 species were encountered in only one transect, while an additional 39 species occurred in only two transects. Overall, the most commonly occurring species were *Scirpus acutus* (hardstem bulrush; 54% of transects), *Nymphaea odorata* (44%), and *Eleocharis smallii* (spike-rush; 43% of transects), followed by *Najas flexilis* (slender naiad, 40%), *Ceratophyllum demersum* (coontail, 47%), *Utricularia vulgaris* (great bladderwort, 39%), and *Elodea canadensis* (common waterweed, 39%). For a complete list of emergent zone species and their ubiquity values, see Appendix III-A.

In order to clarify regional patterning within aquatic species, the TWINSPAN analyses were based on 88 aquatic species (including emergent, submergent, and floating-leaved species) found in three or more transects. The resulting ordered two-way table in presented in Table 11 (see also Appendix IV).

Table 11
TWINSPAN Ordination of Emergent Zones

```
                  |---| |*001 | |                          *01                           | |                  *1                  |
                  IPPSWEFKEPVWWMLBRSWTABBBCDFGGHHKMMMPRSSSSSSSSSSWWWWBHKMMSBCCCGHSLCCPSFFBPBHTCDCCBBCCDFSCWSELPPBPDLOBPKSOGKMPWHDE
                  NIIAHPAELEOIAUAAAIIHUAAAHUIOOUUEAIUIOACHHQTTUUHHIIAOAIITIAHHROTOHOTWOOIOAAORERRALHHELTLH.AAREAEEICEOA.LAAUOIUER
                  DNNGIOLNCCILUDCRSSGOTIIRECSGGRRHCSNNANOIIUCUGGIILLDNKNNOGRUUAGMNERMANNGKDRBOLAORAIIXYEIICSKESDNATOTKLLDLLSTLREI
                  ICCASUSYAKGDGLLKPKWMREELBKHOOSSPKMUECDTNNALRAAPPDDRJAKKCSPRRNIAGBYONDDSERDIOANONCPPTNRNTOTESHRTDTNSEALWIAKADORE
                  AOONKFEOJBHIOAABBEAPADDAOBDMMLLSIES_HITGGWAGRRPPIIIOGABKHPCCDSRIOEUCUUAGIWCKNBKEKPPENLTELBVQTIWHLTIGMOOEMEWFNCB
                  NNNIEE_NOATSSKBAEWMSIEEKYAAAAEE_NRCR S LL IE__LLSSVHO  TOIHH NTSYOLRLLBAVOOEEEETBEERCIOBWAIUIVAOEOEAAYMNAGAB RA
                  _BANY P NY AHEEYRI ONWWEGYMIIYYPA OI N EE ROABEEBEMNN  OAN__ DINGNL ABLMBO DYRDT WW  NN EYEEGATR   MZDA ZOTA _Y
                  B  G  R     A LART N AC A  ADABTC NV D BC  N  AB   A   NLEAB  NDC E   EA D A RC  AB  G  L W O RS   BD N ANTY B

81 typh  lat  ---------------------1111-1--111---1--11--------1--11-----111-------1-1331-----------------------1----1---------1--  0000
 7 carx  lac  -------------------------------------1------------1-1-----------------3-21------------------------------------------  0000
 8 carx  las  ------------------------3--------1-1--11-------------------------------3-3-------------------------------------------  0000
12 duli  aru  --------------12------1-----------------1-----------1------------------1-------------------------------------------  0000
21 junc  bre  -----------------------1-------1---------------------1------11----------------------------------------------------  0000
60 pote  pal  ----------------------11-----1--11---1----------1--------------------2111----1-------------------------------------  0000
77 spar  flu  ---------------123---------------------------1-----2----------------------------------------------------------------  0000
82 utri  cor  -----------------------1------------------------------1--------1-----------------------------------------------------  0000
14 eleo  sma  ------------1--------11-1-2321111-121121121-2-121-311-3-11222-121---111-2-111----------1----1-----1--------1-----  0000
30 myri  het  ---------------2-2-----1-1------1-1----11--1---111-------11-----------------1---------------------------------------  0000
49 pota  gra  -----1---------------11--1122111111111111111211111--1---12-1-14-11-11-----------------2----------1-----------1-  0000
62 ricc  nat  -------------------------------------1----------1----------------------1--------------------------------------------  0000
16 equi  flu  ---------------------1------121111-1-11113---2221---1-----121---------11-------------------------------------------  0000
18 hipp  vul  -----------------------1-1-----1---------------------------------------------------------------------------------  0000
19 isoe  sp.  -----------------------------------------1-------------1--2-------------------------------------------------------  0000
32 myri  ten  --------------------------1-------1----2-----------------2--------------------------------------------------------  0000
40 phra  aus  ------------------2---1-----------1-1-1------1-1-------------------------1-----------------------------------------  0000
50 pota  ill  -----------------------1----1--1-11-111-11--11111---------------1---------------------------------------------------  0000
71 scir  sub  ---------------11-------2---111111322-214---2--------121--3----------------------------------------------------2-  0000
23 junc  pel  ---------1------------------1--------------------------1-2-----1---------------------------------------------------  0001
67 scir  acu  -----1321---2------112111212212122212123312 11-3211----3-3323--3-11----1--2--1------------1-1---1-----------------  0001
27 mega  bec  ---------------12---1---1-11--------1-1--------------221-------------------------------------------3---------------  0001
33 myri  ver  --------------------3-----------------1-------------2----2---2----------11-------------------------2-------------  0001
56 pota  ric  ---1------------1-1-11--11-1-1111-111111-1111-1111-1--1-1-11-----------------1------1-------------1-1-------------  0001
57 pota  rob  --------------------1-11-------1---1-11--------11----1------------1----------------------------3------------------  0001
53 pota  obt  -----------------------11---1-1-1--111--12----11------------------------------------------------1--1--------------  0001
 1 acor  cal  ---------------------1------1------------------------------------------11----1--------------------------------------  0010
43 pota  amp  ----------------2------------------1-11-----------------1-------------------------------------1--------------------  0010
51 pota  nat  -------------11---------1--1-1211-112-31212-2-1-21---111-1--------------1---------12-------1--1-2------------------  0010
34 naja  fle  ----1--------13----13-11-131---111111-12---22131132111-2---------2--1111------1-31----13---1---1---11--------------  0010
10 char  sp.  -1-21331332323----------111--1-1-21---1--3121--------1--2-1---------------1-------21---1-----------2---1-----------  0011
22 junc  can  ---1-12-------------------1-------1------------------1----------------1--1------------------------------------------  0011
68 scir  ame  33-111--1---1-------1--1---111-------3-1-------2---111-1---------1-121--11----------------------1------------------  0011
 3 alis  pla  ---11----------------------------------------------------1---------12-----2---------------------1-----------------  0100
37 nuph  var  -----1-2------1-213--3111--1-1---1---111---1---111-11-321-1-1----------------11-311-------------------12------------  0100
41 poly  amp  --11-11----------------11---111-11111--11--11-1--1-1----1-------1------------1-1------------------1--1---1------1-2---  0100
```

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64 sagi  gra   -----1-1-------2-----------1--------------------------------1--1--------22-1------------------------------3-----------  0100
80 typh  gla   ---2---------------1----2------------------11------1-----------------131--1-----1-----------11------------------1-1---  0101
83 utri  int   ---------------------11----1----11--11-------------------------1-------1-3----2----1--------------1---------------  0110
79 typh  ang   ------------------1--1-1---1---1-1112---11-----------1-----------11-111---441-------1-1----------1112-----------12--  0110
17 hete  dub   ---1------------3-412-----1---------3-1------11----11----------------------------11111--1-------2--1-1-1---------1---  0110
35 nite  fle   ------------------11--1-----------1-1------------1-----1-----------2-----------1-1----------------------------------3  0110
65 sagi  lat   -----1----------------1---11-1-----1-11-1---11-3----111111-12----1---1221123--11-------1---------2-121122------11-2--  0110
75 spar  chl   ---------------------1----1--1------1-1-----1---1------11------------------1-----3--1---------------------------1----  0110
85 vall  ame   --11--------1-------221----2-11-111-111-11--12121-1121-1-----------------1-------1222-3122---2-2-----31--------------  0110
42 pont  cor   ---1--------------------11--111111-111-11111-2-111111121----11---------------------------------22-22--1------11--2-1-11-  0111
55 pota  pra   ------------------------------1-----------------1------------------------------------------1-------------------------  0111
61 ranu  lon   ----------------------------111--1--------1-----------------------------------------1---------------2---1-------------  1000
84 utri  vul   -------------1--1---4-21--11111-121--21---1---11--1-1111-1-----11------111-23-2-33-3333--21-1------1-------------3-  1000
15 elod  can   -------------------22-21112--121--2-1-11-111111---21--1--1-1------------------11232-2212-3222321--24-------------  1001
66 sagi  rig   ---------------3-----------------------------------11111--------------------------32-------111-----------------  1001
29 myri  exa   -------------1--1-1--1-----12---------12-------11--1-1112111---------------------22221222-1------1---211----------------  1001
44 pota  ber   -------------1--------1-1--1---11-1----------------------------------------------2-----1-1----------3----------------  1001
88 ziza  aqu   --------------2--1------1--1----------------1-1---------1131-------------------------31--2--21----------13------1-----2------  1001
54 pota  pec   -------------1-------1-----1---------1---1-----1--2--11-----1-1----------11--1------1-2------112--------11112--1----------3  101
76 spar  eur   ---1-------------13----------212-----------------------13-1-----------------11213-----11----------3---1--411113---111-11--  101
 2 algae  sp   -----------------------------------------------------------------2-------------------------232------------------------  1100
26 lemn  tri   ----------------------------------1-----------------------------------------------12321333324222221-----------------3-----  1100
31 myri  spi   -11---------------31------------------------1------------1-------------1------------2-1-----2-21112---11---1----------  1100
45 pota  cri   ---------------------------------------------1------------------------3------------12--1--11-1--------1---1-------1------  1100
48 pota  fri   --------------1------2---------1-------------------1-1----------------------------2114--1--11--------------------------  1100
52 pota  nod   --------------------1--------------------1----------------------------------------1------------------3------------------  1100
59 pota  zos   ---------------1--12------1-1111111-1---1-1----1---1-1-1---------------1------3-121313331--312--11------------------  1100
 4 bras  sch   ---------------------11--------------------------------------3--------------------------------------1--3-------------------3-  1100
 5 carx  com   -------------------------1----------------------------------------------------1----11---------------------------------1---  1100
38 nymp  odo   -------------1-----1---1-1-1------11111--11112211111---------------1--1-1----1--233133123122313-1--11-24--1-11-3-  1100
 9 cera  dem   ----------------1--1---2-----------11---1---1--1---211------------------1111---2311232353433352413343312 11--11------  1101
78 sprd  pol   ---------------------------------------------------------1-------------------1----3-112-3-23-3-311--3111-111-53441---  1101
36 nuph  adv   -----------------------------------------------------------------------------------------1--------2232--1--1--2--4113-43-  1101
39 pelt  vir   ---------------------------------------------------------------------------------------------------------------43-2244----  1101
86 wolf  col   ----------------------------------------------------------------------------------------------3---------1-----------2-22----  1101
87 wolf  pun   ------------------------------------------------------------------------------------------------------------1----------2-2-------  1101
11 deco  ver   ------------------------1-----------------------------------------------------1-------------------------------------111-----  1110
13 eleo  ery   ------------------------------------------------------------------1-----------------------------------------------11---  1110
25 lemn  min   ---1------------------1-----------1------1-----------------1---------1--1-------1-----1--3--------21131-22142-2-----  1110
70 scir  flu   ------------------------------------1-------------1------------------1--------------------------------11---1---1-------  1110
24 leer  ory   ---1-------------1---------------------------------------------1------1--12-1-----------------------------------1-1-----21-1-2  1111
72 scir  val   --111-2-------------1-----11------------1-------------1---------------11-13111---1---------------2---11-11111-----111-2-22  1111

               00000000000000000000000000000000000000000000000000000000000000000000000001111111111111111111111111111111111
               00000000000000111111111111111111111111111111111111111111111111111111111110000000000000000000000000001111111111
               00111111111111100001111111111111111111111111111111111111111111111111111110000000000000000000001111110000000001
                 000111111111       000000000000000000000000000000000000000000000000000011111111110000000000001111111000001000000001
```

Group *01 = northern (open-water) emergent marsh

Group *001 = northern, marly emergent marsh

Group --- = northern depauperate emergent marshes

Group *1 = southern (protected) emergent marsh

The primary dichotomy separates a generally northern group (Group *0, N=75) from a generally southern group (Group *1, N=36). The northern group is concentrated within Lake Superior, the St. Marys River, and northern Lakes Michigan-Huron as far south as Saginaw Bay; the few sites south of Saginaw Bay are borderline assignments. In contrast, the more southern group is concentrated in southern Lake Michigan, Lake Erie, and Lake Ontario. A substantial number of borderline and misclassified sites fall near this N-S boundary, and suggests that the concept of tension **zone** is more appropriate than that of a sharp border.

Indicator species for the northern emergent marsh Group *0 include *Scirpus acutus* (hardstem bulrush, 60% of group) and *Eleocharis smallii* (spike-rush, 55%); *Potamogeton gramineus* (pondweed, 49%) is also strongly preferential to this group. *Megalodonta beckii* (water-marigold), although not widely distributed, is a northern species restricted to this group. Cover values for *Scirpus acutus* are highest along the St. Marys River and in the Straits area (up to 30% cover), and decrease sharply toward the south (Fig. 39). South of Saginaw Bay, dense beds of this species were encountered only along the St. Clair river delta. The spatial pattern for *Eleocharis smallii* is similar; cover values are generally highest along Lake Superior, the St. Marys River, and northern Lake Michigan, and quite low in the southern Lower Peninsula.

All of these species are characteristics of open, clear waters. *Scirpus acutus* prefers good water circulation in the root zone and sediments low in organic content, and can stand exposure to wave action (Eggers and Reed 1987; Pirnie 1935); *Eleocharis smallii* is known to occupy a similar habitat, although somewhat shoreward of *Scirpus acutus* (Liston et al. 1985:664). The submergent *Potamogeton gramineus* is similarly associated with clear, cool, well-oxygenated waters (Stuckey 1989:234, 1975b), and is generally absent where agricultural erosion has generated silty substrates and/or high turbidity levels (Stuckey 1989:234). This northern group occupies predominantly open-water sites, including coastal embayments (39%) and channel wetlands (25%), although the more protected site types (estuaries, barrier-beach lagoons, and deltas) are represented as well (Table 12).

A distinct subtype of the northern emergent marsh is represented by a group of sites with marly substrates (Group *001, N=9). Most of these sites are located near the Straits of Mackinac, although Mud Lake (Door Peninsula) is included as well. The dominant species in these vegetatively depauperate sites is *Chara* sp. (muskgrass), a species which strongly prefers mineral-rich (limey) water (Eggers and Reed 1987); several of these sites contain the calciphile *Eleocharis rostellata* (spike-rush) as well. *Chara* is also encountered on non-marly sites throughout the northern emergent marsh zone, where its presence may relate to water current or wave activity. This species does not have true roots but is strongly attached to the bottom; it can withstand considerable wave and current action and is often found where other plants have not become established (Liston et al. 1985:722).

Indicator species for the southern emergent marsh Group *1 include *Ceratophyllum demersum* (coontail, 81% of group), *Spirodela polyrhiza* (great duckweed, 64%), and *Lemna trisulca* (star-duckweed, 47%) (Figs. 40 and 41). Other species preferential to this group include *Lemna minor* (small duckweed, 39%) and *Nuphar advena* (yellow pond-lily, 36%), while *Elodea canadensis*, *Vallisneria americana* (wild celery), and *Utricularia vulgaris* attain higher coverage values in the southern group. Most of these southern emergent marshes are relatively well protected sites, including lacustrine estuaries (53%), barrier-beach lagoons (19%), deltas (14%), or sand-spit embayments (11%), with reduced water flow and substantial accumulations of organic (muck) soils (Table 12). The preferential species *Nuphar advena* and *Peltandra virginica* (arrow-arum) are characteristic of these muck soils, while the large cover values for the floating species *Ceratophyllum demersum* and the duckweeds *Spirodela polyrhiza*, *Lemna trisulca*, and *L. minor* reflect relatively protected waters with a high nutrient content.

Table 12
Distribution of Emergent Marsh Types by Marsh Site Type

Site Type	Emergent Marsh Type			
	Northern		Southern	
	#	% of N.	#	% of S.
Coastal Embayment				
Open	14	18.7	0	0.0
Protected	12	16.0	0	0.0
Connecting Channel				
Channel-side Wetland	12	16.0	0	0.0
Channel-side Embayment	7	9.3	0	0.0
Lacustrine Estuary	12	16.0	19	52.8
Barrier-beach Lagoon	9	12.0	7	19.4
Sand-spit				
Embayment	1	1.3	4	11.1
Swale	3	4.0	1	2.8
Delta	5	6.7	5	13.9
Total	75	100.0	36	100.0

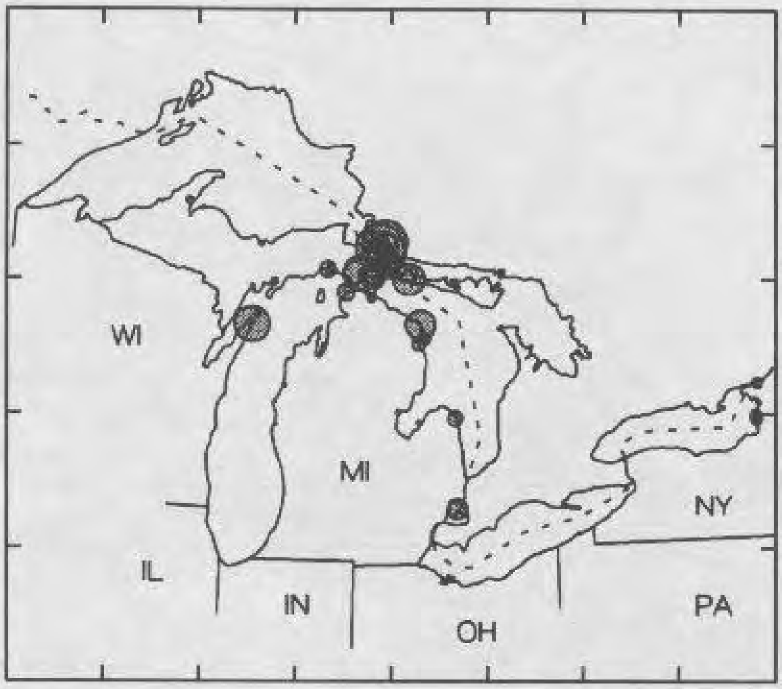
Subdivisions within the southern group are not strong; rather the TWINSPAN ordination appears to chain together a series of closely related subtypes. In general, the sites are ordered geographically, suggesting a gradual and minor shift in species composition from Lake Ontario-St. Lawrence River (most similar to the northern emergent marsh type) to the estuaries of southern Lake Michigan (least similar to the northern emergent marsh type).

Several species are preferential to Lake Ontario and the St. Lawrence River, including *Lemna trisulca* and *Potamogeton zosteriformis* (flat-stemmed pondweed) (Fig. 42); the exotic *Hydrocharis morsus-ranae* (frog's bit) is also restricted to these sites. Voss (1972:371) notes that the largest and most luxuriant masses of *Lemna trisulca* are found in cold, spring-fed streams, while *Potamogeton zosteriformis* is considered among the group of submergents associated with clear, open water (Stuckey (1989:230, 235). Many of these sites are in fact fed by cold-water streams flowing off the uplands.

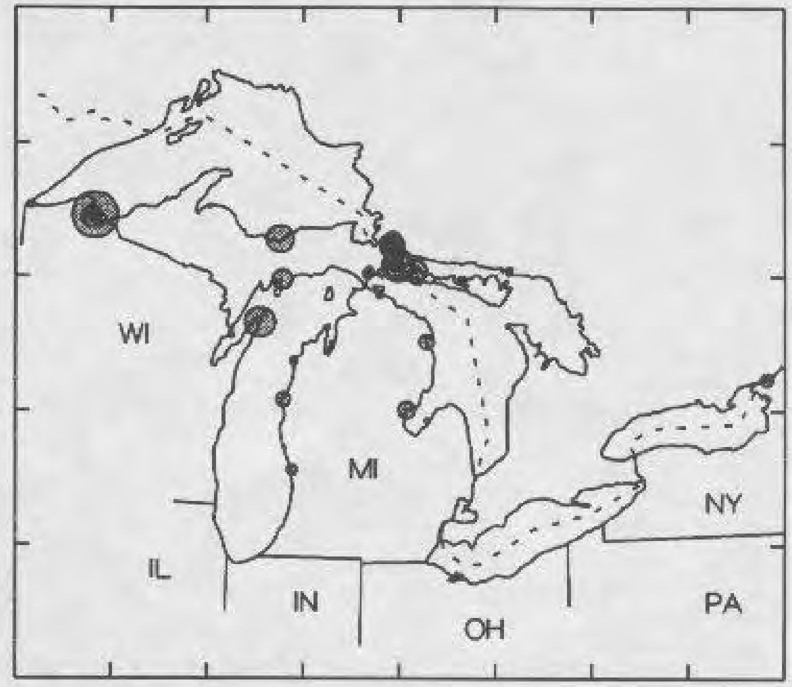
In contrast, *Lemna minor* and *Peltandra virginica* are concentrated in Lake Michigan (Fig. 43). Unlike *Lemna trisulca*, *L. minor* floats on the surface of standing, even stagnant water, while *Peltandra virginica* is at home in shallow, muddy waters (Voss 1972:367). These species distributions suggest that minor differences in latitude and/or water flow may generate

Table 13
Species Associated with Regional Subdivisions of Emergent Marsh Zones

Species	Ubiquity (% of transects)					Average Cover Value (%)				
	Northern		Southern			Northern		Southern		
	Non-Marly	Marly	Total S.	Lake Ontario	Lake Michigan	Non-Marly	Marly	Total S.	Lake Ontario	Lake Michigan
Scirpus acutus	**66.1**	62.5	11.1	14.3	11.1	**7.7**	6.9	0.6	1.0	0.5
Eleocharis smallii	**66.1**	12.5	16.7	14.3	22.2	**6.0**	0.2	0.7	0.6	1.0
Potamogeton gramineus	**58.1**	12.5	8.3	7.1	11.1	**3.0**	0.5	0.3	0.1	0.6
Megalodonta beckii	**17.7**	0.0	2.8	0.0	0.0	**1.0**	0.0	0.6	0.0	0.0
Chara spp.	25.8	**100.0**	13.9	21.4	11.1	1.6	**16.4**	1.3	2.0	1.2
Eleocharis rostellata	0.0	**37.5**	0.0	0.0	0.0	0.0	**6.4**	0.0	0.0	0.0
Ceratophyllum demersum	24.2	0.0	**80.6**	92.9	72.2	1.5	0.0	**20.5**	31.0	12.6
Lemna spp.	11.3	0.0	**77.8**	92.9	83.3	0.3	0.0	**13.6**	17.6	13.5
Spirodela polyrhiza	3.2	0.0	**63.9**	57.1	66.7	0.2	0.0	**11.3**	9.2	15.1
Nuphar advena	0.0	0.0	**38.9**	28.6	50.0	0.0	0.0	**7.7**	3.6	11.6
Lemna trisulca	1.6	0.0	47.2	**92.9**	22.2	0.0	0.0	8.7	**17.3**	4.0
Potamogeton zosteriformis	0.6	0.0	41.7	**85.7**	11.1	1.2	0.0	5.8	**13.7**	0.7
Hydrocharis morsus-ranae	0.0	0.0	19.4	**50.0**	0.0	0.0	0.0	3.5	**9.1**	0.0
Lemna minor	9.7	0.0	38.9	14.3	**66.7**	0.2	0.0	4.9	0.4	**9.5**
Peltandra virginica	0.0	0.0	16.7	0.0	**33.3**	0.0	0.0	5.7	0.0	**11.5**

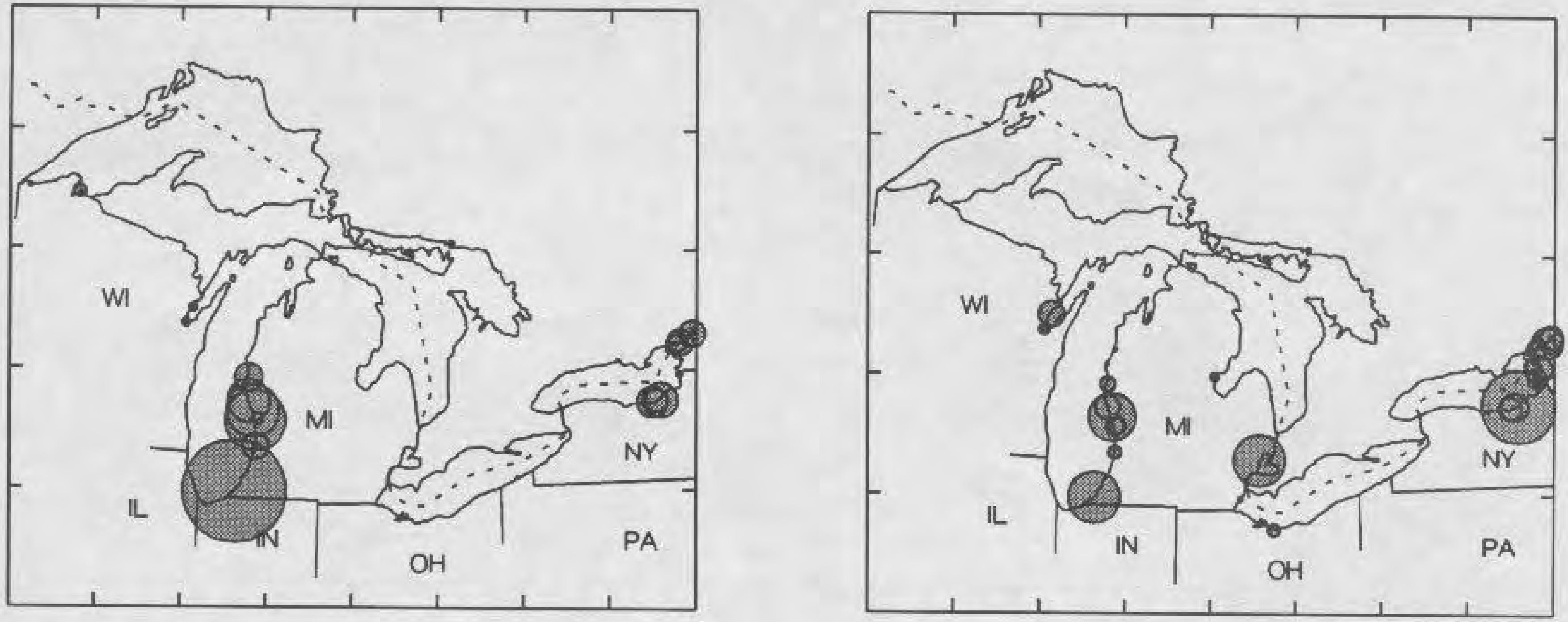


Scirpus acutus



Eleocharis smallii

Figure 39. Distribution of indicator species for northern emergent marsh: *Scirpus acutus* (hardstem bulrush) and *Eleocharis smallii* (spike-rush). (Symbol size reflects mean cover value of species in the emergent zones of 93 coastal Great Lakes wetlands.)



Spirodela polyrhiza

Lemna spp.

Figure 40. Distribution of indicator species for southern emergent marsh: *Spirodela polyrhiza* (great duckweed), and *Lemna* spp. (duckweed). (Symbol size reflects mean cover value of species in the emergent zones of 93 coastal Great Lakes wetlands.)

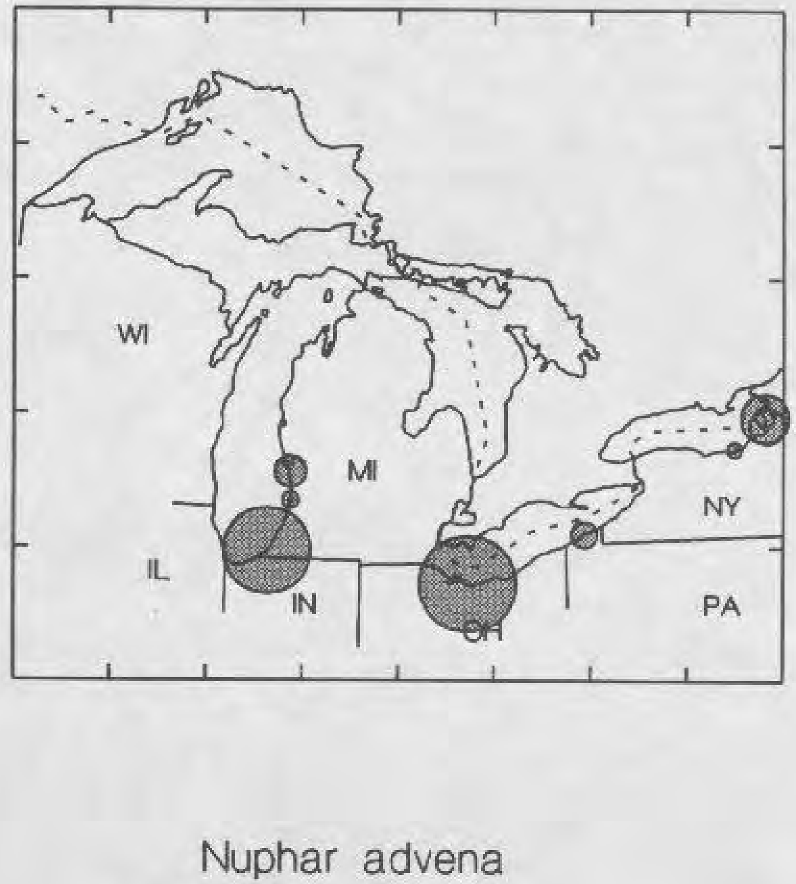
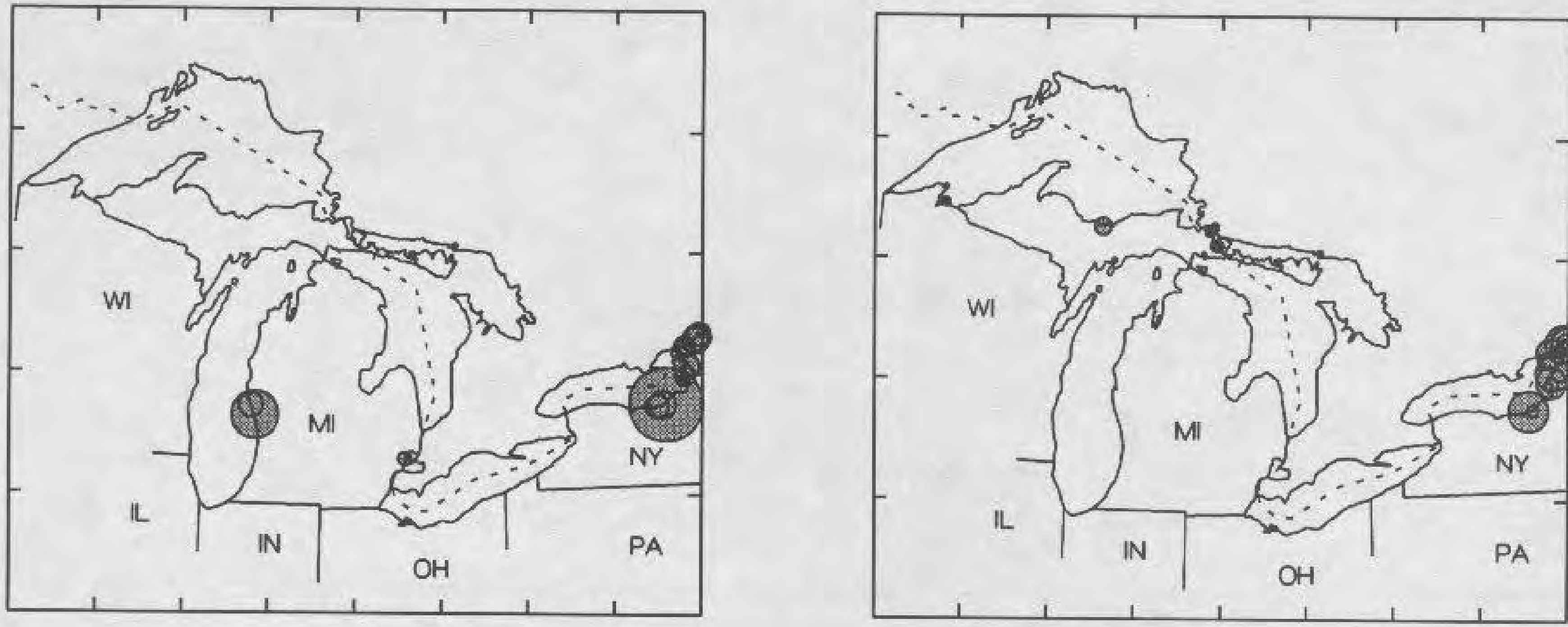


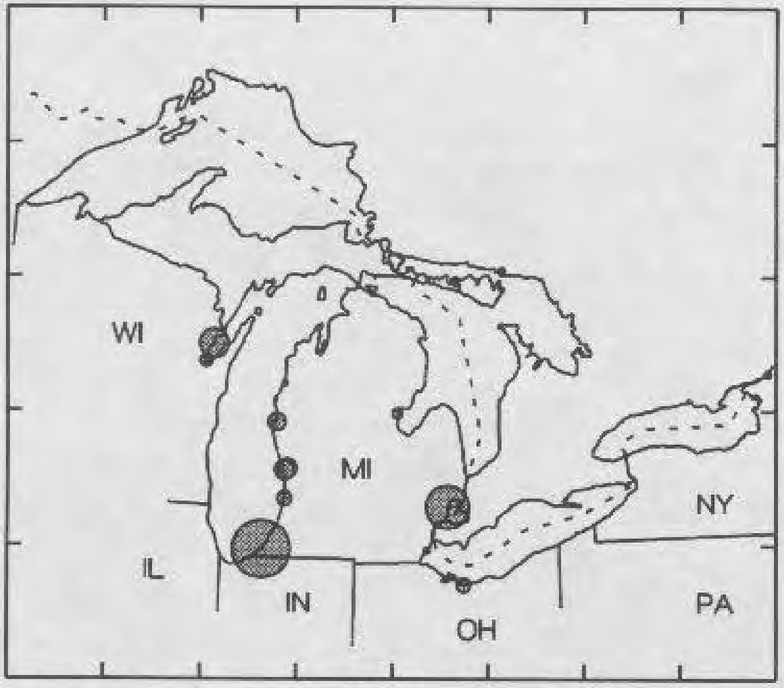
Figure 41. Distribution of indicator species for the southern emergent marsh: *Ceratophyllum demersum* (coontail) and *Nuphar advena* (yellow pond-lily). (Symbol size reflects mean cover value of species in the emergent zones of 93 coastal Great Lakes wetlands.)



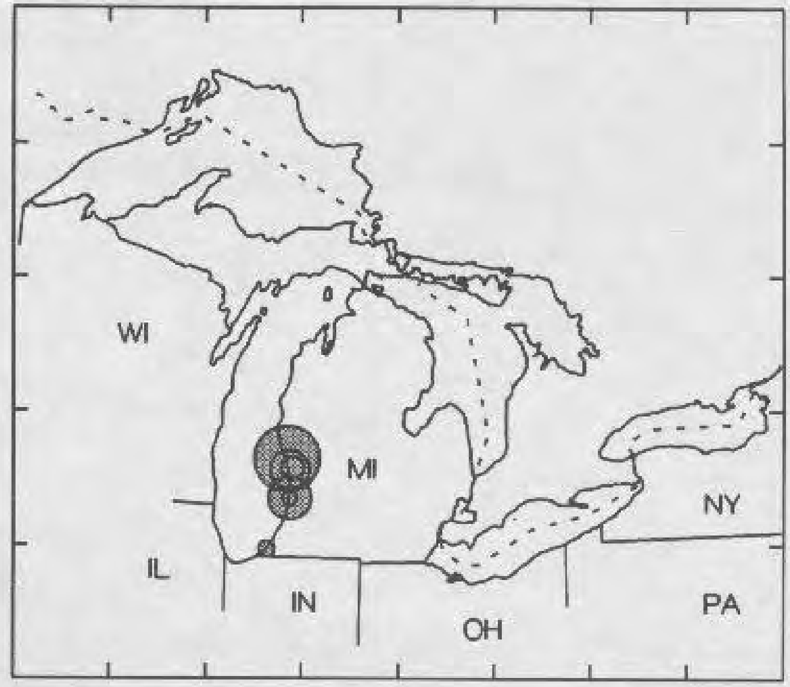
Lemna trisulca

Potamogeton zosteriformis

Figure 42. Distribution of southern emergent zone species preferential to Lake Ontario and the St. Lawrence River: *Lemna trisulca* (star duckweed) and *Potamogeton zosteriformis* (flat-stemmed pondweed).



Lemna minor



Peltandra virginica

Figure 43. Distribution of southern emergent zone species preferential to Lake Michigan: *Lemna minor* (small duckweed) and *Peltandra virginica* (arrow-arum).

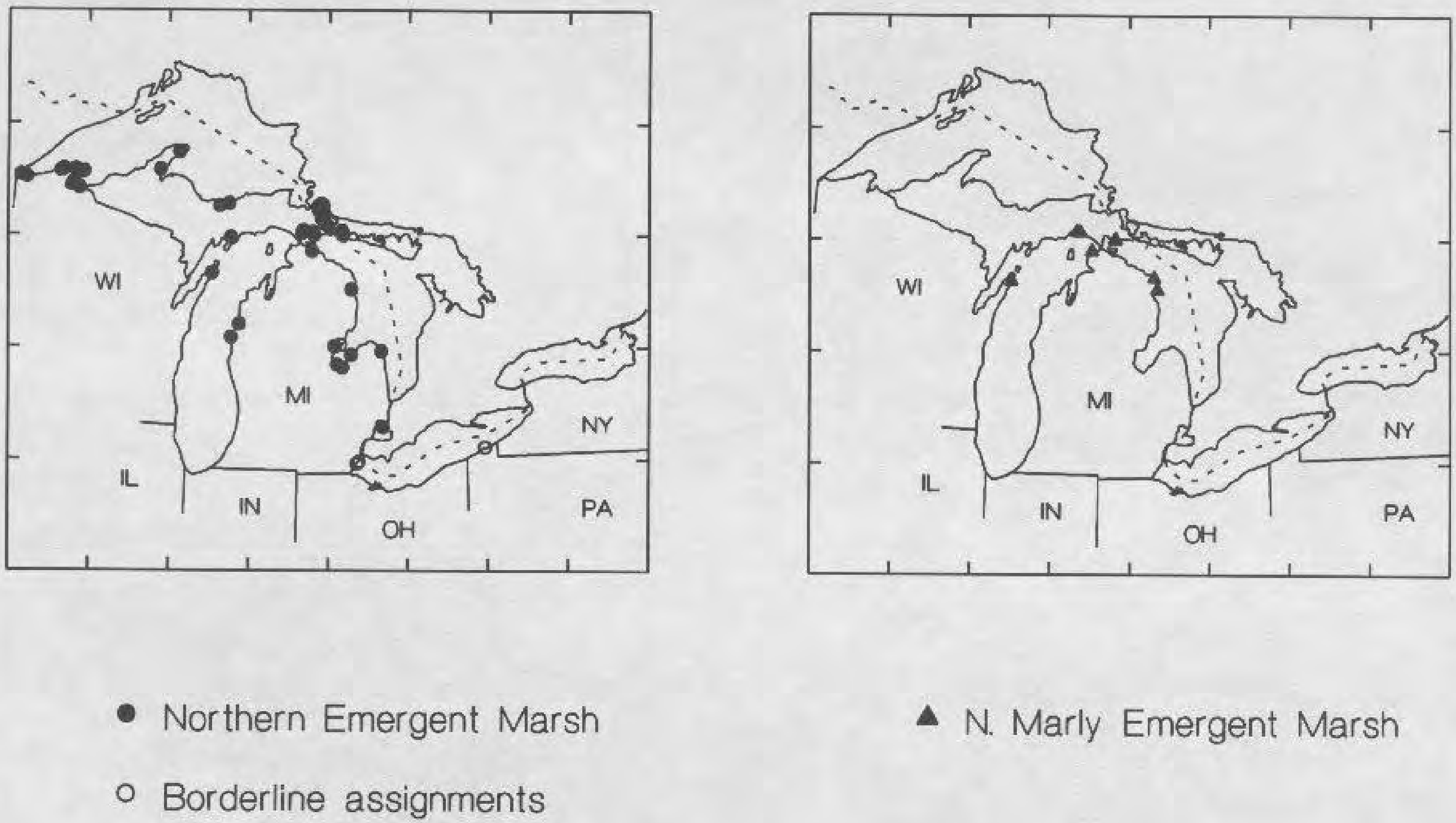


Figure 44. Distribution of northern emergent marsh types.

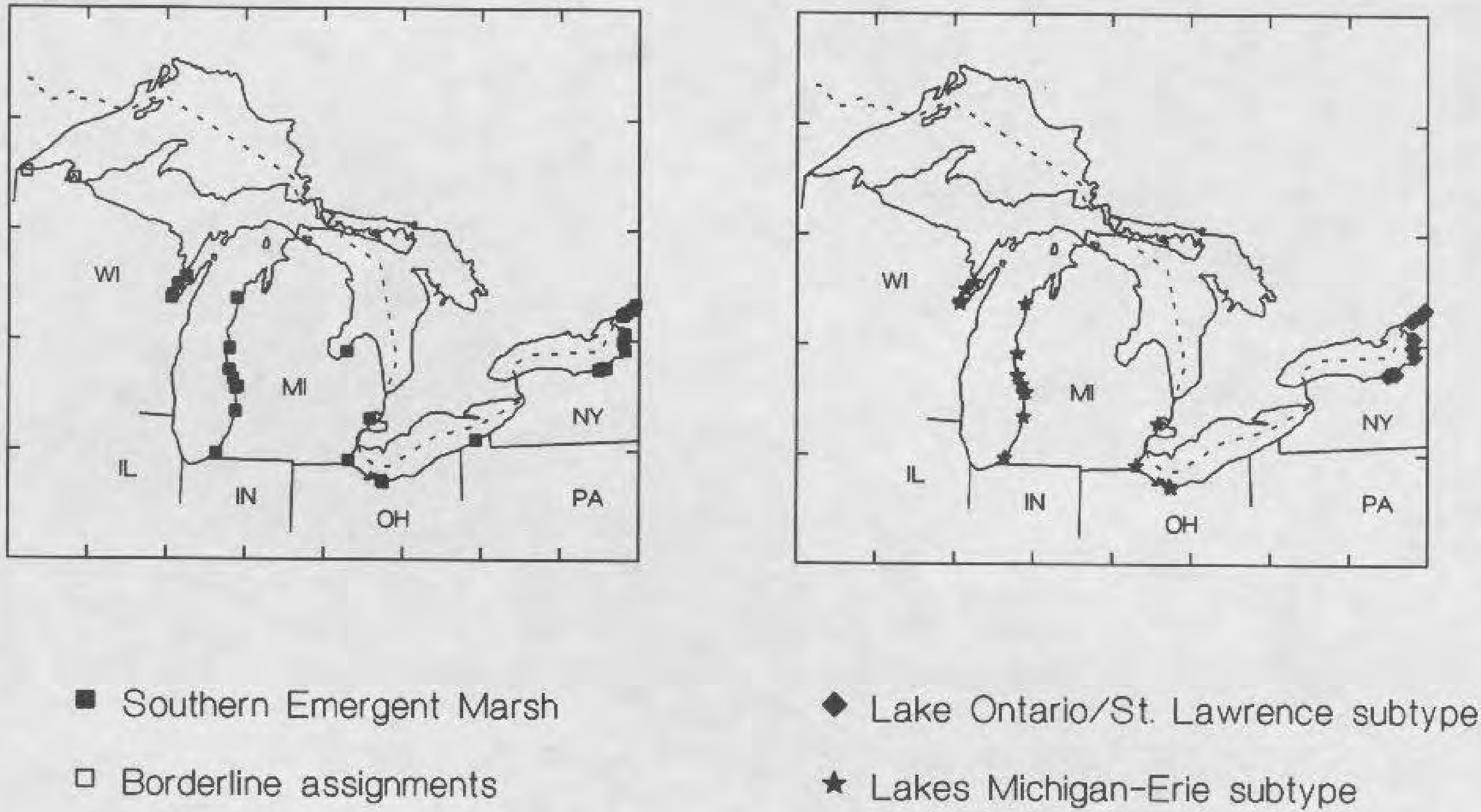


Figure 45. Distribution of southern emergent marsh types.

B. Herbaceous Zone/Wet Meadow

An herbaceous zone was encountered along 109 transects (84%) representing 96 marshes (94% of sample). Wet meadow zones are well represented for all marsh site types for which we have adequate sample sizes, but are least common in association with barrier-beach lagoon sites (Table 14).

Table 14
Distribution of Herbaceous Zones by Marsh Site Type

Site Type	Herbaceous Zone				
	Absent		Present		Total
	#	%	#	%	
Coastal Embayment					
Open	3	18.8	13	81.2	16
Protected	2	15.4	11	84.6	13
Barrier-beach Lagoon	8	33.3	16	67.7	24
Sand-spit					
Embayment	0	0.0	5	100.0	5
Swale	0	0.0	4	100.0	4
Connecting Channel					
Channel-side Wetland	2	16.7	10	83.3	12
Channel-side Embayment	0	0.0	8	100.0	8
Delta	1	10.0	9	90.0	10
Lacustrine Estuary	5	13.2	33	86.8	38
Total	20	15.4	109	84.6	130

A total of 413 species was recorded along herbaceous zone transects; however, 135 species were encountered in only one transect, while an additional 64 species occurred in only two transects. Overall, the most commonly occurring species was *Calamagrostis canadensis* (blue-joint grass, 82% of transects), followed by the sedges *Carex stricta* (56% of transects) and *C. lacustris* (48%), along with *Polygonum amphibium* (water smartweed, 51%), *Impatiens capensis* (spotted touch-me-not, 48%), *Campanula aparinoides* (marsh bellflower, 47%), and *Typha latifolia* (broad-leaved cat-tail, 44%). For a complete list of emergent zone species and their ubiquity values, see Appendix III-B.

Owing to the very large number of species recorded, the TWINSPAN analysis was limited to 140 species found in 5 or more transects. The ordered two-way table these species and herbaceous-zone transects is presented in Table 15 (see also Appendix V). Even with this reduced data matrix, the main TWINSPAN divisions are marked by low eigenvalues and multiple border-line cases. However, the vegetation data do suggest several distinct types of herbaceous zone, along with several transitional or intermediate types.

Table 15
TWINSPAN Ordination of Herbaceous Zones

```
                *00       *010                                   *01011         *0110                      *0111         *1
                EKEPVBCCWFPPBBCDGHKRSSSSWWKRBCCFGHHIMMMSSSTLMMMPWBCCCDDLSWDFPSCPDOBCGKKPPPPSWCPHSTLCFEOPSWWCWWWHWWGSBAPRSLPBH
                PELEOIHHAOOOAAHUOUEOAHUUHHAAAAHIOOONAIUCHTOOIIUE.AHRREEAT.EATTHRECELAAAAEIOTHOTUHHIRLRTIWHIOHIIAIIRIAUEATAOAO
                ONCCIGEEUNKKDIUCGRMANIGGIIKSIRISGGGDCSNOIMBNNNDSTRIAOLXKETELMCIEAOTILLLWNNTOILPREOTOYITNAILRIGLRLLASDTQSOCRRN
                UYAKGSBBGDEERERKOSPCDNAAPPAPEPPHOIIIKMUTNAIGKKLHWNPNOATERWRSOLPSDNSNIAAPTCANTWEOLMTONEEENTDYSWDDDDNKRRUPCLTKJ
                FOJ HHOOOUGGIDCBMLSHIGRRPPGBDPPDMSSAIESTGRCIRRATIEPBKNEVLIBEUAPQHTITEMMAWOWYEENNDPLKNBR CEIEKAIWFIDEIAABKAABO
                ENO TOYYSLAAVAHAAE  SL__LLOEEIEAANNNNRC LTOSIIKINTEEEERIIN  LIEUOOEONAAWANA_ALI OSEECA  RBSOEMSOBS WVIMETBGAH
                T N  AGGHAMMMWAYIY   EABEENRWNWMIDD A O EI NVVEG_TWRDY EN_  LRWER  N ZZ TNTC LN NO D Y    LNY LOAL IBNIROEEYN
                T    LBCACAB A  DB   C  AB BCEA AAB C N BN DAB OA ARA  WGB  E B S    AD RATR     N C      E   ADYB T  NANL AA

 93 pote  nor   --1-1-1------------1-------1--------------1----1-1--------1--------1---------1-------------------------------  000000
 26 carx  vir   122122132----------------------------1----1-1----------------------------------------------------1-----------  000001
 39 eleo  ell   -----21-1---------------------------11---------------------1--1---1-----------------------------1------------  000001
 67 lobe  kal   1111111-2------------------------------------1---------------------------------------------------------------  000001
 91 pote  ans   -2-111211----------------------1----1--1-------------------1-1--11---------------------1--1----11------------  000001
112 scir  ame   1-1--122------1---------------------2-------2------------------211-----------------------------1-1-----------  000001
 18 carx  hys   ------1-1----------------------------1--------2-----------1------111--------1--------------------1-----------  000010
 31 corn  amo   ------1------------------------------------1-----------1-2----1----1---------1-------------1-1---------------  000010
 47 eupa  per   11--111-1----------1----------1-----11----1---111------1---11-----1--1--1-11------1--11----111-111-----------  000010
 49 frax  pen   --1---1-------------1----------------1-11-11---------------11-1--------1---------1------1-----11-1-----------  000010
121 sola  dul   ------1--3----------------------------------------1------1--------1----1----1--------------------------------  000010
 79 phal  aru   ---1-11-1----------------------1-----1-1--1-1-1111---11-2-1-12-1-2-11---1-------41-2--14-1-----1-------------  000011
 80 phra  aus   --------------------1-1--------------111----11--1-1--------1-1--1----1----1-----32---21-2-11-----1----------4  00010
  3 alis  pla   ------------------------------------1-----------------1-------1-----------1--------1-11-1---11-1-------------  000110
  6 ascl  inc   ----------------------------------------1--1-1-----1-1----1--111---1---11----1---------1---------------------  000110
  8 bide  cer   --------------1--1-1---1--------------------------1-----------------1--21-3---1------1-242-3533112-----------  000110
 12 caly  sep   -------------------------------------------1-------11-------------1-1---1-------2212-1-----1-----------------  000110
 16 carx  com   ----------------------------------------------------112---1----1--11------11--------2------------1-----------  000110
 32 corn  foe   ---------------------------------------------------111--------13-------------------22------------------------  000110
 35 deco  ver   ----------------------------------------------------11---1-1--------1--1--3---2------------------------------  000110
 42 epil  col   -----------------------------------------------------1--------1---1--1--1-1--------11-----------11-----------  000110
 54 impa  cap   ----------3-3-1-11-1-------1---11--11------1-121-21211211-1--1-1--1125221323123111223111212--11---1----------  000110
 61 junc  eff   -------------3------------------------------1----------------1--121-----1------------------------------------  000110
 66 leer  ory   --------------------------------------------1-------------------111-1-211-1-1-1------21-31--1-----1----------  000110
 72 lyth  sal   ------------3--1---------------------------13---1--1-1------31--13-1-11---1--1----1--11----1-----------------  000110
 78 pelt  vir   -------------------------------------------------------1--2---------3-22--3--11------------------------------  000110
 81 pile  pum   ---------------------------------------------------1-----1----------1--12-2-1-----1---1--1-------------------  000110
 84 poly  lap   -------------------1---------------------------------------------1-11111-2111--------32-42-1----1------------  000110
 85 poly  per   ---------1---------------------------------------------------------------------------111-1111111-2-----------  000110
```

```
 86 poly  pun  ---------------------------------------------------------------1-------11-1-1-1---1----1--11------------------  000110
 95 ranu  sce  -------------1--1-1------------------------------------------1-----------1-1-1--------1-111-1-111------------  000110
 97 rori  pal  ------1-----------1-----------1---------------------1--1-111----111-11121121-------2123322111112-----------  000110
115 scir  flu  ---------------------------------------------------1----1-1----------1--1111--------1-12-11-------------------------  000110
123 spar  eur  ----------------1-1-------13---1---1--------1-----1111---1----12111-11121-12112---1--11-121--11----1---------  000110
132 typh  ang  ------11-------11----1-----------------1-----11---433132342312-3122-33--32----3111-333224111--11111-----------  000110
134 urti  dio  --------1------------------------------------------------1---------1-----12111--1--1----1--------------------  000110
137 verb  has  ----------------------------------1-----1------------------111-1-1----11-111-----1--11----1---1-1-----------  000110
  2 acor  cal  ---------3---------------1--------------------1-----11-21---------------------------------------------------  000111
 15 carx  beb  ---------1-------1--------------1---1----1---2-11--------1-1111-11-------1-1--------------------------1-----------  000111
 50 gali  pal  ----------------------11-------------------------------222-----------------------21------------------2----------  000111
 65 lath  pal  ----------------1--1----------1-1----1---11--1111-1-1-1------11---1------------------1---------------------------  000111
 83 poly  amp  -------------1111-11--1-21----111---1111121-11211211122211-2-11--112-52-1-1--11---1-1-1--221-11-121----------  000111
100 rume  orb  ----------------1----------11----------------------11-1-1----1----1---1--1-1--111--------1-----------------------  000111
118 scut  gal  ----------------21-11---1------111---111--121-11---1-111111-111----11--121--1-11--1-111111-1------1------------  000111
 68 lycp  ame  --1---111-------11-11----------------11----1---------1-1-1-1--111----1-11--1-11-12--11-1--1----1---11-1---1-----  000111
 11 cala  can  541111211---3311223312233-1-232243221232322-33335211222114-2431544311113251-443-333221-2-321--13211--1-1-1---  001000
 29 cicu  bul  1--------3---1----1--1--1-11--------11-----1--11111-1-111111----111111-11-132-111---111-----1------11-11----------  001001
 46 eupa  mac  ----------------------1--------------11-1-11-112111---------1--------1-1-111-111-----1-------------1-21-----------  001001
 51 gali  tri  ---------------111-111-----------1-----1-1--11---112-1112---1--1-1-111-1--1---11-----112111-11------1111----------  001001
111 scir  acu  --11221-1------------------1----1------111211---11-------1------1----11--1------1--------------------111-----1--------  001001
117 scir  val  -----1-------3-----------------------1------1--1------1-----1----11221-211-1-11---------11111-23131-11----------  001001
 20 carx  lac  ---------3344--441433423-233--2--------231--1-11312112114-1-----1-11---1111--13-1---1------1-1--111-1-1---------1  001010
 23 carx  ros  ---------3--4---------211--12-------------1------1-------1---------11-----------1-------------------1------1-----------  001010
 33 corn  sto  --------------------------1---------1--11--1-11111--1------11----1---1--------11--------------------111-1-----------  001010
 71 lysi  thy  -------1--------1--1-------2------1--121-----1-111-221112121211--1----1-----------21-----11-----------------11---------  001010
 76 onoc  sen  ---------5-----------1----------------------11--1-1-111-1--1----1--------------1------1-11-----------------1----------  001010
125 spir  alb  ------1-------31-1-11-11-2-1-1-1111-1-2-21-1----11--1-2-3--1----11------------1-1---------------1-------1--1---1-----  001010
127 thel  pal  ---------------------------------1-----1-------2-1111-21111213111-11------1------11--3----1----------------1----------  001010
 44 equi  arv  -------------2-------1---------1-----1--1-1------------------------------------1--------------------1-2------1-------  001011
114 scir  cyp  -------------1------1--------------------1----1--1----1---------1-1------------1-------1-----------------------------1  001011
120 sium  sua  ---------------1-1-1--------11-1-------1-------------111-1-------------------1---------1-----11--------1--1------------1---  001011
 25 carx  str  3-----11-----514-12-13133-511-133332-13432242112322111--2--1-1-313-131--2-2-1-2------121---1-2-----1112-----------  00110
108 salx  pet  ------1--------1-11111-1------1-12111111-1-11-1--1---11----11-----1--------------------------1----------------------  00110
103 salx  can  -----11-----------------------11---1121-1-1--11--1------------1------------------1-----------------------------------  00111
 14 carx  aqu  ---1-----1------3111111--2-11-322-2221--2--1--2121--1122---11------11-------2-2311--------------------12-1-----------12  01000
107 salx  ped  ------------1------1-11-111--11---------1--1-------------------1--------------------------------------------1----------  01000
 13 camp  apa  1--11-1-------1-11--1---1--2-111111-1211-111122212211111111-1-1---11--1--1-1211---------------------111---------  01001
 69 lycp  uni  ---11----------1-------------------1--1------2-1111121-11---1--------------------1---2--1-------1---111--1---------  01001
 87 poly  sag  ----------------------1-------------------1----------11-11--------------11----------------1---------------1------------  01001
133 typh  lat  -------1-1----131121112112123-1--1-11--1111---11-1-111---------------11--112-111-------2--1-1-1---------111-------1--  01001
  4 alnu  rug  -----11--3---2-2---1-1-1--1--111-1-1-11-11--111-11-11--1-2---------1---------111-------------------1-----11-11---1--  01010
 94 pote  pal  1-------------311-1-11-111-1111-1-111121-11---1111-1111--1211---1-------------1---1-----------------------1---1121-1--1--  01010
 45 equi  flu  ------1---3---3-1--1-11----------1---2----11----------11--1-------1----------------------------------------1-1-1---1-1  01011
 55 iris  ver  --------------------------11------1--1-1-2-1--111-----------------------1------------------------------------11-----1--  01011
 70 lysi  ter  1----------------1------1------1-2------1-----11-----------------------------1---------------------------1-----------1  01011
 73 ment  arv  ---------3-----------------------------------1--11--------------1-------1-11-----11-----11--------------------1---------1--  011
 88 pont  cor  -------------11-11---11-------------------------------------1----------1-1-1-1-------1--------1----1----1-----------1-1  011
101 sagi  lat  -----11------3---1----1-----2---------11-----1--11111111111--1----11121------1-11133----------11------21--1-11-----1-3  011
 52 glyc  can  ------11-1------------------------1-----------11------1-------------1--------------------------------------------1----------  10
 57 junc  bal  -3211-1-1-----------------------11----1-------12-----------------------------------------------1---------------11-1----------  10
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 92 pote  fru  --1111111----------------------1----2-1-----------------------------------------------------------1-1--1-------  10
131 trig  mar  1-1--1111---------------------------11------------------------------------------------------------1--1---------  10
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 58 junc  bre  -----2-11----------------------------1----1-1-------------------------------------------------------2---------1  11000
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110 sarr  pur  --1-1-1--------------------1------------------------------------------------------------------------11121211---  110010
 22 carx  lim  ----1------------------------------------------------------------------------------------------------112121-1--  110011
 28 cham  cal  ----------------------------------------------------------------------------------------------------1121111-111  110011
 74 meny  tri  ----------------------------------------------------------------------------------------------------11312211---  110011
 82 pogo  oph  ---------------------------------------------------------------------------------------------------3-1111-12---  110011
 96 rhyn  alb  ----------------------------------------------------------------------------------------------------11-22221---  110011
124 spha  sp.  ---------------------------1-------------------------------------------------------------------------1313135---  110011
 19 carx  int  --11--------3-------------------------------1-1------------------------------------------------------11--------  110100
 37 duli  aru  ------------3--------1----------------------1-------11-----1----------------------------------------1--1--1-133  110101
 75 myrc  gal  ---1111------11-------11---1-2211-2-1-1--1--1--3-----------1----------------------------------------2131232-221  110101
129 tria  fra  ---------------------------1--1-----1--------1-1-----1----1-----------------------------------------111--1--1--  110101
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 98 rosa  pal  ---------------------------1---------------1---11------------------1-------111----------------------111-1------  111

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Group *1 Northern Poor Fen
Group *00 Northern Rich Fen
Group *010 Northern Wet Meadow
Group *01011 Transitional Northern-Southern Wet Meadow
Group *011 Southern Wet Meadow

The initial dichotomy separates out a small group of Lake Superior sites containing northern poor fen (Group *1; N=11) from all other sites (Group *0; N=98). Indicator species for the poor fen group are *Chamaedaphne calyculata* (leatherleaf, 91% of transects) and *Menyanthes trifoliata* (buckbean, 73%) (Fig. 46). Other species preferential to Group *1 that are characteristic of poor fen include *Sarracenia purpurea* (pitcher-plant, 73%), the *Sphagna* (64%), *Rhynchospora alba* (beak-rush, 64%). In general, poor fens located along the Lake Superior shoreline (the coldest of the Great Lakes) are characterized by a reduced rate of organic decomposition (resulting in deep accumulations of organics) and sandy substrates. Poor fens are typically acid; organic soils from along Lake Superior yield pH values in the range of 3.7 to 4.4 (extremely acid), while underlying sandy subsoils average 4.5 (very strongly acid) (Comer and Albert 1993).

The second dichotomy separates out northern sites containing a well-developed rich fen (Group *00; N=9). In contrast to poor fens, rich fens have marly soils in the herbaceous zone. These marls may have a pH as high as 8.2 (strongly alkaline), while associated organic and mineral soils have pH values typically in the range of 6.3 to 7.5 (neutral to mildly alkaline) (Comer and Albert 1993). The high pH of these sites results from several interacting factors: (1) substrates are either calcareous clay tills or lacustrine clays, although they may have a thin veneer of sand; exposure to wave action erodes or prevents build-up of organic materials; (2) seepages off the adjacent limestone bedrock or limestone-rich till continually resupply calcium-rich groundwater; and (3) in shallow protected waters, warm temperatures and carbonate saturation leads to algal precipitation of calcium carbonate. The result is the formation of distinctive "marly flats" such as are found near the Straits of Mackinac at Indian Point, Epoufette Bay, Kenyon Bay, Peck Bay, Voight Bay, and Big Shoal Cove in the Upper Peninsula, as well as at El Cajon Bay, Duncan Bay (Cheboygan), and Waugoshance Point in the Lower Peninsula.

Indicator species for the marly group include the sedge *Carex viridula* (100% of transects), *Lobelia kalmii* (Kalm's lobelia, 89%), and *Cladium mariscoides* (twig-rush, 89%). The first two species show a distribution concentrated in the Straits area (Fig. 47), while *Cladium mariscoides* is characteristic of northern fen across the entire range of conditions from more acid, poor fen to calcareous, rich fen (Crum 1988). Other preferential species that are good indicators of rich fen include *Potentilla anserina* (silverweed), *Panicum lindheimeri* (panic grass), *Triglochin maritimum* (common bog arrow-grass), and *Hypericum kalmianum* (Kalm's St. John's-wort).

The large number of remaining sites (Group *01; N=89) contain wet meadow in the herbaceous zones. Overall, the most common species are *Calamagrostis canadensis* (85% of transects) and *Carex stricta* (tussock sedge, 64%); however, both of these species also occur within rich fen sites (Fig. 48). *Carex lacustris* (56%) and *Polygonum amphibium* (62%) are identified as less wide-spread, but more sensitive indicator species for the wet meadow group. Subdivision of the meadow group identifies a northern wet meadow and a southern wet meadow, as well as two geographic areas that appear to be transitional in nature.

Indicator species for the northern wet-meadow group (Group *010; N=50) include *Potentilla palustris* (marsh cinquefoil, 68% of transects), *Campanula aparinoides* (68%), and *Salix petiolaris* (meadow willow, 50%); *Carex aquatilis* is also widely present (Fig. 49). Most sites in the northern group are located along Lake Superior, the St. Marys River, and northern Lakes Michigan-Huron; however, a small group of spatial outliers occurs along eastern Lake Ontario and the St. Lawrence River. These outlier sites are distinguished in a subsequent subdivision as a separate group (Group *01011; N=10) which displays strong species affinities to the southern wet meadow sites. Particularly characteristic are their higher densities of *Typha angustifolia* (narrow-leaved cat-tail, 100% of transects) and the widespread presence of *Thelypteris palustris* (marsh fern, 100%) which link them to other Lake Ontario sites (Fig. 50).

In contrast, the southern wet meadow sites (Group *011) are located along southern Lake Michigan, Saginaw Bay, and Lakes St. Clair, Erie, and Ontario -- portions of the Great Lakes region associated with higher levels of agricultural activity and urbanization. The most northern sites of the southern group are all fairly protected sites, and include Dead Horse Bay and Little Tail Point (both sand-spit embayments in southern Green Bay), Oconto (a large delta site in southern Green Bay), the White River estuary (a barred lacustrine estuary on Lake Michigan), and False Presque Isle (a barred lacustrine estuary on Lake Huron).

Indicator species for southern wet meadow group include *Rorippa palustris* (yellow cress, 69% of group) and *Scirpus validus* (softstem bulrush, 56%); *Typha angustifolia* is also widely present. Overall, the southern wet meadows are characterized by higher levels of both early successional species and exotic weeds. Agricultural erosion and shoreline siltation can create extensive, fertile mud flats along the shoreline, and favor species adapted to the cyclical exposure of this habitat as lake levels fluctuate. High densities of early successional species, including *Polygonum lapathifolium* (nodding smartweed), *Bidens cernuus* (nodding bur-marigold), *Rorippa palustris* (yellow cress), and *Scirpus validus*, are closely associated with areas of high upland erosion and turbidity such as western Lake Erie, Saginaw Bay, and Green Bay (Fig. 51a). As a complex, these colonizing species may be useful indicators of coastal wetlands adversely affected by agricultural runoff.

Both agricultural and urban disturbance favor the introduction of exotic shoreline species, particularly *Lythrum salicaria* (purple loosestrife), *Phalaris arundinacea* (reed canary grass), and *Phragmites australis* (giant bulrush). The greatest concentration of exotics occurs in marshes within heavily disturbed areas (Fig. 51b). In contrast, wet meadows located within the forested portions of the Great Lakes region have very low coverage values for exotic plants.

Subdivision of this southern wet meadow group identifies a possible subtype (Group *0111; N=13) characterized by still higher densities of certain colonizing and/or exotic species (*Scirpus validus*, *Bidens cernuus*, *Polygonum persicaria* [lady's thumb], all present in 100% of transects), and correspondingly lower densities of the common wet meadow dominants, *Calamagrostis canadensis* and *Carex stricta*. This group of southern wet meadow sites is restricted to Saginaw Bay and western Lake Erie (Fig. 52), where the flat, clay-rich lakeplain soils have been intensively farmed with row crops up to the wetland edge.

Overall, two geographic regions stand out as being transitional between northern and southern wet meadow, and contain sites assigned to both of these groups. The first area is eastern Lake Ontario-St. Lawrence River, as discussed above. The second is Green Bay/Door Peninsula; here, the more protected sites within the Bay are more southern in character, while those along the Door Peninsula are more northern in species composition.

In summary, six distinct types of herbaceous communities can be distinguished vegetatively within the TWINSPAN ordination (Figs. 53 and 54). Key species differences among these groups are summarized in Table 16.

Table 16
Species Associated with Regional Subdivisions of Wet Meadow Zones

Species	Ubiquity (% of transects)						Average Cover Value (%)					
	N. Poor Fen	N. Rich Fen	N. Wet Mea.	N-S Wet Mea.	S. Wet Mea.	S. Dis-turbed	N. Poor Fen	N. Rich Fen	N. Wet Mea.	N-S Wet Mea.	S. Wet Mea.	S. Dis-turbed
Carex lasiocarpa	**90.9**	33.3	45.0	30.0	0.0	0.0	**21.6**	4.0	5.8	2.1	0.0	0.0
Myrica gale	**90.9**	44.4	37.5	10.0	0.0	0.0	**12.0**	1.5	2.8	0.7	0.0	0.0
Chamaedaphne calyculata	**90.9**	0.0	0.0	0.0	0.0	0.0	**4.6**	0.0	0.0	0.0	0.0	0.0
Menyanthes trifoliata	**72.7**	0.0	0.0	0.0	0.0	0.0	**9.1**	0.0	0.0	0.0	0.0	0.0
Sarracenia purpurea	**72.7**	33.3	2.5	0.0	0.0	0.0	**4.9**	0.3	0.0	0.0	0.0	0.0
Sphagnum spp.	**63.6**	0.0	2.5	0.0	0.0	0.0	**13.2**	0.0	0.0	0.0	0.0	0.0
Rhynchosporus alba	**63.6**	0.0	0.0	0.0	0.0	0.0	**5.6**	0.0	0.0	0.0	0.0	0.0
Carxex viridula	0.0	**100.0**	7.5	0.0	0.0	7.7	0.0	**10.7**	0.2	0.0	0.0	0.4
Cladium mariscoides	63.6	**88.9**	2.5	0.0	0.0	7.7	13.4	**8.6**	0.0	0.0	0.0	0.4
Lobelia kalmii	0.0	**88.9**	2.5	0.0	0.0	0.0	0.0	**4.6**	0.0	0.0	0.0	0.0
Potentilla anserina	0.0	**77.8**	7.5	0.0	15.4	30.8	0.0	**4.9**	0.2	0.0	0.5	0.9
Potentilla fruticosa	18.2	**77.8**	7.5	0.0	0.0	7.7	0.8	**3.8**	0.5	0.0	0.0	0.2
Triglochin maritimum	9.1	**66.7**	5.0	0.0	0.0	7.7	0.0	**2.0**	0.2	0.0	0.0	0.2
Calamogrostis canadensis	36.4	100.0	**85.0**	**90.0**	**92.3**	**69.2**	1.7	15.0	**16.9**	**13.7**	**26.5**	7.9
Carex stricta	9.1	33.3	**82.5**	**50.0**	**53.8**	**38.5**	1.0	2.4	**17.8**	2.8	6.0	3.5
Potentilla palustris	54.5	11.1	**65.0**	**80.0**	11.5	7.7	2.2	0.6	**3.0**	4.7	0.5	0.2
Campanula aparinoides	27.3	44.4	**62.5**	**90.0**	38.5	0.0	0.8	1.1	**4.0**	4.1	1.6	0.0
Carex aquatilis	27.3	22.2	**57.5**	**60.0**	26.9	15.4	1.5	0.4	**5.9**	4.1	2.6	1.4
Salix petiolaris	0.0	11.1	**52.5**	**40.0**	3.8	7.7	0.0	0.2	**1.8**	0.8	0.0	0.1
Typha angustifolia	0.0	22.2	15.0	**100.0**	65.4	84.6	0.0	0.5	0.7	**26.3**	11.6	9.2
Thelypteris palustris	9.1	0.0	17.5	**100.0**	30.8	0.0	0.1	0.0	1.0	**8.8**	1.7	0.0
Impatiens capensis	0.0	0.0	40.0	**80.0**	**80.8**	61.5	0.0	0.0	2.3	6.6	**11.3**	3.8
Polygonum amphibium	9.1	0.0	60.0	**90.0**	**53.8**	61.5	0.1	0.0	3.6	6.7	**6.4**	5.1
Peltandra virginica	0.0	0.0	0.0	**20.0**	**23.1**	0.0	0.0	0.0	0.0	1.2	**4.4**	0.0
Rorippa palustris	0.0	11.1	5.0	20.0	53.8	**100.0**	0.0	0.1	0.0	0.2	1.9	**10.7**
Bidens cernuus	0.0	0.0	10.0	10.0	19.2	**84.6**	0.0	0.0	0.2	0.8	1.7	**18.4**
Scirpus validus	9.1	11.1	10.0	20.0	42.3	**84.6**	0.1	0.2	0.6	0.1	2.2	**8.1**
Polygonum lapathifolium	0.0	0.0	2.5	0.0	38.5	**46.2**	0.0	0.0	0.0	0.0	1.6	**8.7**
Polygonum persicaria	0.0	11.1	0.0	0.0	0.0	**84.6**	0.0	0.0	0.0	0.0	0.0	**4.1**

These herbaceous groups are:

(1) **Northern poor fen** (Group *1; N=11). These sites are located along Lake Superior, and are typified by a harsh northern climate, deep accumulation of organics over sandy substrates, and acidic soils. Characteristic species include *Chamaedaphne calyculata*, *Menyanthes trifoliata*, *Sarracenia purpurea*, *Sphagnum* spp., and *Rhynchospora alba*.

(2) **Northern rich fen** (Group *00; N=9). These sites are located in the Straits-area of northern Lakes Michigan-Huron, where marly (alkaline) soils are at the surface. Characteristic species include the northern calciphiles *Carex viridula*, *Lobelia kalmii*, *Potentilla anserina*, *Panicum lindheimeri*, *Triglochin maritimum*, and *Hypericum kalmianum*; the northern wet meadow dominant *Calamagrostis canadensis* is generally present as well.

(3) **Northern wet meadow** (Group *010; N=40). This group includes all herbaceous zones along the St. Marys River and non-marly sites from northern Lakes Michigan-Huron with circum-neutral soils. This type is also present along Lake Superior where connectivity with the lake reduces soil acidity. Dominants are the gramminoids *Calamagrostis canadensis* and *Carex stricta*. Other common species include *Potentilla palustris*, *Campanula aparinoides*, and *Carex aquatilis*.

(4) **Transitional northern-southern wet meadow** (Group *01011; N=10). This group is restricted to eastern Lake Ontario and the St. Lawrence River, and shows clear affinities with both northern and southern wet meadow types. *Calamagrostis canadensis* and *Carex stricta* are common dominants, but the high densities of *Typha angustifolia* link this type to the south.

(5) **Southern wet meadow** (Group *011; N=26). This type contains herbaceous zones of southern Lake Michigan, and Lakes St. Clair, Erie, and Ontario. *Calamagrostis canadensis* is the common meadow dominant along with *Carex stricta*, but a range of colonizing species associated with disturbance make their appearance as well, including *Impatiens capensis*, *Polygonum amphibium*, *P. lapathifolium*, *Rorippa palustris*, *Bidens cernuus*, and *Scirpus validus*.

(6) **Southern, disturbed wet meadow** (Group *0111; N=13), associated with Saginaw Bay and western Lake Erie, where agricultural activity is intensive and closely approaches the shoreline. Common early successional and exotic species attain high densities, while the commmon wet meadow dominants, *Calamagrostis canadensis* and *Carex stricta*, are correspondingly lower.

The primary abiotic dimensions underlying the TWINSPAN divisions appear to be a combination of latitude and soil pH, along with disturbance (Table 17). Most of the herbaceous marsh types fall either north or south of the climatic tension zone (Figs. 53 and 54). For the herbaceous vegetation, this line appears to extend from Green Bay, Wisconsin across the Lower Peninsula of Michigan north of Saginaw Bay; sites along the eastern end of Lake Ontario and the St. Lawrence River appear to straddle this line. North of the tension zone, soil pH separates the herbaceous zones into poor fen (characterized by acidic soils, retarded organic decomposition, and deep organic accumulations), rich fen (characterized by alkaline soils with little or no organic depositions), and the gramminoid-dominated northern wet meadow (typified by circum-neutral soils) (Minc 1996b). Where connectivity with the lake is high, the acidity of Lake Superior's bedrock is diluted, and northern wet meadow replaces poor fen.

South of the tension zone, the herbaceous vegetation is a southern wet meadow, also characterized by circum-neutral soils. Here, higher levels of disturbance accommodate a range of colonizing and/or disturbance species along with the typical wet meadow dominants. Significantly higher levels of these species suggest the presence of a distinct southern wet meadow sub-type along Saginaw Bay and western Lake Erie.

Table 17
Primary Abiotic Factors Affecting Herbaceous Zone Species Composition

Herbaceous Zone Type	Latitude	Soil pH	Disturbance
Northern Poor Fen	Northern	Acidic	Low
Northern Rich Fen	Northern	Alkaline	Low
Northern Wet Meadow	Northern	Circum-neutral	Low
Transition N-S Wet Meadow	Tension Zone	Circum-neutral	Medium
Southern Wet Meadow	Southern	Circum-neutral	Medium
Disturbed S. Wet Meadow	Southern	Circum-neutral	High

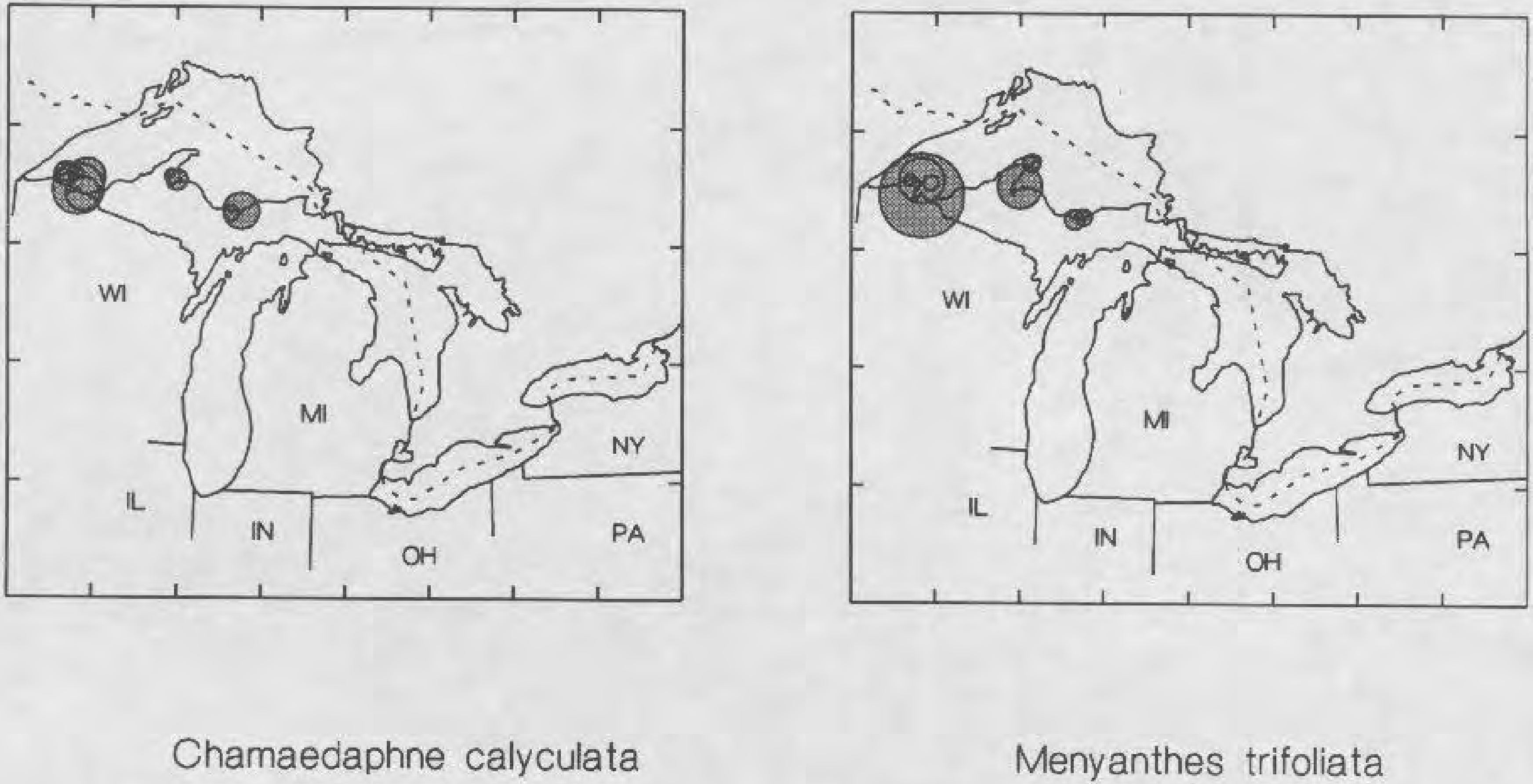


Figure 46. Distribution of indicator species for the poor fen group, *Chamaedaphne calyculata* (leatherleaf) and *Menyanthes trifoliata* (buckbean). (Symbol size reflects mean cover value of species in the herbaceous zones of 96 coastal Great Lakes wetlands.)

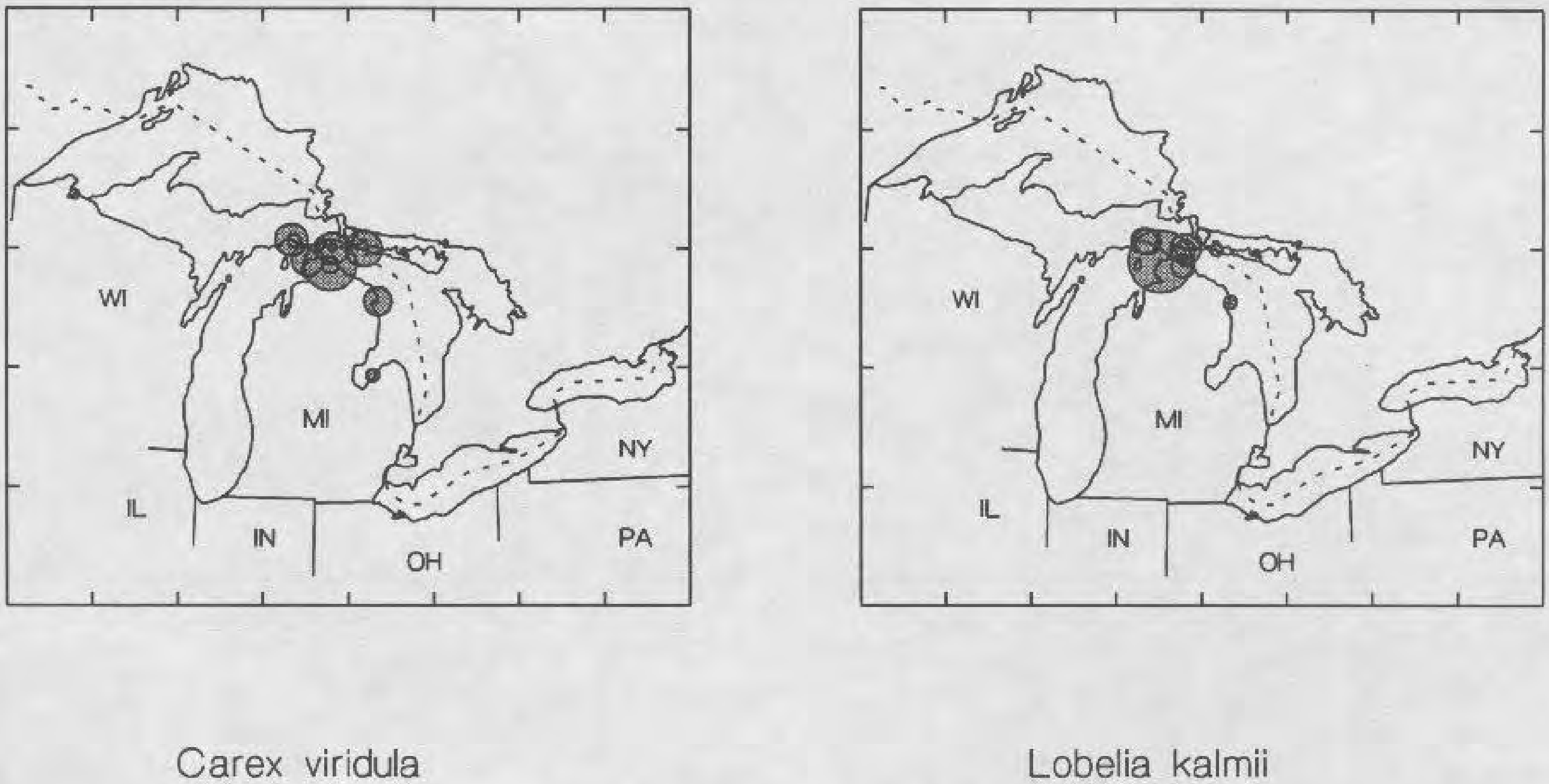


Figure 47. Distribution of indicator species for the rich fen group, *Carex viridula* (sedge) and *Lobelia kalmii* (Kalm's lobelia). (Symbol size reflects mean cover value of species in the herbaceous zones of 96 coastal Great Lakes wetlands.)

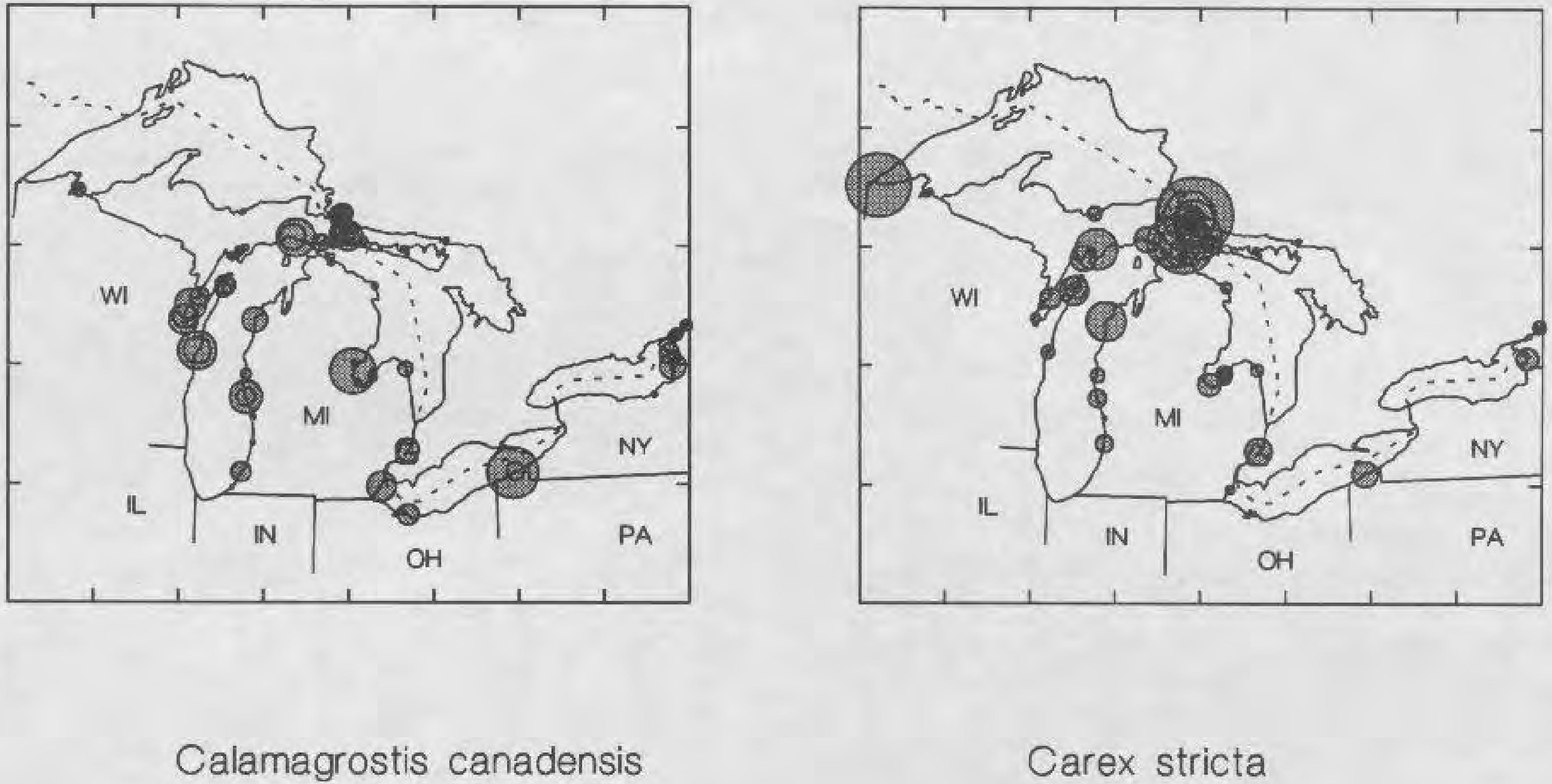
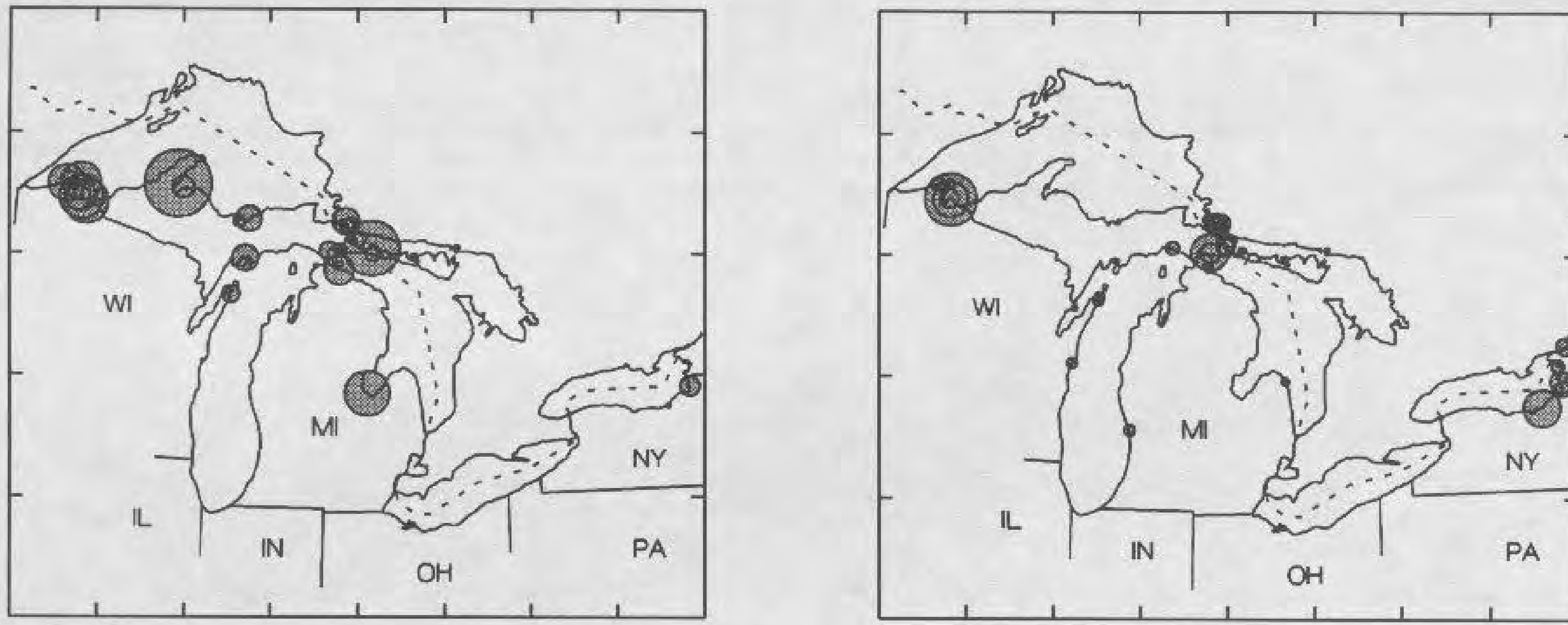


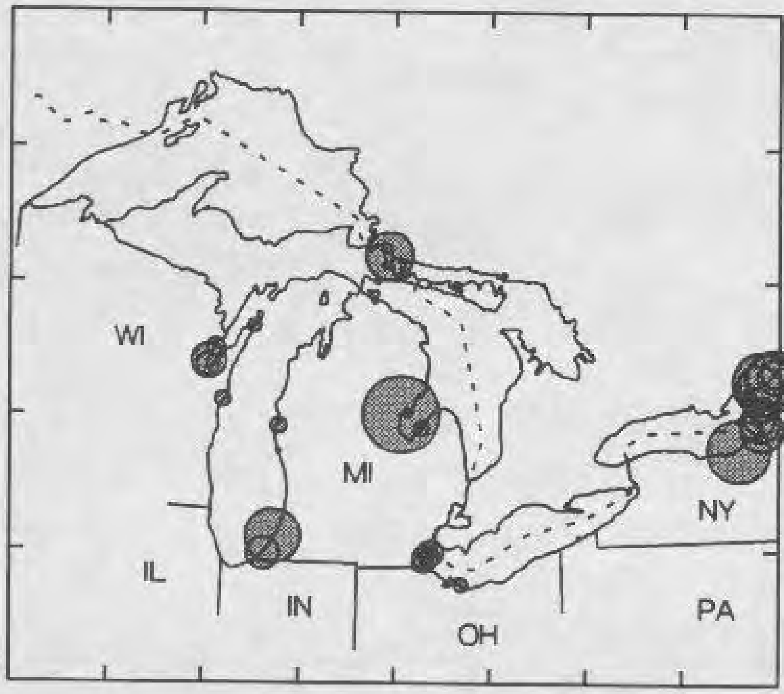
Figure 48. Wide-spread distribution of common wet meadow dominants, *Calamagrostis canadensis* (blue-joint grass) and *Carex stricta* (tussock sedge). *Carex stricta* attains its highest densities along the St. Marys River, while *Calamagrostis canadensis* becomes more dense further south. (Symbol size reflects mean cover value of species in the herbaceous zones of 96 coastal Great Lakes wetlands.)



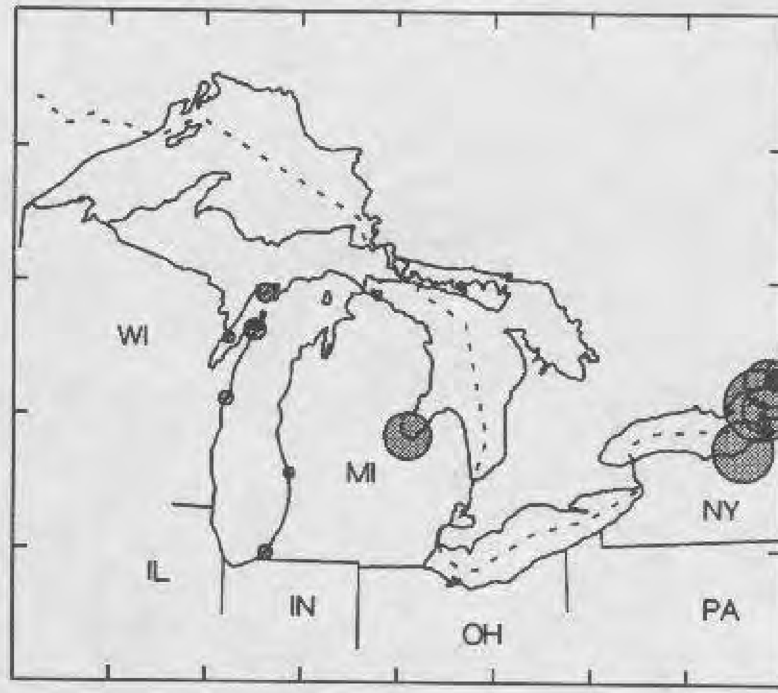
Carex lasiocarpa

Potentilla palustris

Figure 49. Distribution of species preferential to the northern wet-meadow group, *Carex lasiocarpa* and *Potentilla palustris* (marsh cinquefoil). (Symbol size reflects mean cover value of species in the herbaceous zones of 96 coastal Great Lakes wetlands.)

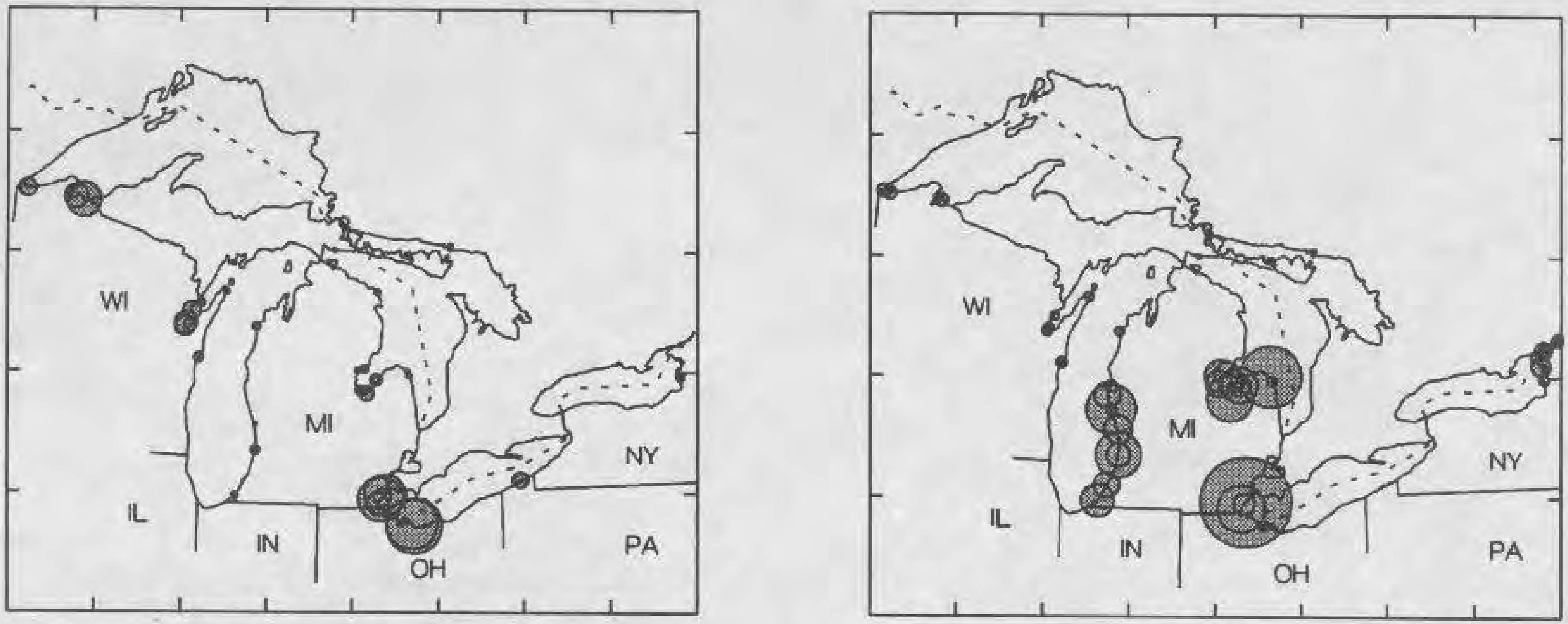


Typha angustifolia



Thelypteris palustris

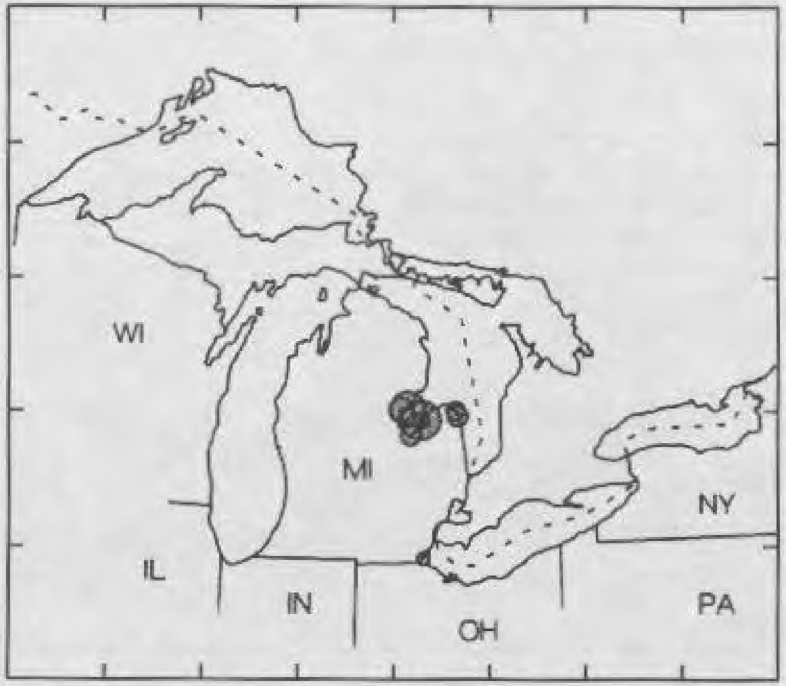
Figure 50. Herbaceous zone species characteristic of Lake Ontario-St. Lawrence River. Higher densities of *Typha angustifolia* (narrow-leaved cattail) and the presence of *Thelypteris palustris* (marsh fern) distinguish Lake Ontario-St. Lawrence River sites from northern wet meadows of Lake Superior, the St. Marys River, and northern Lakes Michigan-Huron. (Symbol size reflects mean cover value of species in the herbaceous zones of 96 coastal Great Lakes wetlands.)



Exotic Species

Colonizing Species

Figure 51. Regional concentration of exotic and early successional species. Higher densities of early successional or colonizing species (*Bidens cernuus* [nodding bur-marigold], *Impatiens capensis* [spotted touch-me-not], *Polygonum lapathifolium* [nodding smartweed], *Rorippa palustris* [yellow cress], and *Scirpus validus* [softstem bulrush]) and disturbance species (including the exotics *Lythrum salicaria* [purple loosestrife], *Phalaris arundinacea* [reed canary grass], and *Phragmites australis* [giant bulrush]) characterize southern wet meadows. (Symbol size reflects mean cover value of species in the herbaceous zones of 96 coastal Great Lakes wetlands.)



Polygonum persicaria

Bidens cernuus

Figure 52. Exotic and early successional species concentrated in Saginaw Bay. Higher densities of certain introduced species such as *Polygonum persicaria* (lady's thumb), and some colonizing species such as *Bidens cernuus* (nodding bur-marigold) characterize southern wet meadow sites adjacent to Saginaw Bay and western Lake Erie. (Symbol size reflects mean cover value of species in the herbaceous zones of 96 coastal Great Lakes wetlands.)

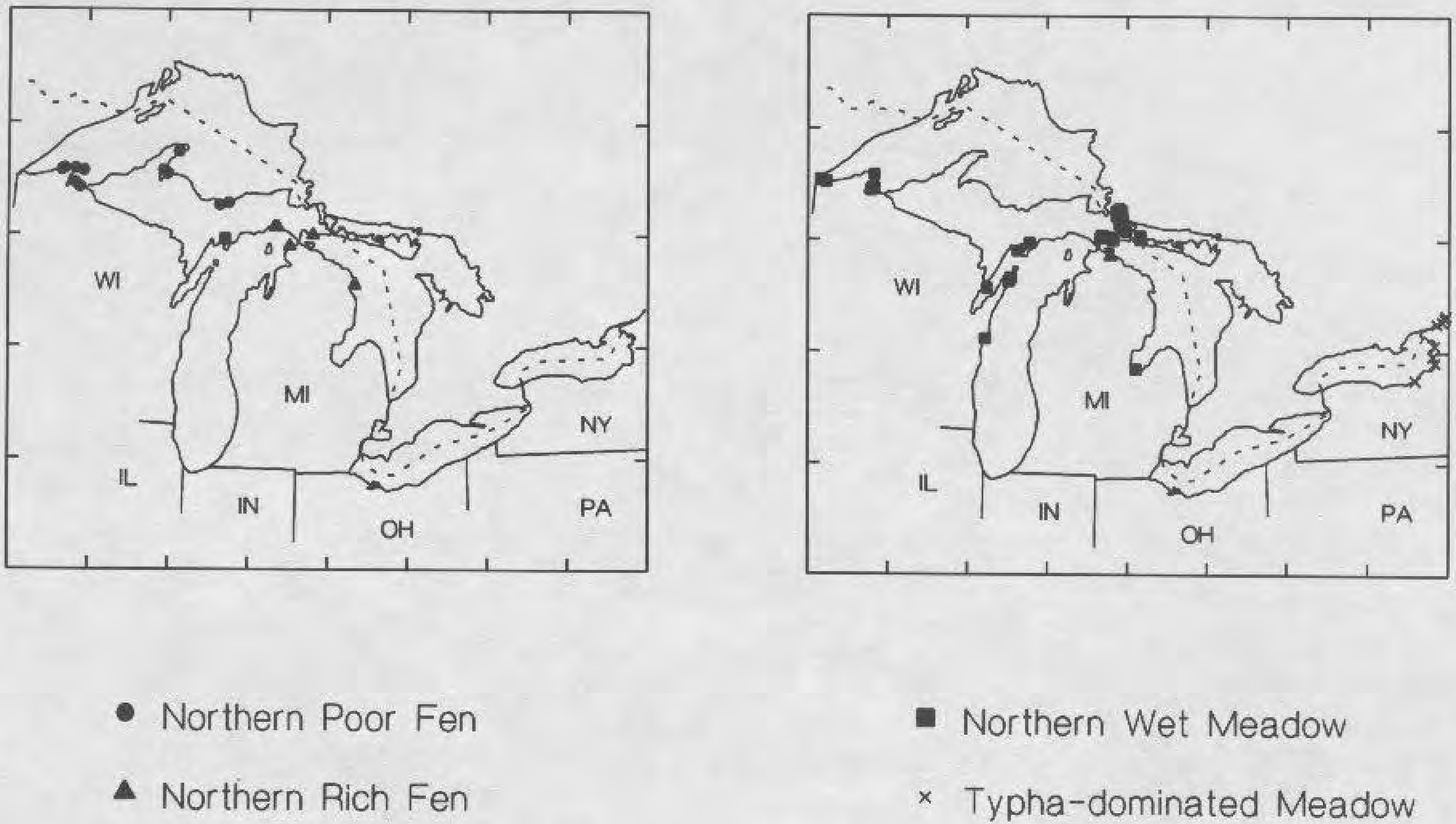


Figure 53. Distribution of northern herbaceous zone types.

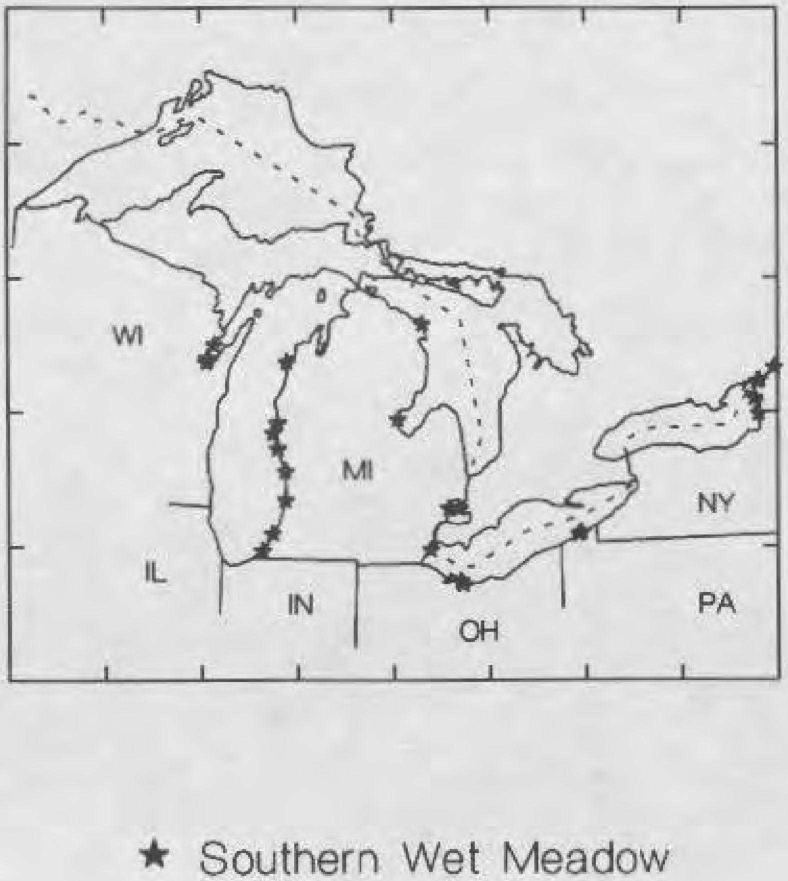


Figure 54. Distribution of southern herbaceous zone types.

C. Shrub Swamp

Shrub swamp zones were encountered along only 36 transects (28%) representing 32 marshes (32% of total) (Fig. 55). Shrub swamp zones are clearly best represented from barrier-beach lagoons; 62.5% of transects placed within lagoons crossed a shrub swamp zone. Elsewhere, shrub swamp zones were encountered adjacent to roughly one-quarter to one-third of connecting channel marshes, lacustrine estuaries, and protected coastal embayments (Table 18).

Table 18
Distribution of Shrub Swamp Zones by Marsh Site Type

Site Type	Shrub Swamp Zone				
	Absent		Present		Total
	#	%	#	%	
Coastal Embayment					
Open	13	81.2	3	18.7	16
Protected	10	76.9	3	23.1	13
Barrier-beach Lagoon	9	37.5	15	62.5	24
Sand-spit					
Embayment	5	100.0	0	0.0	5
Swale	3	75.0	1	25.0	4
Connecting Channel					
Channel-side wetland	8	67.7	4	33.3	12
Channel-side embayment	7	87.5	1	12.5	8
Delta	9	90.0	1	10.0	10
Lacustrine Estuary	30	78.9	8	21.1	38
Total	94	72.3	36	27.7	130

A total of 212 species were recorded along portions of the marsh transects crossing shrub swamp zones; of these, 81 species were present along only one transect. Many of the most commonly occurring species are also dominants of the herbaceous zone; however, cover values for woody species are significantly higher in this zone (22-72% of total). The most frequently occurring woody species include *Alnus rugosa* (speckled alder, 82% of transects) and *Myrica gale* (sweet gale, 61%). Herbaceous species with the highest ubiquity values were *Calamagrostis canadensis* (56% of transects) and *Potentilla palustris* (53%), followed by *Carex stricta*, *C. lacustris*, *Campanula aparinoides*, and *Utricularia intermedia* (all occurring in 41% of transects). For a complete list of shrub swamp zone species and their ubiquity values, see Appendix III-C.

The TWINSPAN analysis was limited to 131 species found in 2 or more transects. The ordered two-way table of species and shrub-swamp transects is presented in Table 19 (see also Appendix VI).

Table 19
TWINSPAN Ordination of Shrub Swamp Zones and Species

```
                       Group *00    *010    *011   *10    *11

                       LPBRSBBHDISHKAHISHHSCCCESTWWFPBBEPSB
                       AELATAAOENIOAUONUUUAAHHPAHEHOOILATTA
                       CQASUDRNEDSNKTGDGRRNREEOGOSINTGASPER
                       LUCPRRKJREKJARIIASSDPBBUAMTTDASCTERL
                       AAKBGIBO_PEOGASARLLI_OOFNPTEUWAKBNLA
                       BM_EEVAHCEWHOILNIEESRYYEISWRLAB_AIIK
                       EIAROEYNRNINNND SYYLIGGTNOIIATLBYNNE
                       LN RNR B DTA     ABDVACTGNNVCTE  SG

  21 carx  int   ----11--111-------------------------  000
  43 eleo  sma   -------11-1-------------------------  000
  46 equi  pal   ---1--1---1-------------------------  000
  57 iris  ver   ----111-11-----1--------------------  000
 129 vacc  oxy   -1--1221--1-------------------------  000
   4 andr  gla   12132322221-------------------------  000
   5 aron  mel   -11-----12--------------------------  000
  24 carx  lim   -111-1--1-1-------------------------  000
  41 dros  rot   1111-112--1-------------------------  000
  45 equi  flu   -1--2111-1-----------1--------------  000
  71 meny  tri   1222-321121-------------------------  000
 103 sarr  pur   113211121-1-----------1-------------  000
 113 spha  sp.   33434333322-2-----------------------  000
 128 vacc  mac   11311--121--------------------------  000
  34 clad  mar   1211--311-1----------11-------------  000
  36 corn  can   1-----1--1--------------------------  000
  40 dros  int   -21---11----------------------------  000
  42 duli  aru   1-----1-1---------------------------  000
  48 erio  vir   1-1-1-------------------------------  000
  60 kalm  pol   11----1-----------------------------  000
  62 ledu  gro   11----11----------------------------  000
  73 nemo  muc   11----11-1--------------------------  000
  85 pogo  oph   212--111--1-------------------------  000
  92 rhyn  alb   221---121-1-------------------------  000
 104 sche  pal   11----1---1-------------------------  000
  32 cham  cal   1143322223233-----------------------  000
  23 carx  las   -2123333322-1---2--123--------------  000
  61 lari  lar   111111-1--1---------1112------------  000
 111 soli  uli   11-1-----------------11-------------  000
 124 utri  cor   -1-----1--------------1-------------  000
 116 thuj  occ   11-------1-------------1------1-----  000
   8 betu  pum   1----1-1---11-----------------------  001
  27 carx  ros   ----1-----1-----1-------------------  001
  99 salx  ped   ----111-1-1-1---1---11-1------------  001
 119 trig  mar   ----------1----------11-------------  001
 125 utri  int   111-11111-2----11331--1-------------  001
  79 pice  gla   ----------------------12------------  010
  89 pote  fru   ---------------------122------------  010
 105 scir  acu   --------------------111-------------  010
  15 carx  aqu   --1----11---1221-3--2---------------  010
  54 glyc  can   ---------------1---1--1-------------  010
 100 salx  pet   -------------1111443-1--------------  010
 107 scir  cyp   -----------1-----1-1----------------  010
 114 spir  alb   ------1---131-1211-1-1-1------------  010
 126 utri  vul   -1--------1-----1311----------------  010
  72 myrc  gal   221333233324232233--2333-----------1  010
 101 salx  pyr   ---------1------1--1----------------  010
  28 carx  str   ---21-------13233-133212--2--1---1--  010
```

58	junc	bal	--------------------113--1-----------	010
77	phal	aru	----1----------------211--1----------	010
91	pote	pal	---2-2111111111-1331-1-2--------111--	010
93	rosa	pal	-1-1-1-2111311---------------1--1---	010
22	carx	lac	----1---111321-1-331------2-3--------	011
67	lysi	ter	-------1111-12------2-12-------3-----	011
97	salx	can	--------------------111------1-------	011
122	typh	lat	-----11--11-12--1-3-1----------3----1	011
117	tria	fra	----11-1-11--1------1----------3--1--	100
68	lysi	thy	-----111--1-1--1-----1-----2----11-1-	100
109	sium	sua	----1---------------1-----------1----	100
55	ilex	ver	-1--------------------1----------2-1-	100
69	lyth	sal	----1---------------------------11---	100
75	osmu	reg	-------11------------12-------1----15	100
118	tria	vir	--------2-------------1---------11-2-	100
11	bide	fro	--------------------------------1122-	100
31	ceph	occ	--------------------------------123--	100
33	cicu	bul	-----------1-1--11--------------11123	100
38	cusc	gro	---------------------------------2-2-	100
39	deco	ver	--1-----------------------------3244-	100
52	gali	pal	--------------------------------1112-	100
64	lemn	min	---------------1----------------121-1	100
65	lycp	ame	----1--1--1------------1-111----2111-	100
76	pelt	vir	--1-----2-----------------------1232-	100
86	poly	amp	-----------------1-------1------11-1-	100
121	typh	gla	--2-----------------------------33-1-	100
123	urti	dio	----------------------------2---3311-	100
110	sola	dul	---------------------------1--3-1111-	101
115	thel	pal	---1---11-1-1--------------1---433-2-	101
18	carx	com	------------------------------3-----1	101
56	impa	cap	-------------1--1---------1323431-131	101
108	scut	gal	-----------------------1--11--4-11-2-	101
35	corn	amo	----------------------1-----3--------	101
63	leer	ory	------1---------------------1-4------	101
74	onoc	sen	----------11-1------------1--33-11---	101
82	pile	pum	--------------------------1--3-------	101
95	sagi	lat	-----1-----1----1------------333--1--	101
96	salx	beb	---------------1----------3--4-------	101
50	eupa	per	--------------------111-1----13------	101
120	typh	ang	----------------------1-1----------1-	101
7	betu	pap	1----------------1-------------4-----	101
37	corn	sto	----------111--1------1--4----4-11---	101
44	equi	arv	-1--------------------------2--------	101
53	gali	tri	----------1--------1-----11--1-------	101
3	alnu	rug	111111121112211111--11-1--4133323-41	101
70	ment	arv	---------------------1-1-11----------	110
78	phra	aus	-----------------1--------2----------	110
51	frax	pen	---------------1-------2-1-4-1-------	110
66	lycp	uni	----1----1----1-------12-22----------	110
12	cala	can	1-----1---11123333123-145334-----11-	111
14	camp	apa	----111---1-1112-1--11-3--1--33-1---	111
94	rume	orb	-------1-----1-1------------------1-1	111

0000000000000000000000001111111111111
0000000000011111111111110000000111111
0011111111100000000011110000011100001

Group *00 Poor Shrub Fen
Group *011 Rich Shrub Fen
Group *010 Northern Shrub Meadow
Group *10 Southern Shrub Swamp
Group *11 Buttonbush Shrub Swamp

The TWINSPAN ordination suggests a five-fold division of shrub swamps which closely parallels divisions seen in the herbaceous zones. This is not surprising, since the two zones are distinguished only on the basis of greater cover values for shrubby species in shrub swamp zone and there is considerable continuity in species composition between the two zones.

The primary dichotomy distinguishes a northern group (*0; N=24) containing sites mainly from Lake Superior, the St. Marys River, and northern Lake Huron, from a more southerly group (*1; N=12) including sites from southern Lake Michigan, Lake Erie, and Lake Ontario. Indicator species for the northern group are the widespread *Myrica gale* (present in 92% of transects in the group), along with *Carex lasiocarpa* (62%) and *Utricularia intermedia* (62%). In contrast, the southern group is characterized by *Impatiens capensis* (83% of transects), as well as higher densities of *Alnus rugosa* than are encountered in the northern sites (Fig. 56).

A secondary division of the northern group separates a poor fen group (Group *00; N=11), from northern wet meadow sites (Group *01; N=13). The poor fen group occupies relatively enclosed marsh sites, primarily barrier-beach lagoons (82%) from Lake Superior and Lake Ontario. In contrast, 85% of transects in northern wet meadow group are associated with sites with greater connectivity to open or flowing water, including coastal embayments, channel-side wetlands, or open estuaries.

Indicators for Group *00 are the standard suite of poor fen/bog species, including the woody species *Andromeda glaucophylla* (bog rosemary, 100% of group), *Chamaedaphne calyculata* (92%), and *Vaccinium macrocarpon* (large cranberry, 67%). Associated herbaceous species include *Sphagna* spp. (100%), *Menyanthes trifoliata* (buckbean, 83%), *Sarracenia purpurea* (pitcher-plant, 83%), and *Drosera rotundifolia* (round-leaved sundew, 67%). These species are generally absent in the transects of Group *01, which contains higher frequencies of wet meadow species, including *Calamagrostis candensis* (92%) and *Carex stricta* (85%). *Spiraea alba* (meadowsweet, 69%) and *Salix petiolaris* (meadow willow, 62%) are the most common woody species. A small subset of this northern shrub group, Group *011 (N=4), contains the marly Straits-area sites having rich fen in the herbaceous zone. *Larix laricina* (larch, 100% of group) and *Potentilla fruticosa* (shrubby cinquefoil, 75%) are the primary preferential shrubby species, but other calciphiles present in this group include *Cladium mariscoides* and *Potentilla anserina*.

Among the southern sites, a secondary division separates Group *10 (N=7) containing wetlands from southern Lake Michigan and Lake Erie, from Lake Ontario sites assigned to Group *11 (N=5). Connectivity may again be a factor in this division; sites in Group *00 are generally estuaries and embayments, while those of Group *11 are all barrier-beach lagoons. *Cicuta bulbifera* (water hemlock, 100% of group) is the indicator species for Group *11; however, the shrubs *Cephalanthus occidentalis* (buttonbush, 80%) and *Decodon verticillatus* (swamp loosestrife, 80%) are common and can be quite dense. Other characteristic herbaceous species include *Bidens frodosus* (common beggar-ticks) and *Galium palustre* (marsh bedstraw), both occurring in 80% of the group, while *Peltandra virginica* dominates mucky openings within the shrub zone. All these species are generally absent from the shrub zones of Group *10, although *Peltandra virginica* is common in the herbaceous and emergent zones of these sites. Instead, the Lake Michigan sites contain a diversity of shrubby species, including *Fraxinus pennsylvanica* (red ash, 60%), *Cornus stolonifera* (red-osier dogwood, 40%), and *Salix bebbiana* (beaked willow, 40%).

Two sites appear to be misclassified. Fond du Lac, as Lake Superior site, is classed with the southern shrub group, based on its high densities of *Alnus rugosa* and the presence of *Impatiens capensis*. Bar Lake, a Lake Michigan barrier-beach lagoon site, is classed with the Lake Ontario sites based on its high cover values for *Cicuta bulbifera*; however, it lacks both of the woody species associated with Lake Ontario sites.

In summary, five major shrub zone divisions are defined (Fig. 57); key species differences among these groups are highlighted in Table 20. These groups are as follows:

(1) **Poor shrub fen** (Group *00) consisting of poor fen sites, generally adjacent to Lake Superior but also including poor fens along Lake Ontario. The shrub *Andromeda glaucophylla* is the indicator species here, along with *Chamaedaphne calyculata* and *Vaccinium macrocarpon* (Fig. 58).

(2) **Rich shrub fen** (Group *011) including the marly Straits-area sites having rich fen in the herbaceous zone. *Larix laricina* (100% of group) and *Potentilla fruticosa* (75%) are the primary preferential species, but other calciphiles present in this group include *Cladium mariscoides* and *Potentilla anserina*.

(3) **Northern shrub meadow** (Group *010) including sites with herbaceous zones identified as northern wet meadow along Lake Superior, the St. Marys River, and northern Lakes Michigan-Huron. Preferential shrub species are *Spiraea alba* and *Salix petiolaris* (Fig. 59), along with the northern wet meadow dominants *Calamagrostis canadensis* and *Carex stricta*.

(4) **Southern shrub meadow** (Group *10), consisting of southern sites (generally lacustrine estuaries) from Lake Michigan and Lake Erie. Higher densities of the southern species *Impatiens capensis* characterize this group; shrubs are diverse and include *Cornus stolonifera*, *Salix bebbiana*, and *Fraxinus pennsylvanica* (Fig. 60).

(5) **Buttonbush swamp-thicket** (Group *11) containing southern, barrier-beach lagoon sites from eastern Lake Ontario. Typical shrubs are *Cephalanthus occidentalis* and *Decodon verticillatus* (Fig. 61), which can attain high densities.

In terms of abiotic factors, the primary dimensions of variability within the shrub zone again appear to be latitude, soil pH, and degree of water flow or connectivity to the aquatic system (whether lake or connecting channel). As in the previous zones, the shrub zone types fall either north or south of the climatic tension zone (Fig. 57). For the shrubby species, this line appears to extend from north of Green Bay, Wisconsin across the Lower Peninsula of Michigan north of Saginaw Bay; sites along the eastern end of Lake Ontario and the St. Lawrence River appear to fall south of this line. North of the tension zone, soil pH separates the herbaceous zones into poor shrub fen, rich shrub fen, and the gramminoid-dominated northern shrub meadow. South of the tension zone, circum-neutral soils predominate; however, poor shrub fen is encountered along Lake Ontario in areas of low water, where the accumulation of organic materials leads to eventual acidification of surface sediments. Water flow and connectivity with the lake may also be a factor separating the two main southern types, the southern shrub meadow associated with estuaries and embayments, versus the buttonbush swamp-thicket found in the more enclosed southern barrier-beach lagoons.

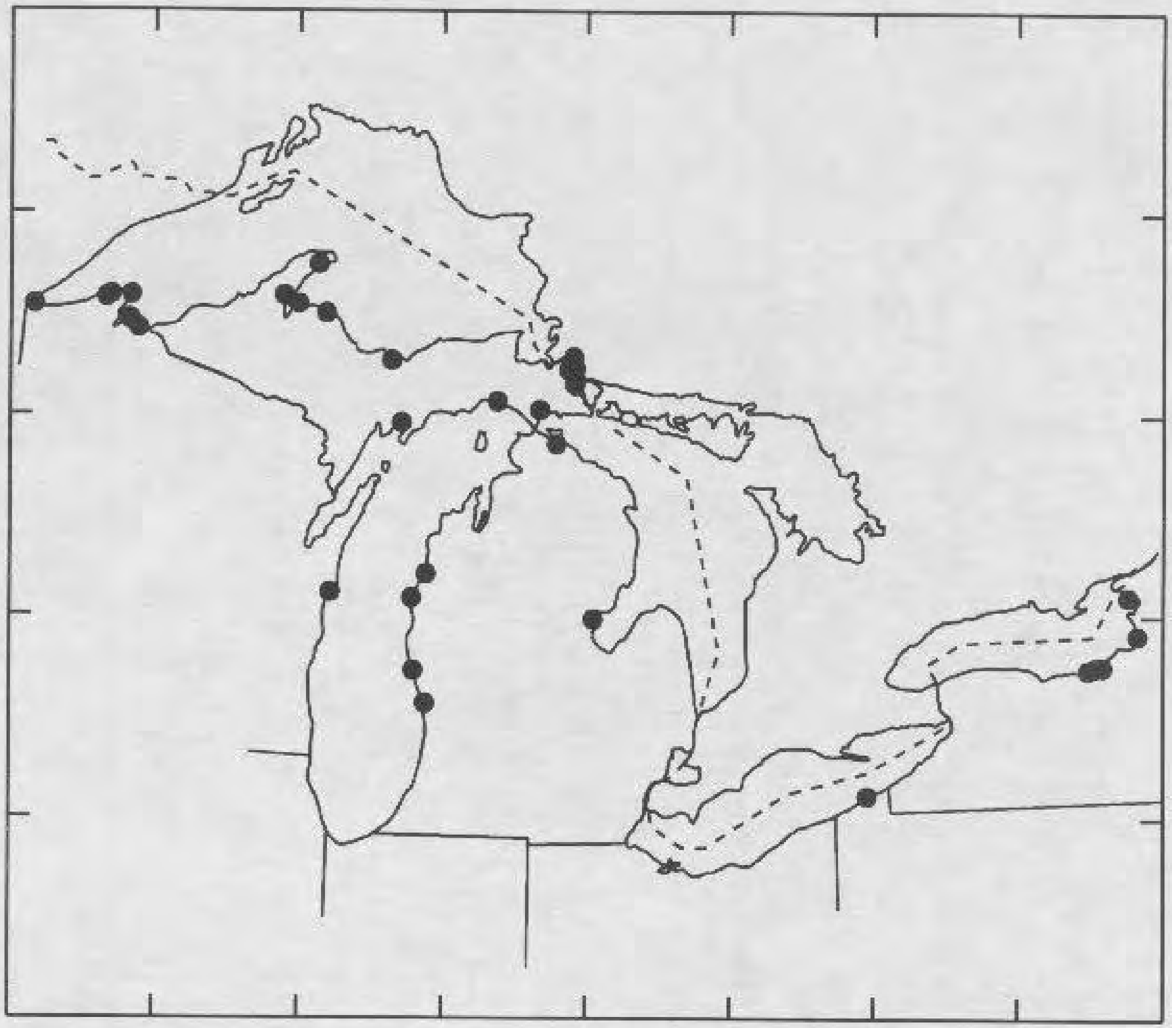


Figure 55. Distribution of shrub zone sites included in vegetative analysis.

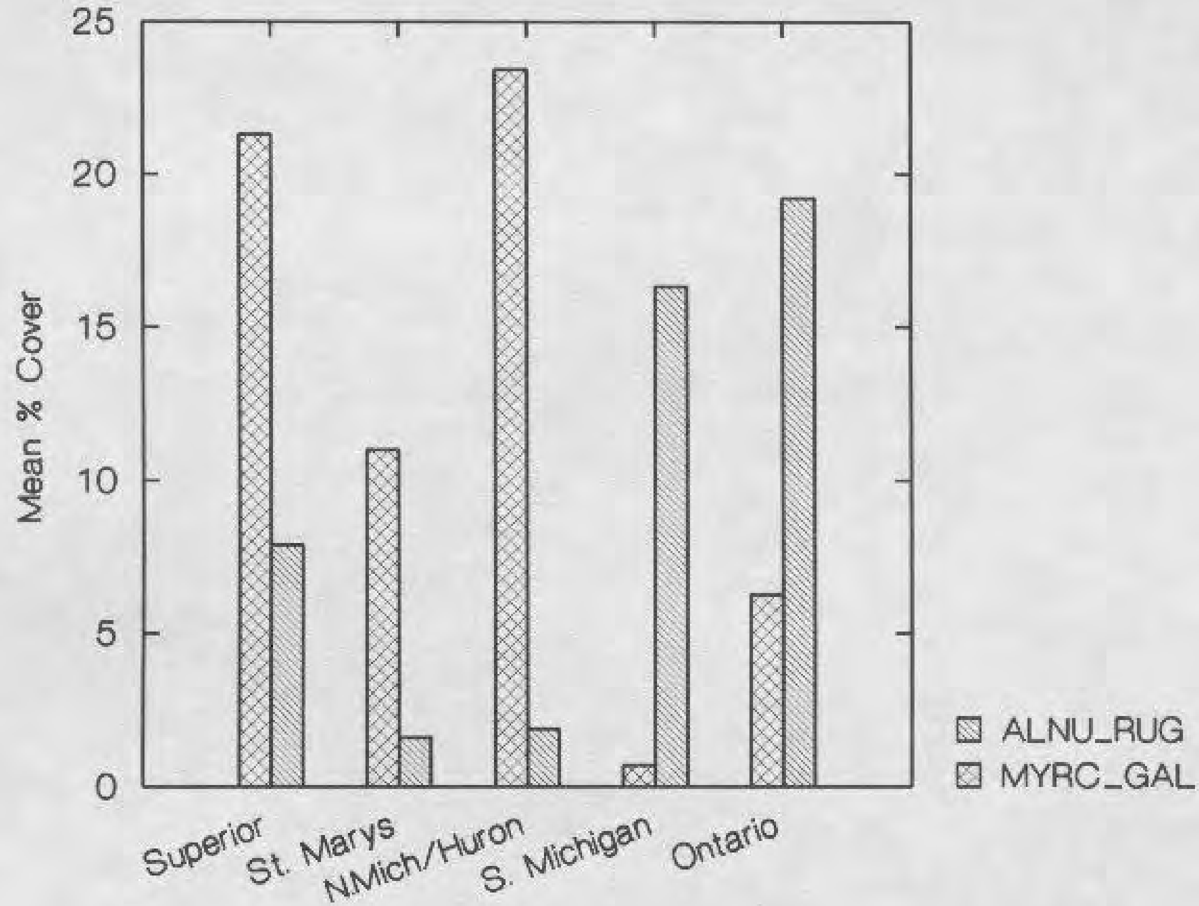


Figure 56. Mean cover values of the most common shrub species, *Myrica gale* (sweet gale) and *Alnus rugosa* (speckled alder), by geographic area. *Myrica gale* achieves its greatest densities in northern sites adjacent of Lake Superior, the St. Marys River, and northern Lakes Michigan-Huron, while *Alnus rugosa* achieves higher densities in more southerly sites adjacent to southern Lake Michigan and Lake Ontario.

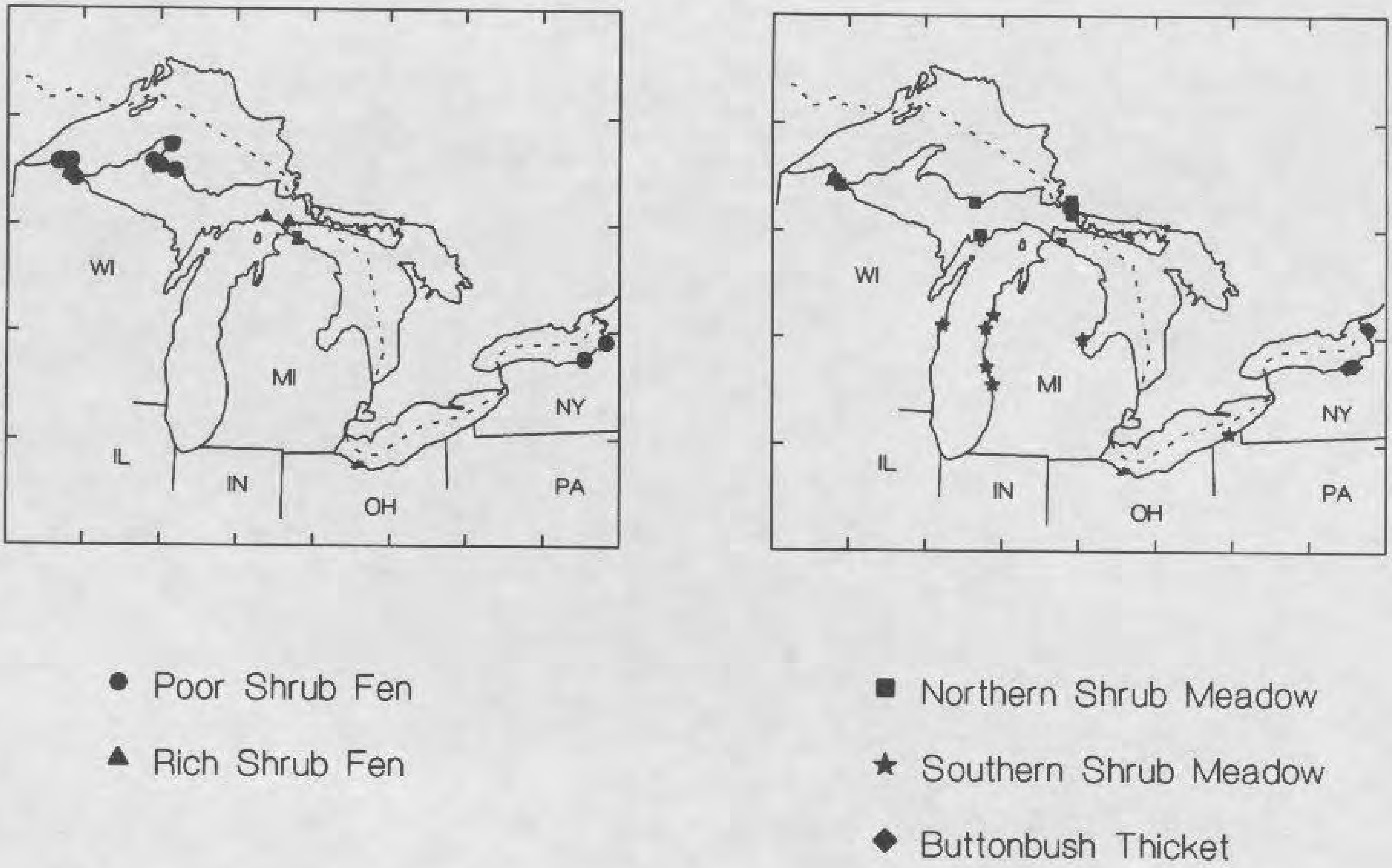


Figure 57. Distribution of shrub swamp types.

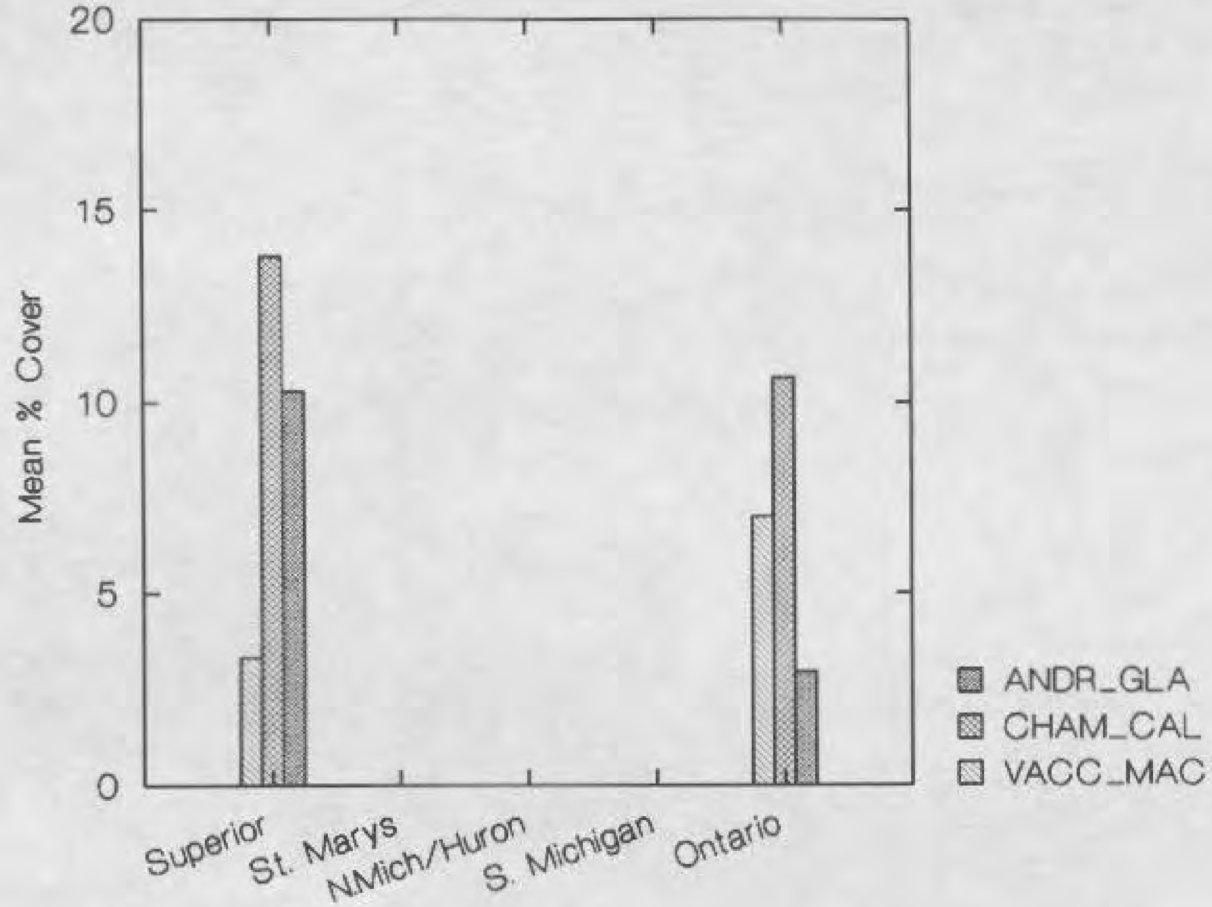


Figure 58. Mean cover values of characteristic poor shrub fen species by geographic area: *Andromeda glaucophylla* (bog rosemary), *Chamaedaphne calyculata* (leatherleaf), and *Vaccinium macrocarpon* (large cranberry). These species are largely concentrated in Lake Superior sites, but are found in poor fens adjacent to Lake Ontario as well.

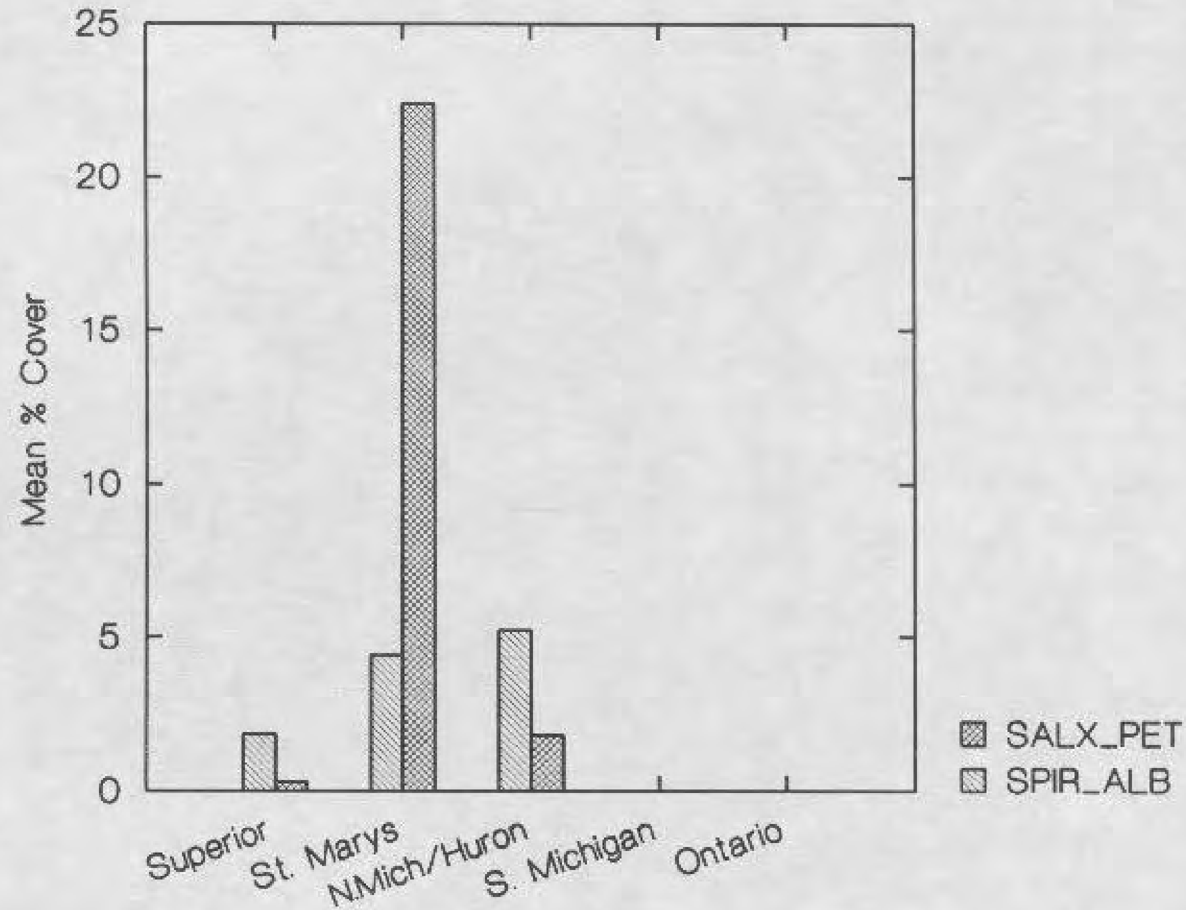


Figure 59. Mean cover values for species characteristic of northern shrub meadow by geographic area: *Salix petiolaris* (meadow willow) and *Spiraea alba* (meadowsweet).

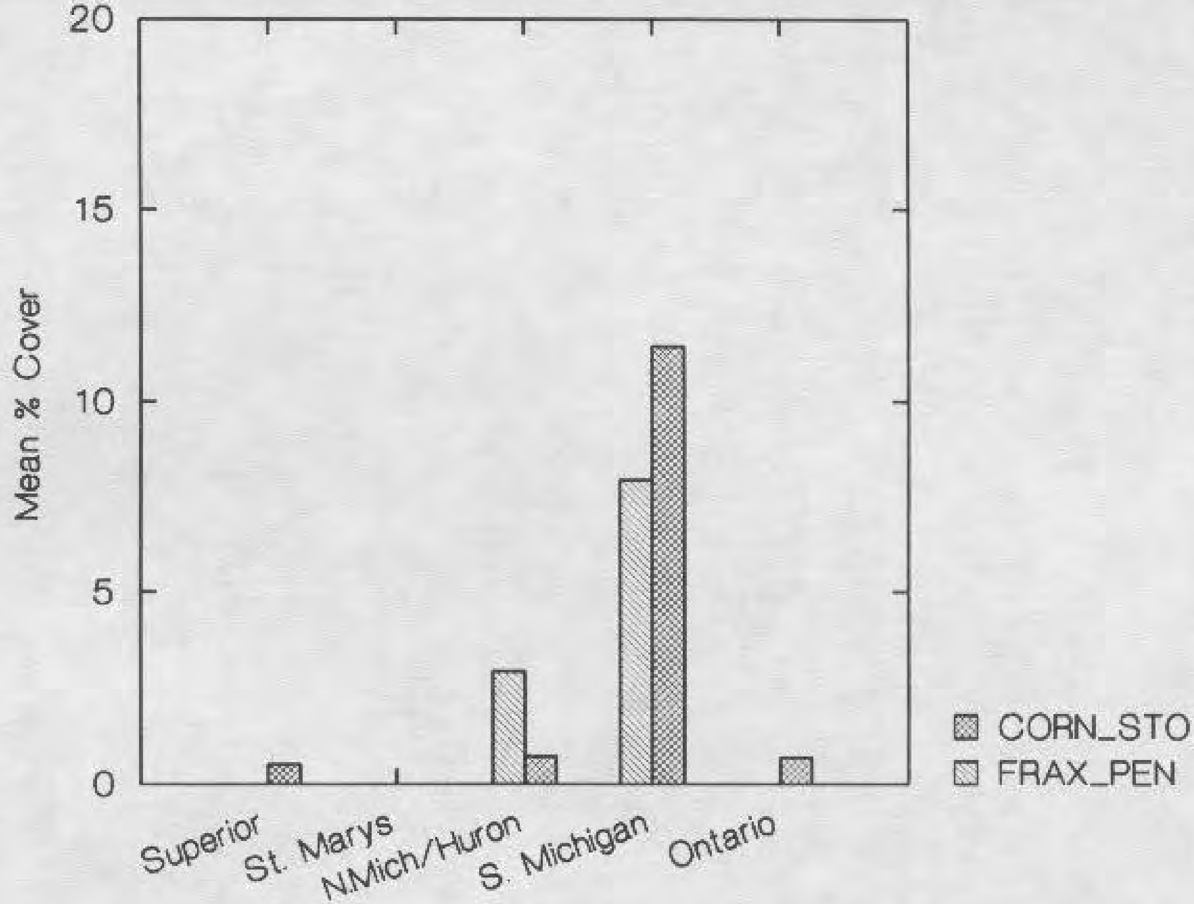


Figure 60. Mean cover values of woody species prevalent in southern shrub meadow by geographic area: *Cornus stolonifera* (red-osier dogwood) and *Fraxinus pennsylvanica* (red ash).

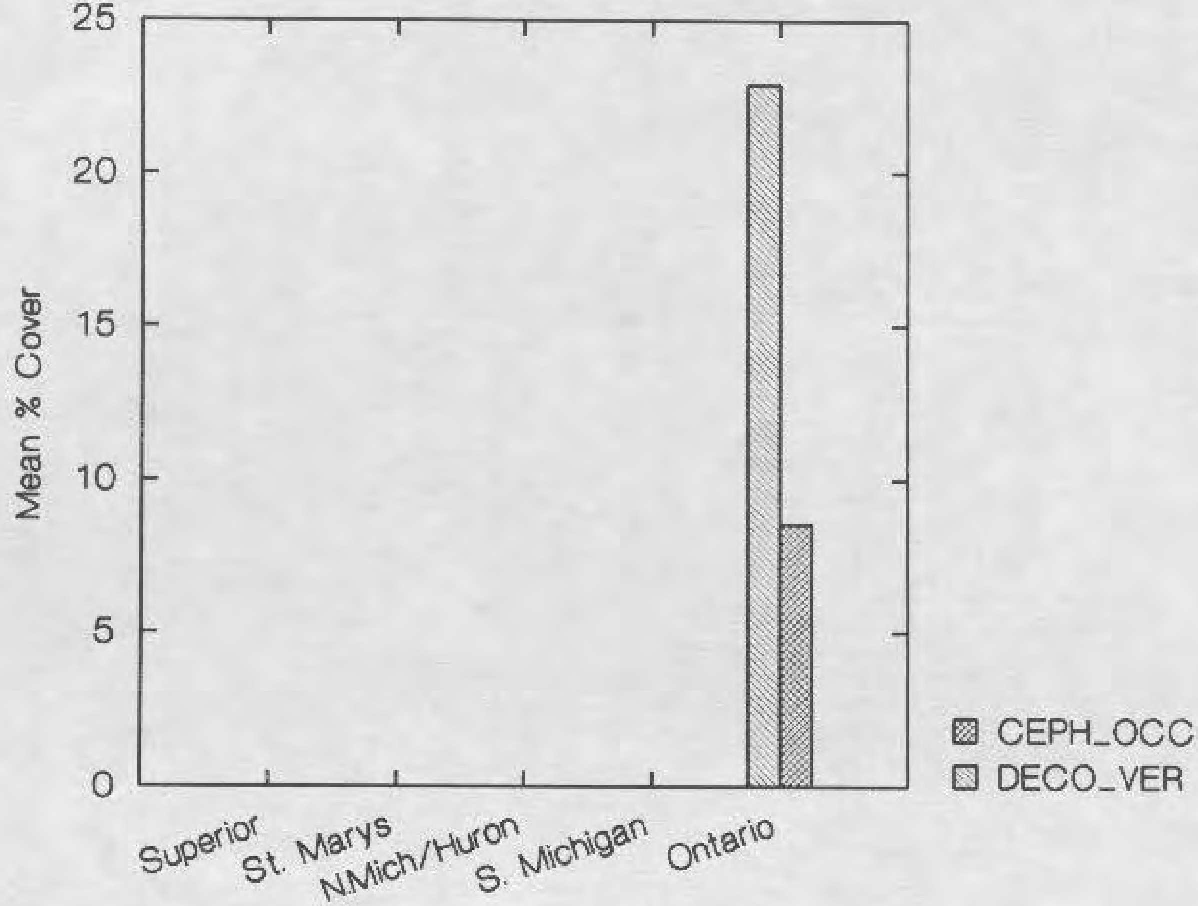


Figure 61. Mean cover values for species characteristic of buttonbush swamp-thicket by geographic area: *Cephalanthus occidentalis* (buttonbush) and *Decodon verticillatus* (swamp loosestrife).

Table 20
Species Associated with Regional Subdivisions of Shrub Swamp Zones

Species	Ubiquity (% of transects)[a]					Average Cover Value (%)[a]				
	Poor Shrub Fen	Rich Shrub Fen	N. Shrub Meadow	S. Shrub Meadow	Button-bush Thicket	Poor Shrub Fen	Rich Shrub Fen	N. Shrub Meadow	S. Shrub Meadow	Button-bush Thicket
Andromeda glaucophylla	100.0	0.0	0.0	0.0	0.0	13.8	0.0	0.0	0.0	0.0
Chamaedaphne calyculata	100.0	0.0	22.2	0.0	0.0	17.7	0.0	5.4	0.0	0.0
Vaccinium macrocarpon	72.7	0.0	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0
Larix laricina	72.7	100.0	0.0	0.0	0.0	1.9	3.6	0.0	0.0	0.0
Potentilla fruticosa	0.0	75.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0
Cladium mariscoides	72.7	50.0	0.0	0.0	0.0	5.9	2.5	0.0	0.0	0.0
Potentilla anserina	0.0	50.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0
Salix petiolaris	0.0	25.0	77.8	0.0	0.0	0.0	1.0	13.4	0.0	0.0
Spiraea alba	18.2	50.0	77.8	0.0	0.0	0.1	1.9	7.0	0.0	0.0
Calamagrostis canadensis	27.3	75.0	100.0	66.7	50.0	0.5	18.9	13.9	34.4	1.1
Carex stricta	18.2	100.0	77.8	33.3	25.0	1.6	12.6	13.8	3.6	0.2
Cornus stolonifera	9.1	25.0	33.3	33.3	50.0	0.1	0.4	0.8	13.3	1.0
Fraxinus pennsylvanica	0.0	25.0	11.1	50.0	0.0	0.0	3.1	0.2	9.3	0.0
Salix bebbiana	0.0	0.0	11.1	16.7	0.0	0.0	0.0	0.1	3.3	0.0
Impatiens capensis	0.0	0.0	22.2	83.3	75.0	0.0	0.0	0.3	15.4	8.7
Cephalanthus occidentalis	0.0	0.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	12.8
Decodon verticillatus	9.1	0.0	0.0	0.0	100.0	0.2	0.0	0.0	0.0	33.8
Cicuta bulbifera	9.1	0.0	33.3	0.0	100.0	0.1	0.0	0.3	0.0	5.0
Bidens frondosus	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	9.9
Galium palustre	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	6.8

[a]Apparent misclassifications have been excluded.

SYNTHESIS AND CLASSIFICATION

The final, synthetic classification of Great Lakes marshes combined the classifications based on the three individual vegetation zones (emergent marsh, herbaceous zone, and shrub swamp). In assigning marshes to a specific group, greatest emphasis was placed on the emergent and herbaceous zones, since these are best represented in our sample. The shrub zone is generally a continuation of the herbaceous zone and provides duplicate information. In a few cases, geography was the deciding factor in assigning marginal cases to a specific group, in that neighboring sites tend to share similar climate, lake level regime, substrates, and shoreline disturbance.

Overall, 9 groups were identified (Table 21), each with a restricted geographical distribution. Vegetation zonation and key species (i.e. species showing a preferential distribution relative to each group) are discussed below. For details on vegetation composition by zone, see Appendix VII.

(1) Lake Superior Poor Fen. The group consists of the majority of marshes (N=14 sites) from the Lake Superior shoreline (Fig. 62a). These sites are characterized by fairly acidic, sandy soils and an extreme northern climate. As a result, organic decomposition is retarded and deep muck soils develop. These marshes occupy sheltered sites, including barrier-beach lagoons (64%), estuaries (29%) and tributary river deltas (7%), since marshes cannot develop along unprotected stretches of Lake Superior's harsh shoreline.

Emergent zones (present in 62% of these sites) are typically only a narrow fringe along open water, and contain species associated with clear, well-aerated waters. Most northern emergent marshes feature *Scirpus acutus*; however, these Lake Superior sites contain a low-density mix of *Eleocharis smallii*, *Sparganium fluctuans* (bur-reed), and the bulrush *Scirpus subterminalis* (each with mean cover value of 5%). Common floating-leaved species include *Nuphar variegata*, *Brasenia schreberi* (water shield), and *Megalodonta beckii* (water-marigold), while *Potamageton gramineus* is the most frequently encountered submergent species.

The herbaceous zone (present in 69% of cases) is consistently a northern poor fen. Species showing strong preferences for this habitat include *Sphagna* (especially *S. subsecundum* and *S. papillosum*), the forbs *Sarracenia purpurea*, *Menyanthes trifoliata*, *Rhynchospora alba*, *Triadenum fraseri* (marsh St. John's-wort), *Pogonia ophioglossoides* (rose pogonia), and the shrubs *Chamaedaphne calyculata*, *Myrica gale*, *Vaccinium macrocarpon*, and *V. oxycoccus* (small cranberry). The shrub zone (present in 69% of cases) is a poor shrub fen, and represents a continuation of the poor fen herbaceous zone. Dominant shrubby species include *Andromeda glaucophylla* (mean cover value 11%), *Chamaedaphne calyculata* (13%), and *Myrica gale* (22%), with lesser densities of *Vaccinium macrocarpon*, *V. oxycoccus*, and the widespread *Alnus rugosa*. *Sphagna* spp. is frequently the dominant groundcover species (attaining mean cover values of greater than 20%), along with *Carex lasiocarpa*, and the forbs *Sarracenia purpurea*, *Menyanthes trifoliata*, *Rhynchospora alba*, and *Pogonia ophioglossoides*. Continuity in species composition for northern poor fen is strong across a considerable range of lake levels (Minc 1997b), although extreme high lake levels reduce the abundance of some characteristic species, including *Sphagnum* spp. and *Chamaedaphne calyculata*.

Raspberry Bay, Wisconsin, represents a relatively undisturbed wetland site containing both typical Lake Superior Poor Fen and Northern Great Lakes Marsh (defined below) in ecologically distinct areas (Figs. 63 and 64). This site lies adjacent to the Raspberry River where it flows into Raspberry Bay; the lagoon itself represents an old embayment closed off by a narrow barrier beach, which protects it from Lake Superior. The Raspberry River currently bypasses the lagoon; thus there is no major drainage contributing water flow or sediment into the lagoon. The lagoon is underlain by peat in excess of 1 m thick and supports a broad poor fen (140 m wide), while a narrow poor shrub fen borders the upland edge. In contrast, vegetation adjacent to the main channel of the Raspberry River as is flows around the coastal lagoon feature, features a stretch of northern wet meadow adjacent to the stream-side emergent zone. Substrate in the herbaceous zone is sedge-derived peat, while clay underlies the emergent zone.

(2) Northern Rich Fen. This group comprises 11 coastal sites concentrated near the Straits of Mackinac and located on marly substrates (Fig. 62b). Most of these sites occupy embayments of the open, sandy shoreline where limestone bedrock or cobble is at or near the surface. As discussed above, these sites have calcareous soils (with a pH as high as 8.2), resulting either from calcareous substrates, water flow off adjacent limestone bedrock or limestone-rich till, or algal precipitation of calcium carbonate in the relatively warm, carbonate saturated waters. The result is the formation of distinctive "marly flats" and an associated complex of calciphile plant species, as encountered at Peck Bay on Marquette Island, in northern Lake Huron (Figs. 65 and 66).

Chara sp. frequently dominates the emergent zones along with *Scirpus acutus*, and overall species diversity low. The herbaceous zone -- the most distinctive and diagnostic zone -- is consistently a northern rich fen (present along 92% of transects). *Calamagrostis canadensis* can dominate (mean cover value 16%), but the calciphiles *Carex viridula* (8%) and *Lobelia kalmii* (< 5%) are key species for this group. Other species indicative of rich fen along the Great Lakes shoreline include *Cladium mariscoides*, *Potentilla anserina*, *Panicum lindheimeri*, *Triglochin maritimum*, *Eleocharis pauciflora*, and *Hypericum kalmianum*. Many of the rich fen species continue into the shrub zone as well, which was encountered along 31% of the transects. Common woody species of the rich shrub fen include *Myrica gale* (mean cover value 25%) and *Potentilla fruticosa* (8%), while *Larix laricina* and *Salix pedicellaris* (bog willow) are found in low numbers. This characteristic suite of calciphiles make the Northern Rich Fen type readily recognizable across a range of lake-level fluctuations (Minc 1997b).

Epoufette Bay, Kenyon Bay, Peck Bay (see Figs. 65 and 66), Voight Bay, and Big Shoal Cove in the Upper Peninsula, as well as at El Cajon Bay, Duncan Bay (Cheboygan), and Waugoshance Point in the Lower Peninsula are key sites for this type. In addition, several other sites contain calciphiles in at least one vegetation zone, and so appear to be related to the rich fen group. False Presque Isle, a lacustrine estuary of northern Lake Huron, occupies a depression in limestone bedrock and contains a *Chara*-dominated emergent zone. However, the deep organics typical of estuaries appear to have acidified the wet meadow zone, such that calciphiles are absent. A similar situation affects the vegetation of Mud Lake, a barrier-beach lagoon on the Door Peninsula underlain by limestone bedrock. Again, *Chara* dominates the emergent zone, but calciphiles are not strongly present in the herbaceous zone.

(3) Northern Marsh. This group includes all marshes along the St. Marys River, as well as circum-neutral sites of Lake Superior and northern Lakes Michigan-Huron (Fig. 67a); it is the largest group of Great Lakes wetlands sampled (N=29 sites). Marshes of this type occur on a diversity of glacial landforms and substrates, including clay lakeplain, sand lakeplain, and sandy ground moraine. Sites types vary: Lake Superior northern marshes typically inhabit estuarine sites, while those of northern Lakes Michigan-Huron are found in coastal embayments, as typified by Duck Bay, Marquette Island (Figs. 68 and 69). The largest group of sites, however, is the channel-side wetlands and embayments along the St. Marys River.

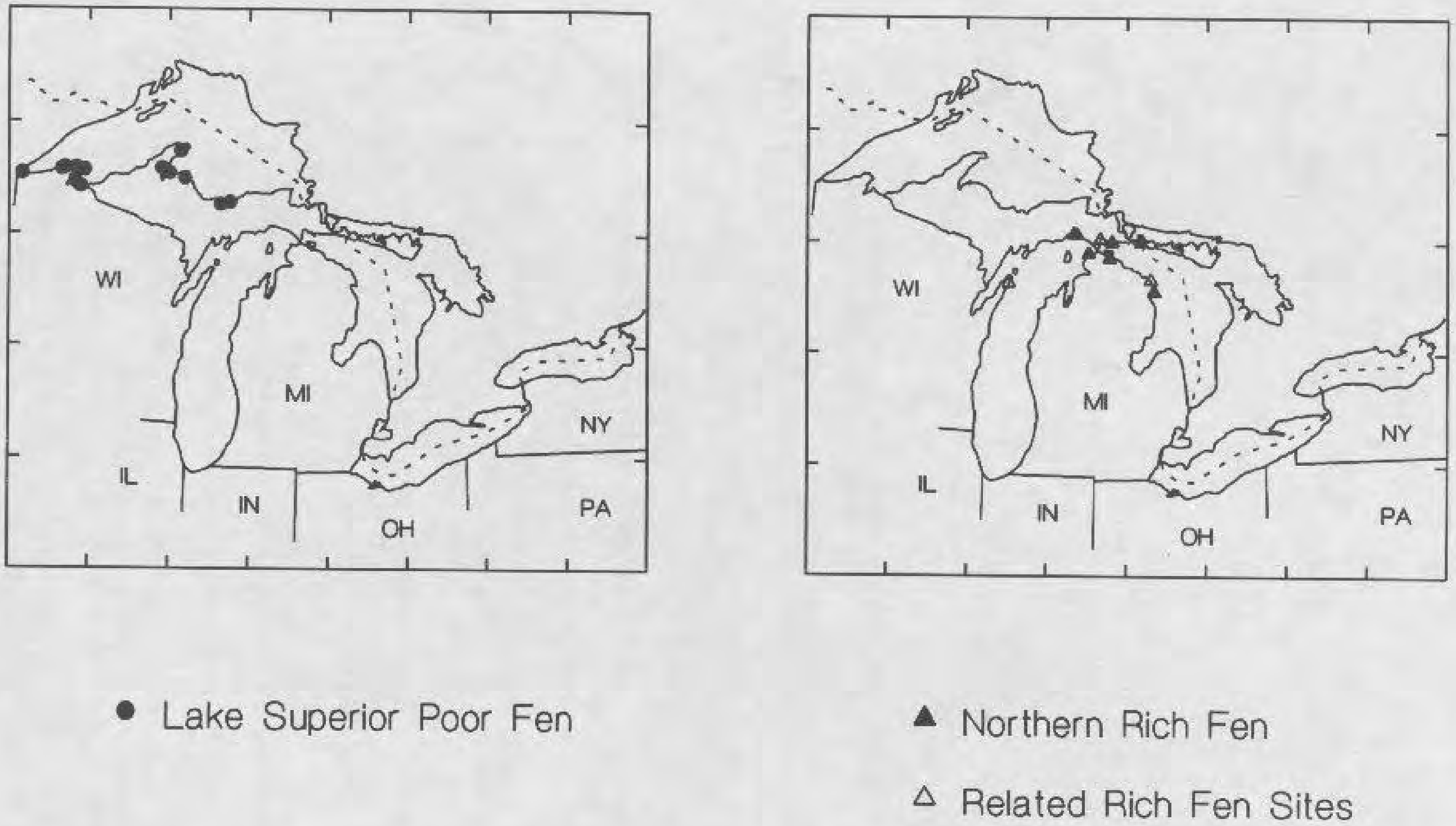


Figure 62. Distribution of sites belonging to the Lake Superior Poor Fen and Northern Rich Fen types in the Great Lakes region.

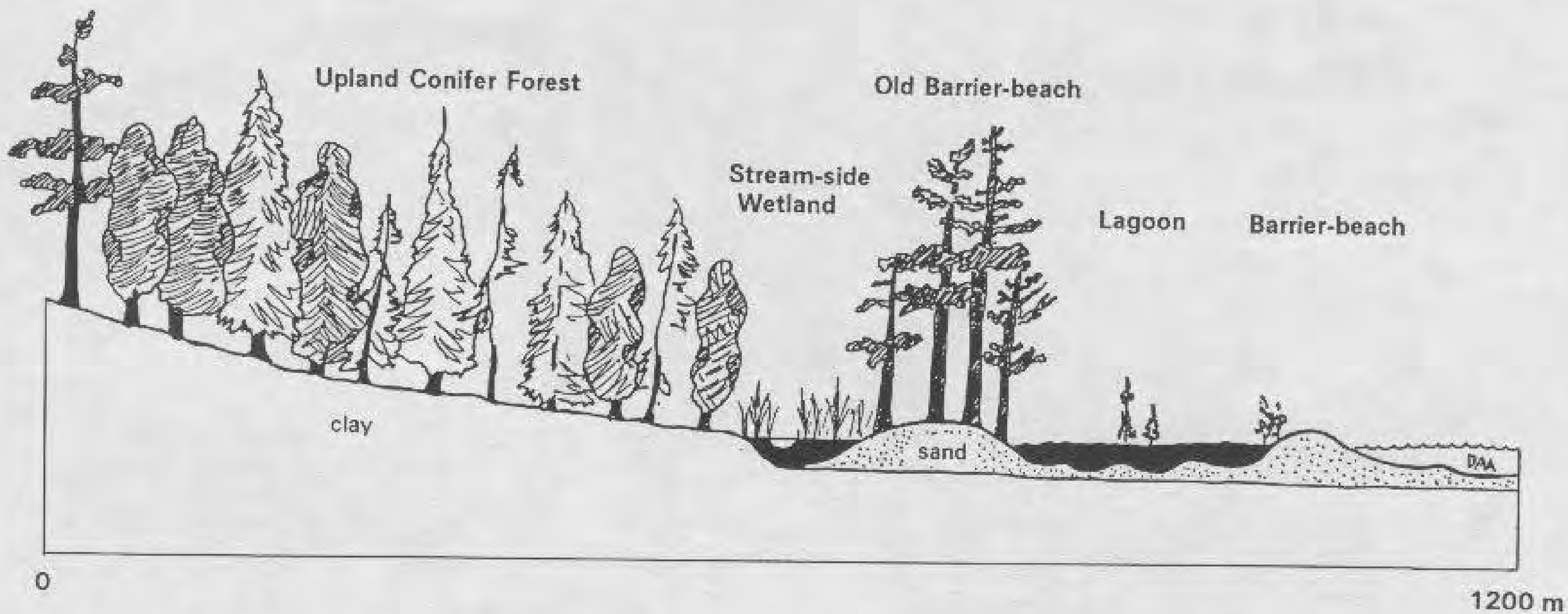


Figure 63. Landscape overview of vegetation zonation at Raspberry Bay, Wisconsin, a Lake Superior Poor Fen site.

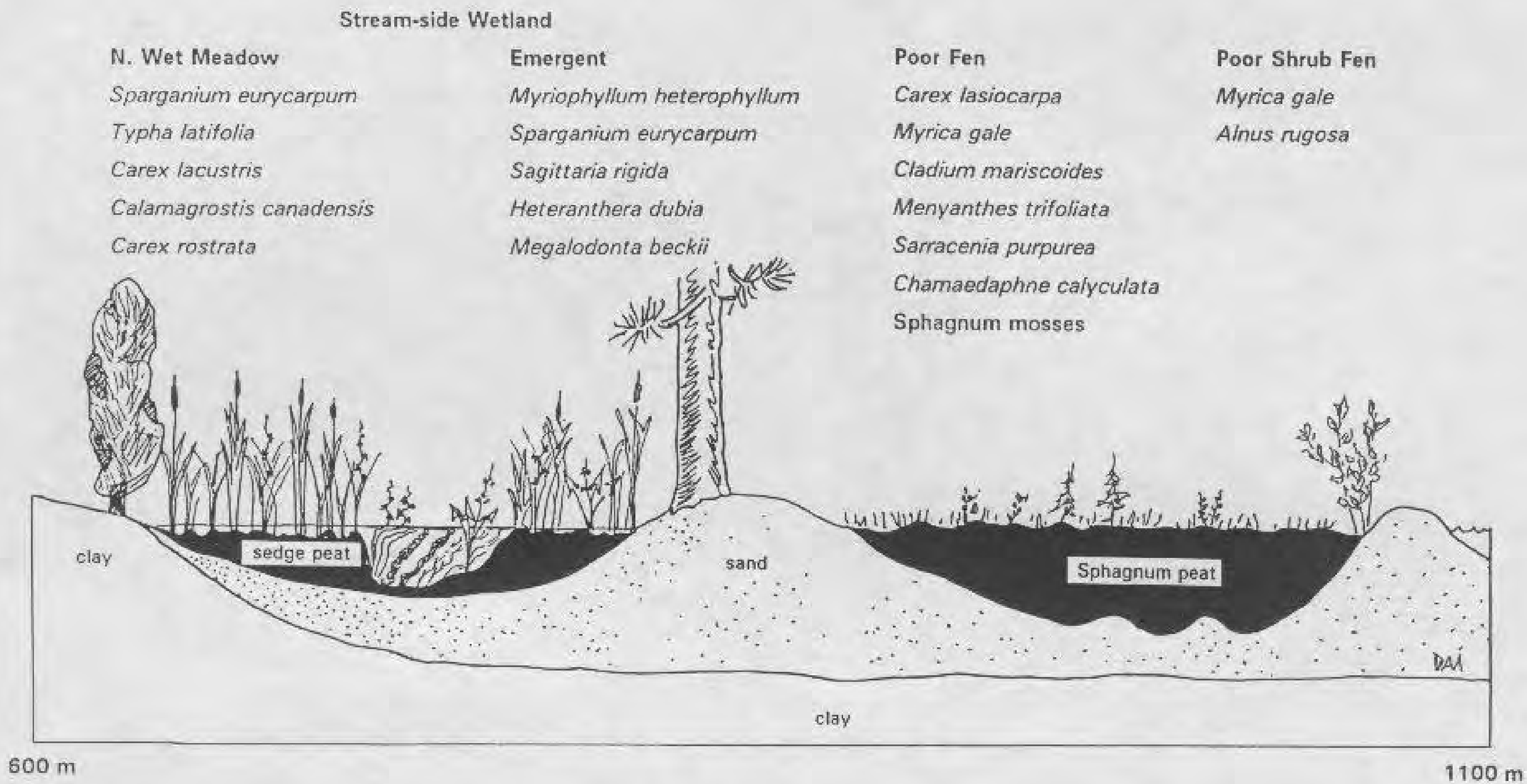


Figure 64. Detail of poor fen and northern marsh vegetation at Raspberry Bay, Lake Superior.

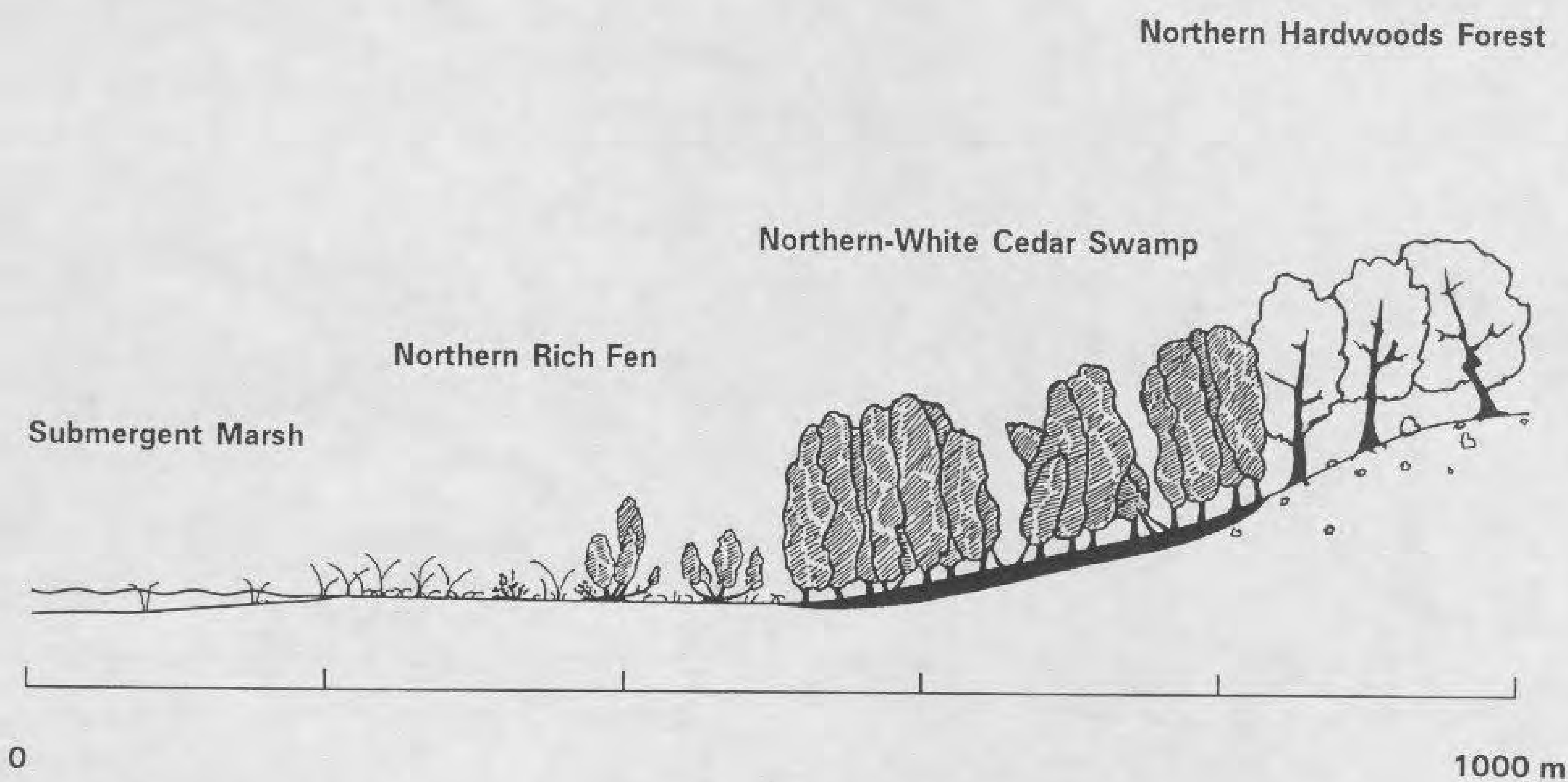


Figure 65. Landscape overview of vegetation zonation at Peck Bay, a Northern Rich Fen site, northern Lake Huron.

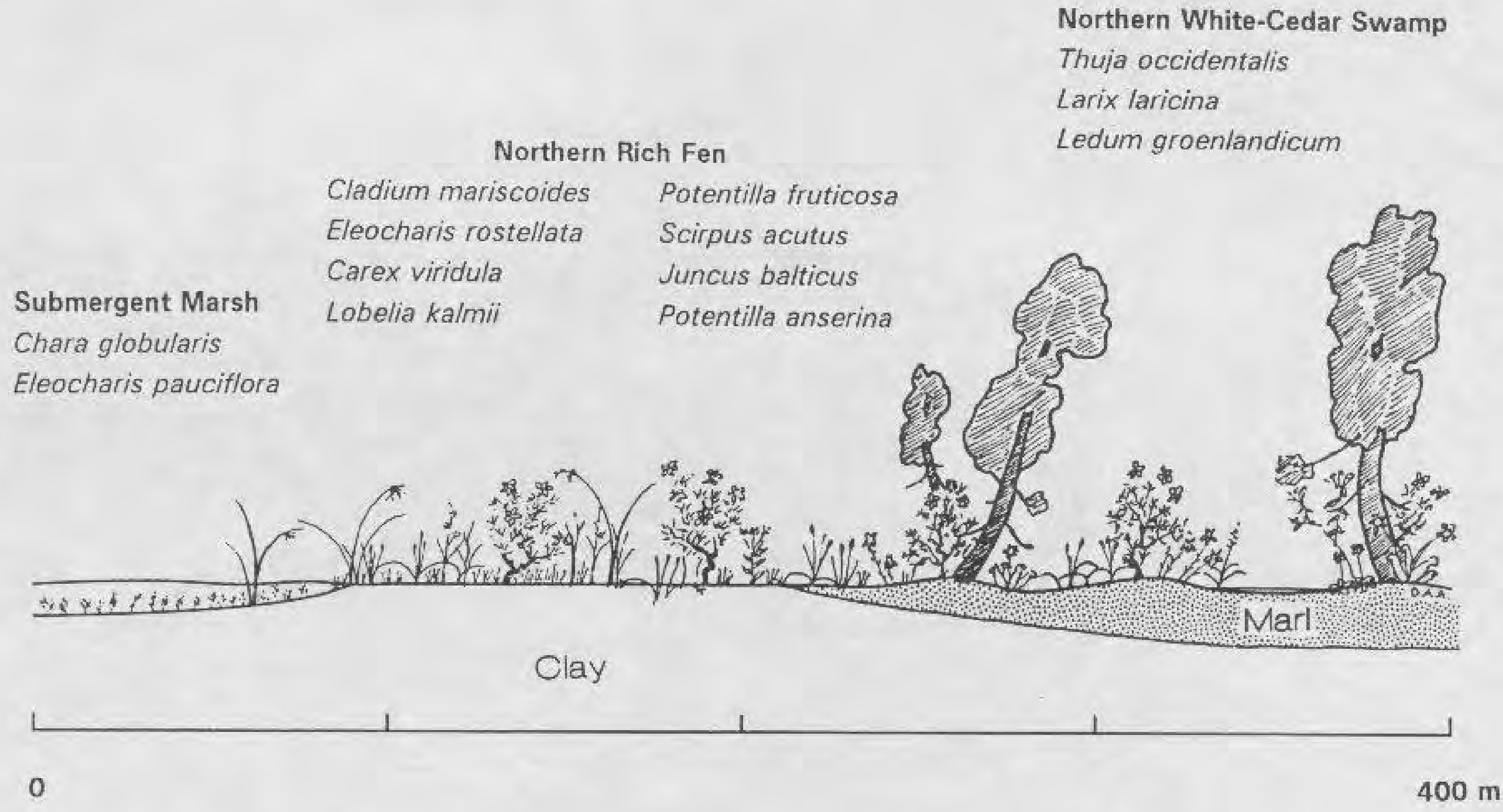


Figure 66. Detail of Northern Rich Fen vegetation at Peck Bay, northern Lake Huron.

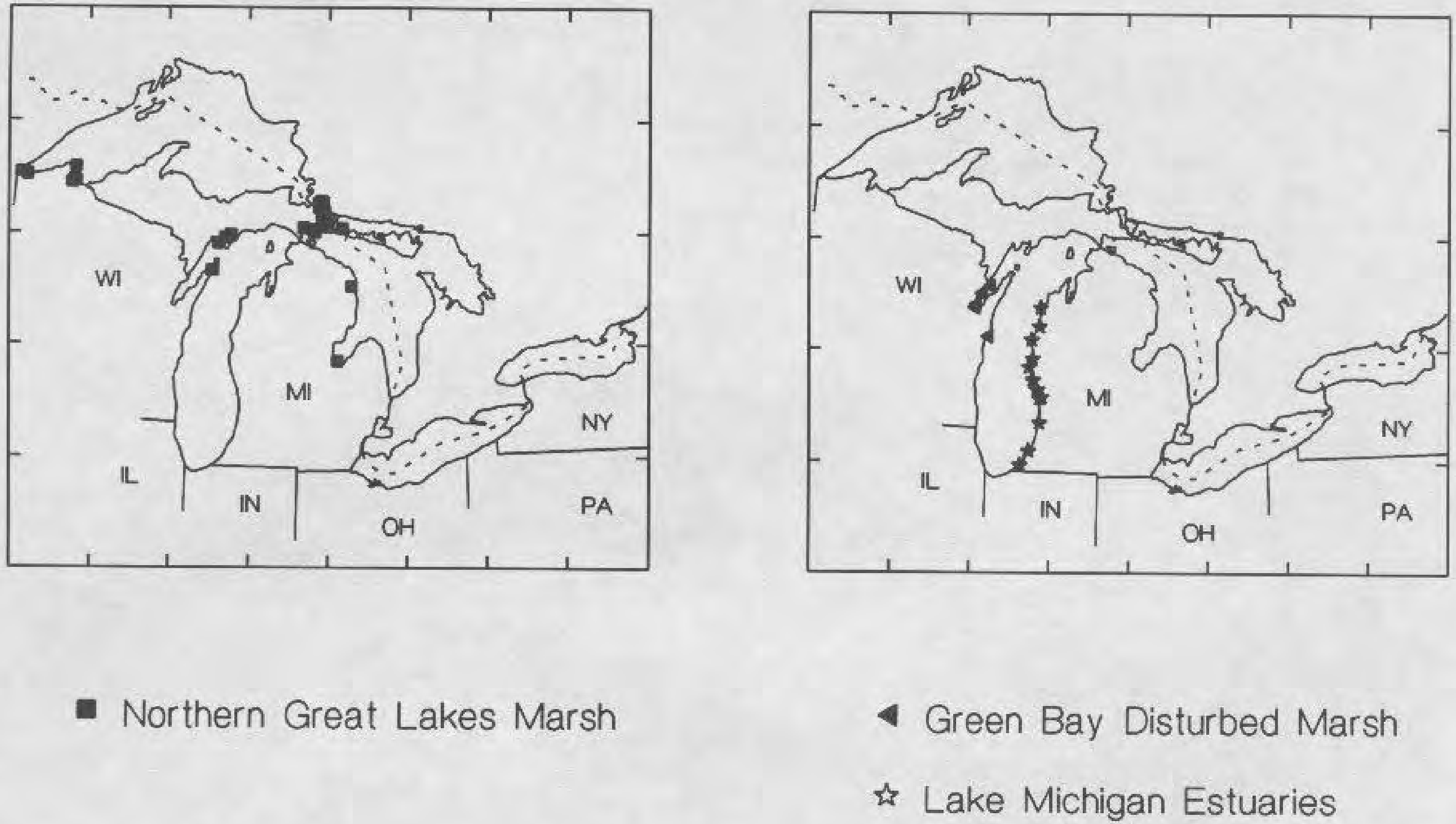


Figure 67. Distribution of sites belonging to the Northern Great Lakes Marsh, Green Bay Disturbed Marsh, and Lake Michigan Estuarine Marsh types.

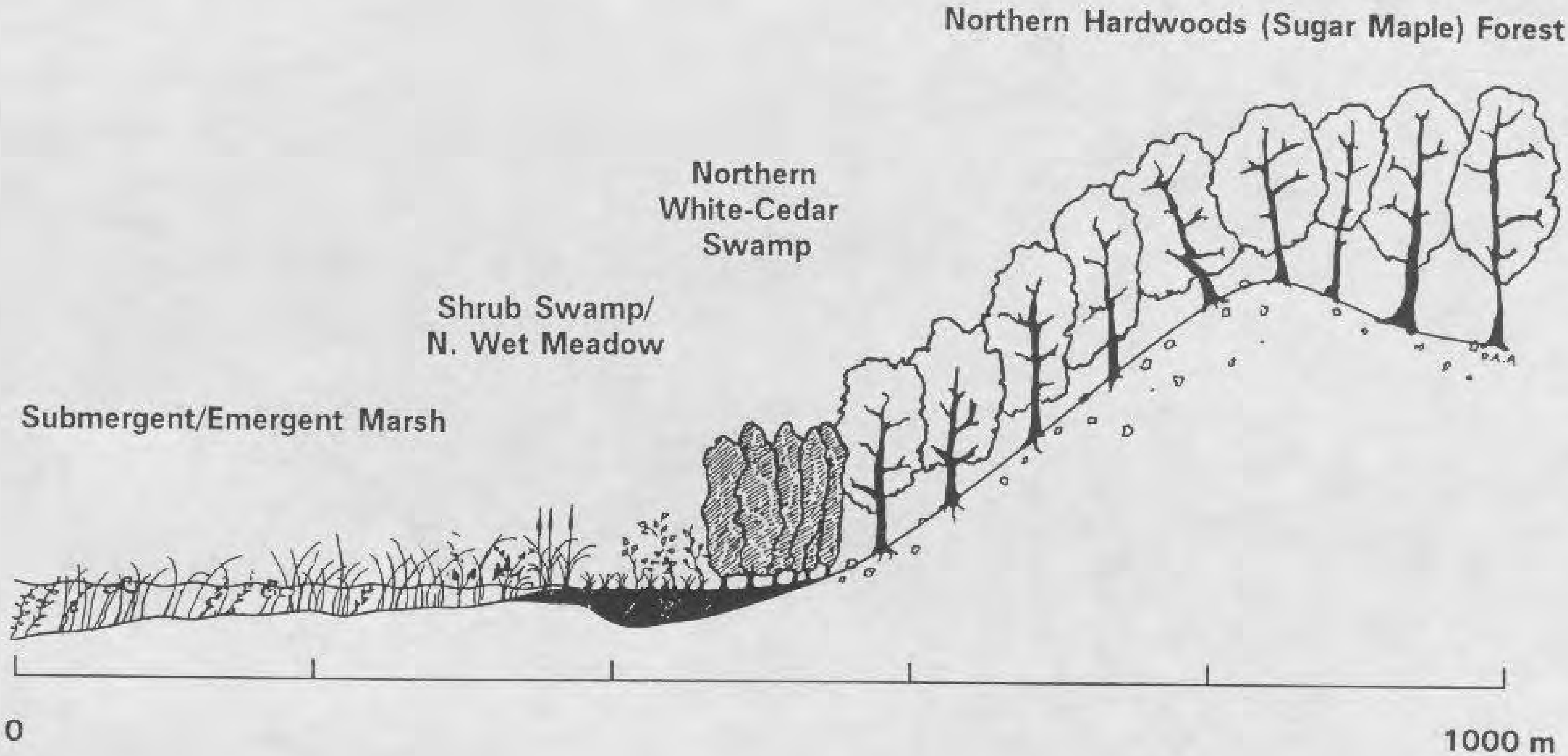


Figure 68. Landscape overview of vegetation zonation at Duck Bay, a Northern Great Lakes Marsh site, Marquette Island, northern Lake Huron.

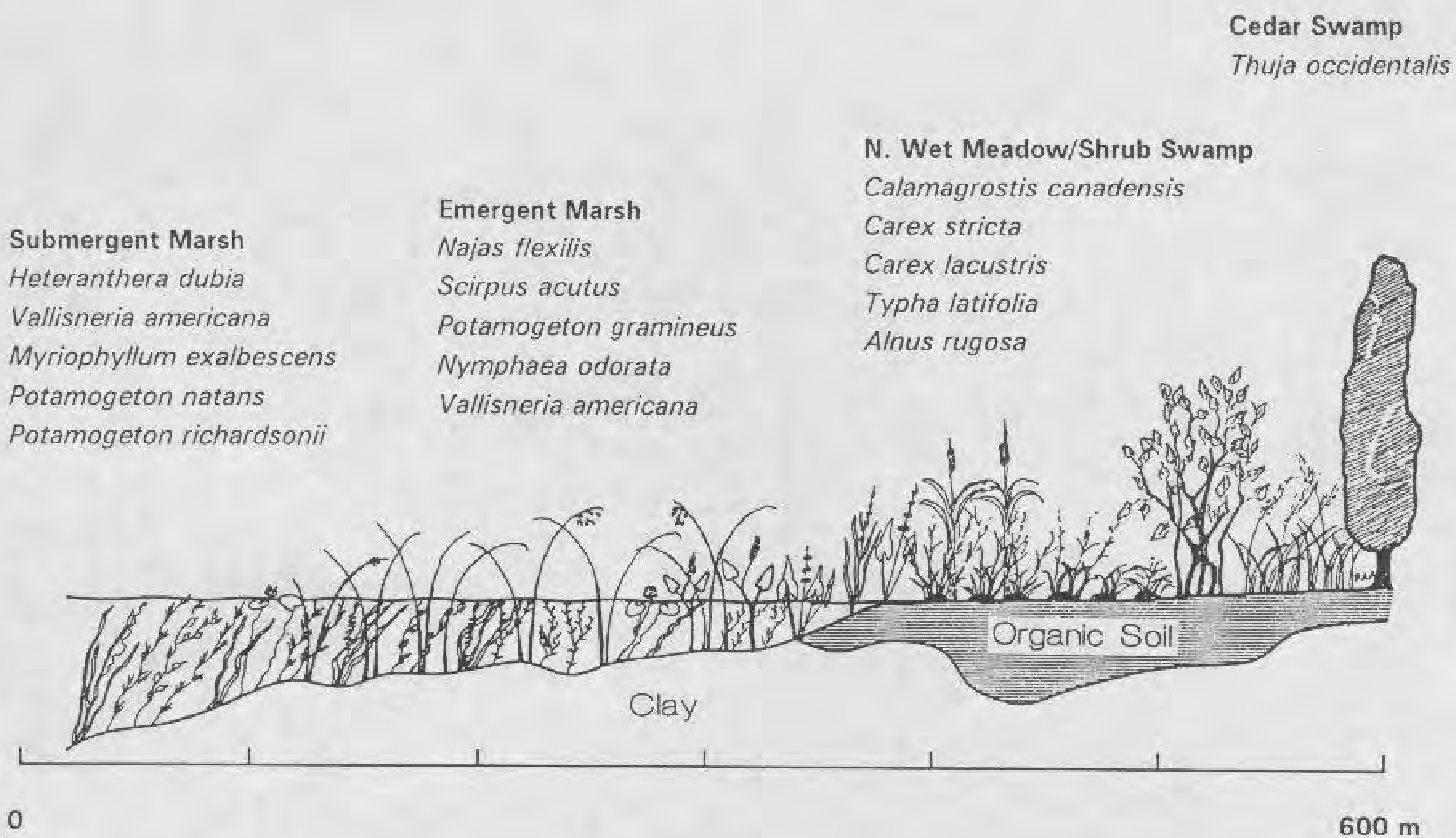


Figure 69. Detail of Northern Great Lakes Marsh vegetation at Duck Bay, Marquette Island, northern Lake Huron.

An emergent zone was almost always present in this type (90% of transects), and can be quite broad (up to 550 m). The open emergent vegetation features low densities of *Scirpus acutus* (10%) and *Eleocharis smallii* (7%), along with *Scirpus subterminalis*, *Equisetum fluviatile* (water horsetail), *Najas flexilis*, and *Sparganium eurycarpum* (common bur-reed). The submergent pondweeds *Potamageton gramineus* and *P. natans* are common occurrences in this zone as well.

The herbaceous zone (present along 90% of transects) is consistently a northern wet meadow. *Calamagrostis canadensis* (mean cover value 15%), *Carex stricta* (18%), and *C. lacustris* (14%) are consistent co-dominants. Key forbs for the northern wet meadow include *Campanula aparinoides* and *Potentilla palustris*.

A narrow band of shrubs, often only 10-20 meters wide, borders many of the marshes, but was encountered in only 18% of the transects. Shrubby species strongly preferential to this group include *Spiraea alba* and *Salix petiolaris*, but other wide-spread woody species are found here as well, primarily *Alnus rugosa* and *Myrica gale*. *Calamagrostis canadensis*, *Carex stricta*, *C. lacustris*, and *Potentilla palustris* remain dominant in the groundcover.

A comparison of vegetation within 6 northern marsh sites for (a) a period immediately following an extreme high water period, and (b) a period of near-normal lake levels indicated that species composition within this type is fairly stable across lake-level fluctuations (Minc 1997b). In general, emergent and herbaceous zones experience a shift in species dominance rather than a major compositional change. Of particular interest is the cyclical decrease and corresponding decrease in wet meadow zone dominants *Carex stricta* and *Calamagrostis canadensis* as lake levels fluctuate. *Carex stricta* forms tussocks, which persist during periods of high water. Within the protective matrix of these tussocks, *Calamagrostis canadensis* can also persist during periods of inundation; however, after dry-down, this species fills in between tussocks and eventually becomes the dominant. A related response is seen in the increase in *Campanula aparinoides*, a very slender plant with a prostrate habit, which is dependent on the stable structure of dominants for support. Both of these responses point to a gradual recovery of existing species following inundation and dry-down. However, field researchers did identify a suite of plants that can rapidly and densely colonize the narrow band of organic-rich substrate or "mud flat" left by receding lake waters. These northern colonizing species include *Eleocharis acicularis* (spike-rush), *E. pauciflora*, *Sagittaria gramineus* (grass-leaved arrowhead), *Juncus pelocarpus* (brown-fruited rush), and *Eriocaulon septangulare* (pipewort).

(4) Green Bay Disturbed Marsh. This Lake Michigan group contains a small number of Wisconsin sites located near the tension zone which display both northern and southern vegetation characteristics, and a high level of disturbance (Fig. 67b). These sites include Peshtigo River, Oconto River, Dead Horse Bay, and Little Tail Point from Green Bay. The West Twin River estuary further south on the western Lake Michigan shoreline is included with this group based on similarly high disturbance levels. All occupy relatively well-protected sites, including deltaic channels, estuarine channels, and sheltered sand-spit embayments, with the latter being most vulnerable to destruction or modification by storms.

These sites also share a highly disturbed habitat. Lower Green Bay is bordered by a flat, poorly drained clay lakeplain which has been intensively farmed with row crops, and waters of the bay are generally characterized as quite turbid, owing to erosion from agricultural activities; industrial and urban pollution are also major contributing factors. At the West Twin River, high turbidity levels have generally eliminated emergent vegetation; field investigators reported that water visibility was less than 15 cm.

In general, the emergent zones of these sites contain a more southern flora high in floating species, while their wet meadow zones span the north-south division. Emergent zone dominants include key southern species (*Ceratophyllum demersum*, *Elodea canadensis*, *Lemna minor*, and *Spirodela polyrhiza*), along with the widespread *Nymphaea odorata* and *Sagittaria latifolia*. As a group, these species represent quiet, nutrient-rich waters. In the herbaceous zone, *Calamagrostis canadensis* is clearly the dominant (mean cover value of 40%), while both *Carex stricta* and *C. lacustris* are present in low levels. Species more characteristic of the south include *Impatiens capensis* and *Typha angustifolia*, and the exotics *Lythrum salicaria*, *Phragmites australis*, and *Phalaris arundinacea*. A distinct shrub zone was seldom encountered in sampling transects, due to heavy disturbance in the upland portion of the landscape.

Owing to the low gradient, fluctuations in Lake Michigan's water level considerably alter the size of these coastal wetlands (Harris et al. 1977), with substantial portions of sandy beach exposed during low water. Harris et al. (1981) discuss successional changes in three marshes along the western shore of Green Bay following a period of high Great Lakes water levels (1973-1976). Receding water levels in the winter of 1976-1977 produced extensive open mud flats, which were quickly colonized by dense stands of *Scirpus validus*, *Bidens cernuus*, and one or more species of *Polygonum*. Neither *Bidens cernuus* nor *Polygonum* spp. were abundant the following year. *Scirpus validus* continued to be widespread, but declined steadily over the next few years and was replaced by a sedge meadow consisting primarily of *Carex* spp. and *Calamagrostis canadensis*.

(5) Lake Michigan Lacustrine Estuaries. This group consists of barred lacustrine estuaries of western Lower Michigan, generally south of the tension zone (Fig. 67b). All of the major rivers along this stretch (including the Galien, St. Joseph, Paw Paw, Kalamazoo, Grand, Muskegon, Stony, Pentwater, and Big Sable) have lacustrine estuaries at their mouths. Most are partially to largely barred by longshore sand transport, and many have artificially maintained channels to Lake Michigan. These estuarine systems can extend for a considerable distance inland (up to 17 miles along the Pere Marquette), where the rivers occupy linear depressions through interior glacial moraines and sand lakeplain. Sites of this group are well protected from wind and wave action, owing to their long, narrow configuration and partial separation from Lake Michigan. This protection results in deep accumulations of organic deposits (typically muck, mucky peat, and/or peat over sand) throughout the emergent and herbaceous vegetation zones, while waters of the inland ponds are generally shallow and nutrient rich.

The location of these sites relative to the tension zone suggests a northern and a southern subtype, which may experience significant differences in growing season temperature and length. Three sites in our sample belong to the northern group: Bar Lake, Big Sable River, and Betsie River. Several other sites not included in the vegetative analysis appear to belong to this group as well, including Pere Marquette and Manistee. Bar Lake is associated with the northern estuary group based on both geography and vegetation, although it is a barrier-beach lagoon now completely separated from Lake Michigan. Sites belonging to the southern group include marshes along the lower reaches of the Galien, Kalamazoo, Grand (Pottawattomi Bayou and S. Lloyd Island), White, Muskegon, Paw Paw, and Pentwater rivers, and Stoney Creek. The primary vegetative differences between the groups appear in the emergent zone, while the two subtypes share a similar southern wet meadow and southern shrub swamp flora.

In the emergent zone, key floating species for both subtypes include *Lemna minor* (mean cover 10%) and *Ceratophyllum demersum* (8%). In contrast, *Spirodela polyrhiza* (23%), *Peltandra virginica* (19%), and *Nuphar advena* (10%) are characteristic of the southern sites, and virtually absent in the north. *Scirpus validus* and *Sparganium eurycarpum* are typical edge species for both subtypes; *Nymphaea odorata* has a wide-spread distribution, but in these protected sites can form particularly dense beds.

The herbaceous zone for both subtypes conforms to the southern wet meadow type. *Calamagrostis canadensis* is a frequent dominant (mean cover value of 19%), but key southern species include *Impatiens capensis*, *Rorippa palustris*, *Polygonum lapathifolium*, and *Leersia oryzoides* (cut grass). The southern shrub swamp is characterized by a mix of *Alnus rugosa*, *Cornus stolonifera*, and *Fraxinus pennsylvanica*, but many of the above-mentioned herbaceous species occur throughout. In addition, *Osmunda regalis* (royal fern) is common here.

Vegetative response to changing lake levels in these estuarine sites appears to be largely a function of site morphometry (Minc 1997b). Steep banks appear to limit shallow water habitats during high water periods such that shallow water vegetation is largely eliminated. As a result, high-water years are marked by a decrease in edge communities and shallow water emergents, including both broad-leaved emergents (*Peltandra*, *Pontederia*, and *Sagittaria*) and narrow-leaved emergents (e.g. *Typha*), and a concomitant increase in floating-leaved communities and associated duckweeds.

(6) Saginaw Bay Lakeplain Marsh. This group contains most sites from Saginaw Bay (Fig. 70a). Formed by a flat glacial lakeplain that slopes gently into Lake Huron, Saginaw Bay is very shallow with a thin veneer of sand over clay. Along the shoreline, low beach ridges and sand dunes alternate with organic-rich clays; the Wildfowl Bay Islands are sand spits formed over local exposures of limestone bedrock. The marshes sampled for this study occupy a range of site types, from protected sand-spit embayments to open coastal embayments.

Marshes in this group contain a mix of northern and southern species; generally they support a northern (open water) emergent marsh complex (but without a strong submergent component), and a southern herbaceous complex. This dual affinity may reflect the location of the climatic tension zone or transition across Saginaw Bay. In addition, most sites contain ample floristic evidence of intensive agricultural land-use.

An emergent zone was usually present (85% of transects), ranging from 200 to 770 m wide. A majority of these sites (64%) contain a northern emergent marsh containing the key northern species *Scirpus acutus* and *Eleocharis smallii*, although not in great densities. However, excessive sedimentation appears to have excluded many submergent species typically found within a northern emergent marsh, including most pondweeds, which are intolerant of turbidity. Both *Scirpus americanus* and the more southerly *S. validus* are frequently present as well, while *Typha angustifolia* and *Najas flexilis* are common co-dominants; floating species (such as the duckweeds) are only minimally present. In a few of the more open coastal embayments *Scirpus americanus* forms near monocultures, apparently due to its greater tolerance of extreme wave action. The remaining sites contained a very depauperate emergent zone in which *Chara* was the dominant (and sometimes only) species.

An herbaceous zone was encountered in 86% of transects, ranging from 60 to 330 m in width. This zone was typically a southern wet meadow with a high percentage of early successional and disturbance species. Typical colonizing species include *Bidens cernuus*, *Impatiens capensis*, *Rorippa palustris*, *Scirpus validus*, and *Polygonum lapathifolium*; common exotics include *Lythrum salicaria*, *Phragmites australis*, *Phalaris arundinacea*, and *Polygonum persicaria*. A distinct shrub-swamp zone was not noted for this group. The absence of a shrub swamp may reflect the intensity of land-use in this area, in which fertile lacustrine soils are farmed as close to Great Lakes coastal wetlands as possible.

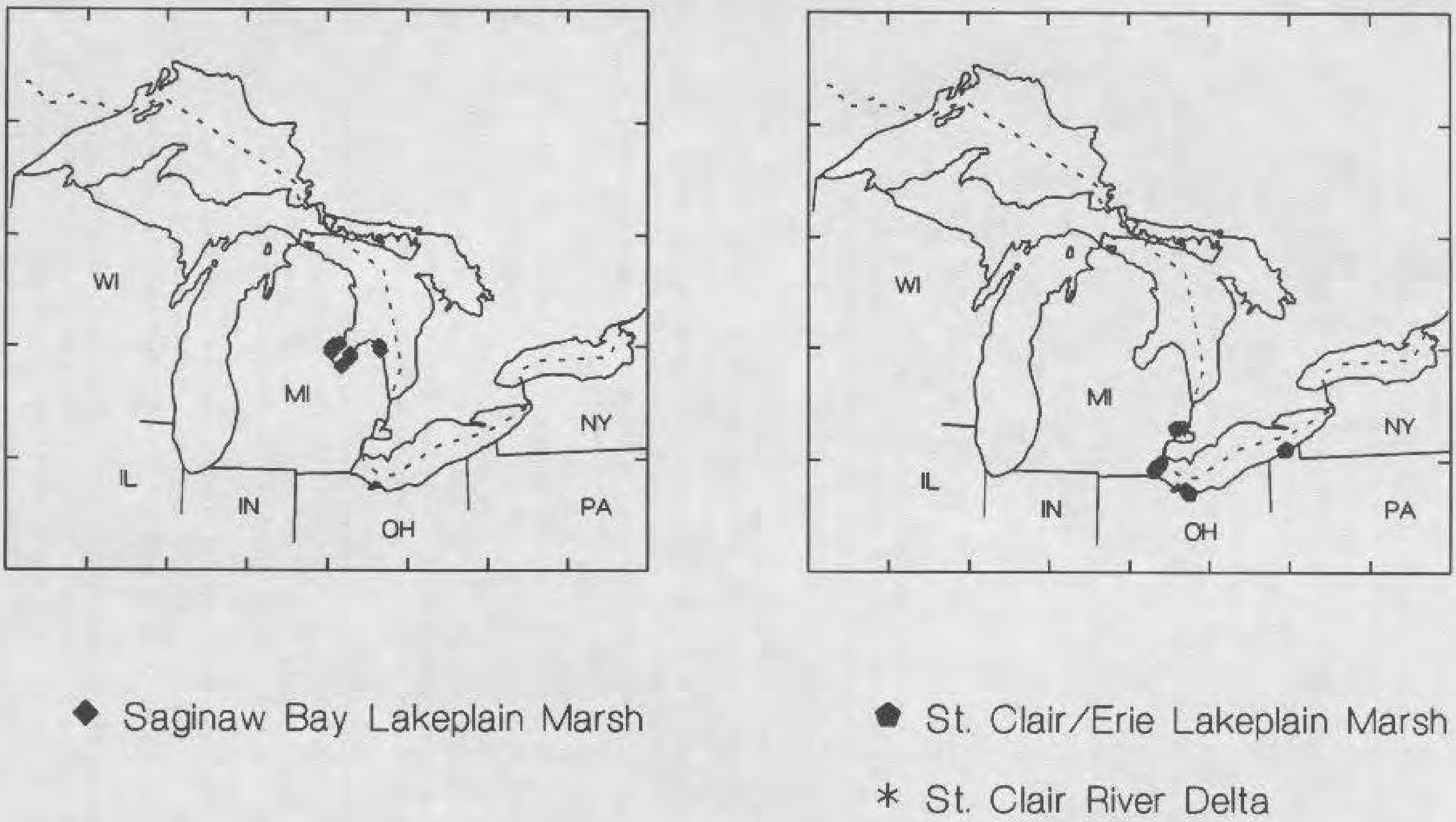


Figure 70. Distribution of sites belonging to the Saginaw Bay Lakeplain Marsh and St. Clair/Erie Lakeplain Marsh types.

In contrast to the other wetland types, the marshes of the Saginaw Bay lakeplain experience significant changes in the abundance and ubiquity of dominant species relative to lake-level fluctuations, particularly in the herbaceous zone (Minc 1997b). Many of the key species for this type, including *Rorippa palustris*, *Bidens cernuus*, *Polygonum lapathifolium*, and *Scirpus validus*, are early successional species which rapidly form dense stands on newly exposed mud flats as lake levels drop. On the Saginaw Bay lakeplain, the gentle slope combined with the heavy deposition of fine sediments create the potential for extensive, fertile mud flats following dry-down and favor species adapted to the cyclical exposure of this habitat. In contrast, when lake levels remain at or below the mean, succession to a more typical wet meadow takes place, with an increased dominance of *Calamagrostis canadensis* and *Carex stricta* and a dramatic drop in the cover values of the colonizing species. Although these successional changes are widespread in the southern Great Lakes, they are particularly characteristic of the shallow marshes heavily affected by agricultural siltation rimming Saginaw Bay.

(7) Lake Erie-St. Clair Lakeplain Marsh. This group includes all marsh sites from the glacial lakeplain of Lake St. Clair and western Lake Erie (Fig. 70b). Although the lakeplain formerly supported extensive marsh and wet prairie communities, the predominant remaining wetlands are the lacustrine estuaries formed at the mouths of rivers drowned by the post-glacial rise in lake level (i.e. buried river mouths). However, even the remaining marshes reflect high levels of agricultural disturbance characteristic of the fertile, flat lakeplain soils, along with heavy manipulation of the shoreline through diking and rip-rap.

Four estuaries were sampled in this study (Swan Creek, Otter Creek, Old Woman Creek, and the Huron River), along with several deltaic and barrier-beach lagoon sites. Two sand-spit swales from the Presque Isle peninsula fall in this group as well. All of the marshes occupy fairly protected sites; in addition, the Lake Erie sites enjoy the most moderate climate of the Great Lakes region. As a result, their emergent marshes feature a relatively southern flora, while herbaceous zones are typically a southern wet meadow with a high proportion of disturbance species.

Emergent zones were encountered in 80% of transects. Common species include the floating duckweeds (*Lemna minor* and *Spirodela polyrhiza*), and the canopy-forming submergents *Ceratophyllum demersum* and *Elodea canadensis*, characteristic of quiet, turbid waters. The southern species *Nuphar advena* is common, while *Nelumbo lutea* (American lotus) attains very high densities at selected sites. *Sagittaria latifolia*, *Scirpus validus*, *Typha angustifolia*, and *T. x glauca* (hybrid cat-tail) are common edge species.

Herbaceous zones (encountered in 90% of transects) are a southern wet meadow dominated by *Calamagrostis canadensis* (21% mean cover value), along with *Phalaris arundinacea* (14%), *Typha angustifolia* (12%), and *Polygonum lapathifolium* (11%). The standard suite of early successional species (*Bidens cernuus*, *Impatiens capensis*, *Rorippa palustris*) and common exotics (*Lythrum salicaria* and *Phragmites australis*) are present as well. A distinct shrub zone was encountered along only one transect. As in the case for Saginaw Bay, the absence of a shrub swamp often reflects the intensity of land-use in this area, in which fertile lacustrine soils are farmed as close to Great Lakes coastal wetlands as possible.

The St. Clair River delta is loosely joined with the St. Clair-Erie lakeplain group; however, the St. Clair "flats" is a unique site in the Great Lakes, and its vegetation differs significantly from sites of Saginaw Bay to the north and Lake Erie to the south. Emergent zone vegetation is more typical of northern, open marshes, perhaps owing to the flow of the river.

Dominant emergent species are a mix of open-water species, including *Scirpus acutus* (14% mean cover value), *Scirpus subterminalis* (13%), and *Najas flexilis* (13%), while *Chara* spp. (18%), *Potamogeton natans* (11%), and *P. obtusifolia* (12%) are well represented in the submergent zone. The herbaceous zone is clearly dominated by *Calamagrostis canadensis* (36%) and *Carex stricta* (21%). Common early successional and exotic species were only minimally present.

(8) Lake Ontario Lagoon Marshes. Eight sites in eastern Lake Ontario make up this group (Fig. 71a); all but one are barrier-beach lagoons. These marshes share a similar protected site type, lake-level regime, and an associated set of distinctive species in the emergent, herbaceous, and shrubby zones.

The lagoon sites represent two distinct shoreline areas. Along the southern shore of Lake Ontario, the lake truncates a field of N-S oriented drumlins; low barrier beaches (generally less than 3 m high) across intervening embayments have created a series of shallow lagoons, including the East Bay, Black Creek, and Sterling Creek sites. These lagoons are typically fed by small streams draining off the drumlin field and are characterized by deep organic deposits accumulated over the last several thousand years.

The second area of barrier-beach lagoons stretches along the eastern end of Lake Ontario. Here, predominant wind and water currents have led to the accumulation of sands, creating a low shoreline characterized by numerous embayments with barrier beaches and sand dunes rising up to 30 m above the lake (Fig. 72). The barrier beaches create a string of shallow lagoons connected by wetlands, most fed by small, cold-water streams. The larger lagoons extend inland up to 3 km, and are bordered by drumlin features of the till plain. Substrates are sands, covered by up to 2 m of organic deposits. The lagoons at Deer Creek, Cranberry Pond, South Colwell Pond, and Lakeview Pond were sampled in this study.

Dexter Marsh, in contrast, represents a delta site at the mouth of the Black River estuary. Along this northeastern stretch of Lake Ontario, streams flowing from the interior are slightly entrenched, and the lake shoreline is deeply indented with bays as a result of the drowning of the lower valleys of these streams (Van Diver 1985:296). These estuarine river mouth embayments and stream channels (including the Black River) provide the context for extensive wetland development reaching several kilometers inland.

The lagoon sites are protected not only by barrier-beaches, but by water level regulation of Lake Ontario, which has significantly reduced the occurrence of extreme high and low water levels on Lake Ontario. Disruption of the natural cycle favors species intolerant of water-depth change and associated stresses, and/or excludes species requiring periodic exposure of fertile substrates, potentially leading to a reduction of species diversity. The dominance of cat-tails in many Lake Ontario marshes suggests a trend toward reduced species diversity following a reduction in the amplitude of natural water-level fluctuations (Wilcox et al. 1993).

The emergent zones of this type (present along 78% of transects) feature very high densities of the canopy-forming submergent species, *Ceratophyllum demersum* (37% mean cover value) and *Elodea canadensis* (14%), along with the duckweeds *Spirodela polyrhiza* (12%) and *Lemna trisulca* (20%). *Nuphar advena* (14%) and *Nymphaea odorata* (19%) are also common. All of these reflect the well-protected and nutrient rich waters of the lagoons, although *Lemna trisulca* may be associated with cold, spring-fed streams. High densities of this last species are distinctive to the Lake Ontario and St. Lawrence sites, as is the prevalence of *Potamogeton zosteriformis*.

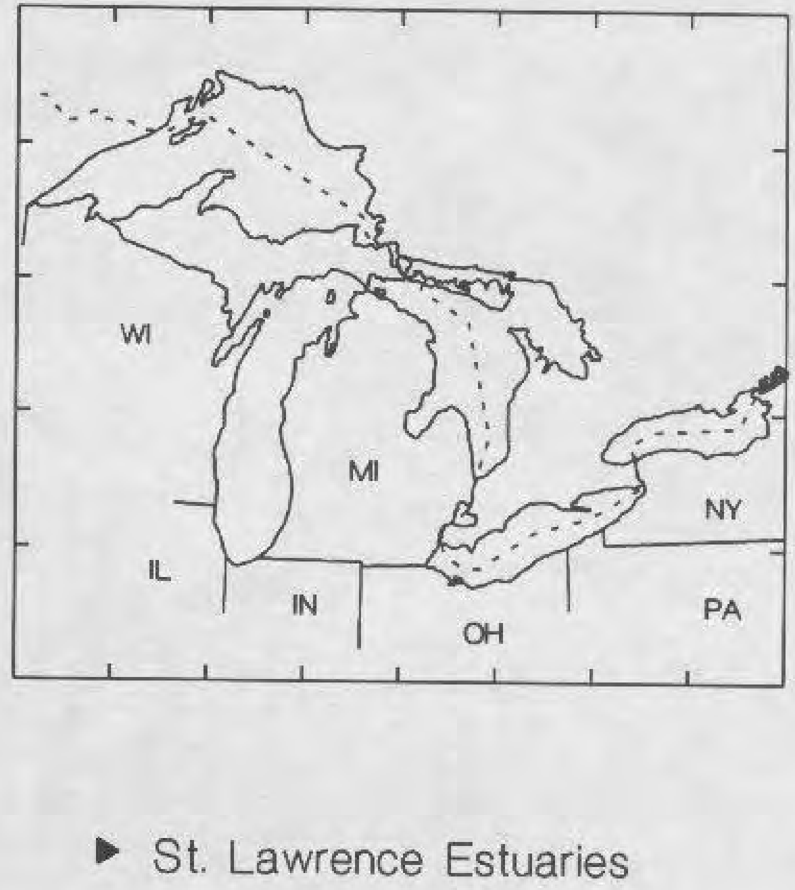


Figure 71. Distribution of sites belonging to the Lake Ontario Lagoon Marsh and St. Lawrence Estuary Marsh types.

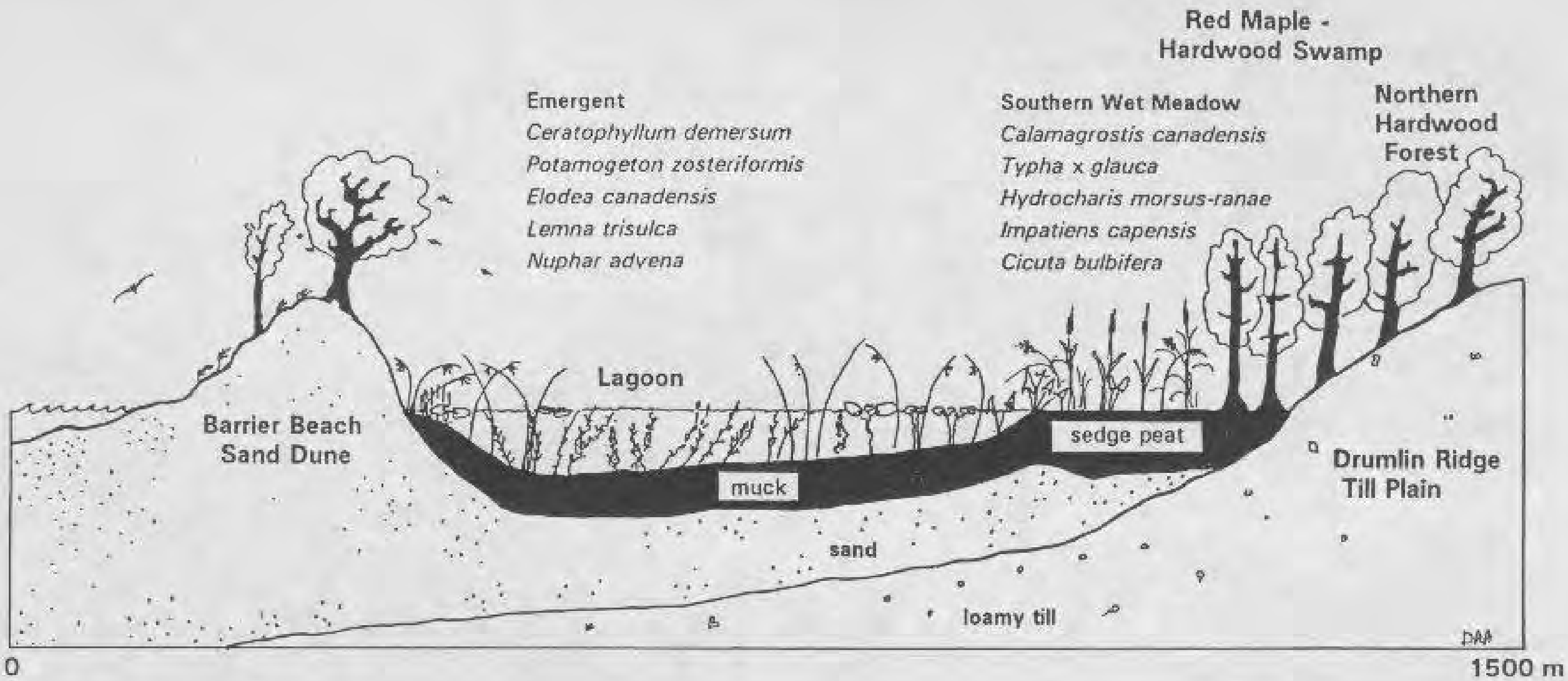


Figure 72. Landscape overview of vegetation zonation at Lakeview Marsh (South Colwell Pond), a Lake Ontario Lagoon Marsh site, eastern Lake Huron. This 3400 acre wetland complex, located behind a 5-mile barrier beach, is representative of barrier-beach lagoon sites along the eastern shore of Lake Ontario. It is fed by two cold water streams, Sand Creek and South Sandy Creek. Some areas adjacent to the barrier beach are ponded and include open water and deep emergent marsh communities. The majority of the site is occupied by extensive shallow emergent marsh in water generally less than 1 m deep.

In the herbaceous zone (encountered along 67% of transects), *Typha angustifolia* typically dominates (mean cover value 24%), along with *Calamagrostis canadensis* (17%) and *Thelypteris palustris* (12%). Cat-tail is particularly sensitive to flooding; its dominance in Lake Ontario corresponds historically to the recent period of lake-level regulation. In contrast, species adapted to the cyclical exposure of shoreline mud flats are poorly represented in these sites.

The shrubby zones divide into two distinct types: buttonbush thicket and poor shrub fen. The former type (present along 44% of transects) features a mix of *Decodon verticillata* (mean cover value 34%) and *Cephalanthus occidentalis* (13%), along with *Alnus rugosa* (25%). *Thelypteris palustris* (22%) and *Peltandra virginica* (14%) dominate mucky openings within the thickets.

In contrast, poor shrub fen was encountered on two transects. Poor shrub fen is best developed in areas of low water flow behind barriers, typically distant from the active stream channel. Accumulation of organic materials leads to eventual acidification of surface sediments, and favors the establishment and survival of plants characteristic of poor fens. Here, *Chamaedaphne calyculata* dominates (mean cover value 32%), along with the typical poor fen shrubs *Myrica gale* (19%), *Vaccinium macrocarpon* (21%), and *Andromeda glaucophylla* (9%). *Sphagna* spp. attain high cover values in the groundcover (mean 41%), as does *Sarracenia purpurea* (15%).

Lakeview Marsh (South Colwell Pond), a 3400-acre wetland complex located behind a 5-mile barrier beach, is representative of barrier-beach lagoon sites along the eastern shore of Lake Ontario (Fig. 72). A substantial barrier beach sand dune creates a shallow, protected lagoon which extends inland to the upland till plain. The lagoon is fed by two cold water streams, Sand Creek and South Sandy Creek. Areas adjacent to the barrier beach are ponded and include open water and deep emergent marsh communities. The majority of the site is occupied by extensive shallow emergent marsh in water generally less than 1 m deep. A red maple-hardwood swamp rims the wetland, while the adjacent uplands support northern hardwood forest.

(9) St. Lawrence River Estuaries. This group contains six sites along the upper reaches of the St. Lawrence River (between Cape Vincent and Chippewa Point), where the river is strongly influenced by Lake Ontario. This stretch features numerous islands and bedrock knobs on the adjacent mainland shore which are the surface expression of the Frontenac Arch, where overlying limestone and sandstone formations have been removed by glacial scouring to reveal the irregular surface of the underlying Precambrian rock. The exposed bedrock is mostly pink, massive rock of granitic composition; most of the exposures are smoothly rounded, even polished by scouring ice.

The St. Lawrence wetland sites are typically estuarine. Small streams or rivers occupy apparent pre-glacial valleys cut through rounded bedrock knobs and ridges which have been partially filled in by outwash and alluvial deposits to form fairly broad, flat basins. Extensive wetlands (up to 1 km wide) line the lower reaches of the streams for several kilometers inland as they flow through the basins; a narrow delta has formed at the mouth of some basins.

As in the preceding group, the emergent zone (present along 100% of transects) is characterized by high densities of floating species, including *Utricularia vulgaris* (mean cover value 14%), and the duckweeds *Lemna trisulca* (15%) and *Spirodela polyrhiza* (7%), along with the canopy-forming submergent species, *Ceratophyllum demersum* (25%) and *Elodea* *canadensis* (7%). Other submergents preferential to this group include *Potamogeton zosteriformis* (14%), *P. friesii* (10%), and *Zizania aquatica* (7%). The exotic *Hydrocharis morsus-ranae* is abundant.

The herbaceous zone (present along 100% of transects) is a broad wet meadow with deep organic soils (often > 4 m), featuring *Typha angustifolia* (mean cover value 27%), along with *Calamagrostis canadensis* (11%) and *Thelypteris palustris* (6%). Again, the dominance of cat-tail may reflect the reduction of natural lake-level fluctuations. However, *Impatiens capensis*, a species adapted to the cyclical exposure of shoreline mud flats is well represented in this group of sites (12%).

Crooked Creek is a high-quality example of this type (Figs. 73 and 74). The broad, meandering stream of Crooked Creek flows north into the St. Lawrence River between rounded bedrock uplands vegetated with mature white pine, red pine, pitch pine, and red oak. Valleys between the knobs are occupied by backwaters of the stream and by stream-side wetlands (up to 1 km wide) underlain by deep organics (> 3 m) over bedrock or clay. A broad wet meadow zone borders the stream; dominant species are *Calamagrostis canadensis*, *Carex aquatilis*, and *C. lacustris*, along with *Sagittaria latifolia*, *Thelypteris palustris*, and *Typha latifolia*. The open water of the channel (ca. 60 cm deep) was dominated by wild-rice (*Zizania aquatica*) with patches of spatterdock and water lily, and contained a diversity of pondweeds (*Potamogeton* spp.), along with *Ceratophyllum demersum* and *Myriophyllum exalbescens*. *Eleocharis smallii* and *Glyceria borealis* (northern manna grass) were common along the stream edges. The exotic *Hydrocharis morsus-ranae* was widely present.

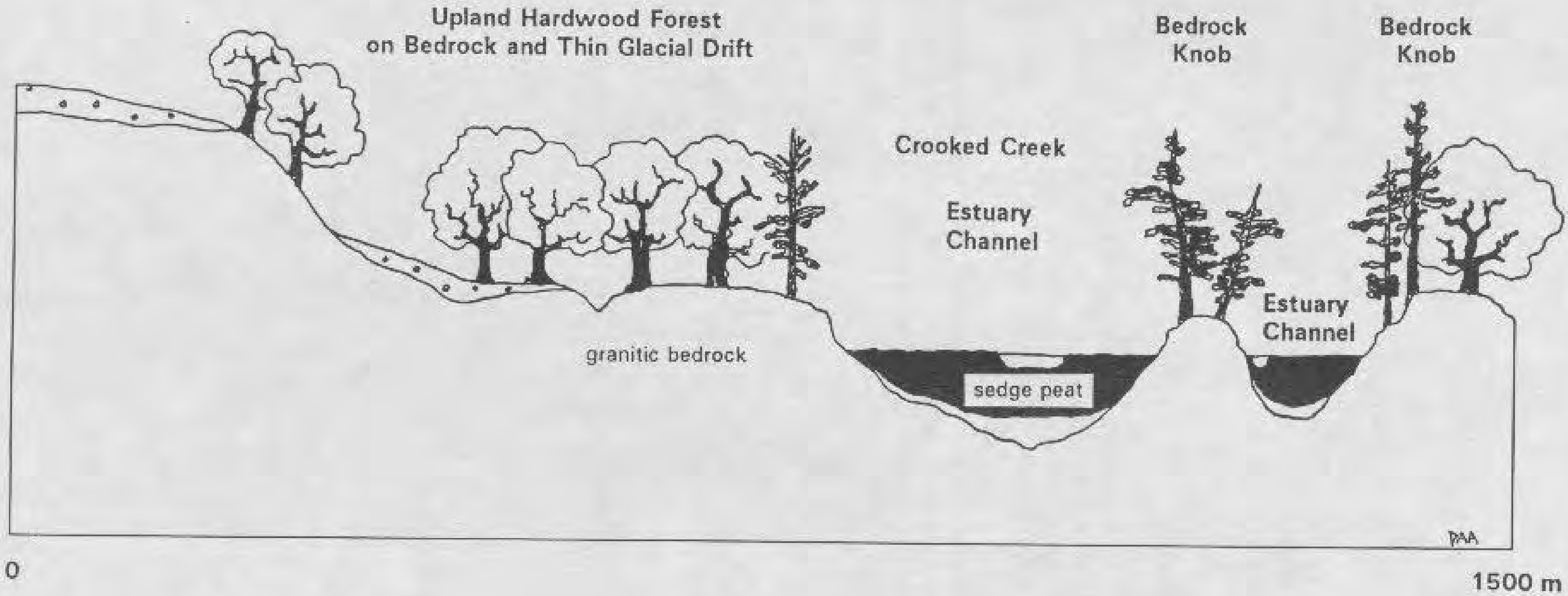


Figure 73. Landscape overview of vegetation zonation at Crooked Creek, a high-quality St. Lawrence River Estuary Marsh site.

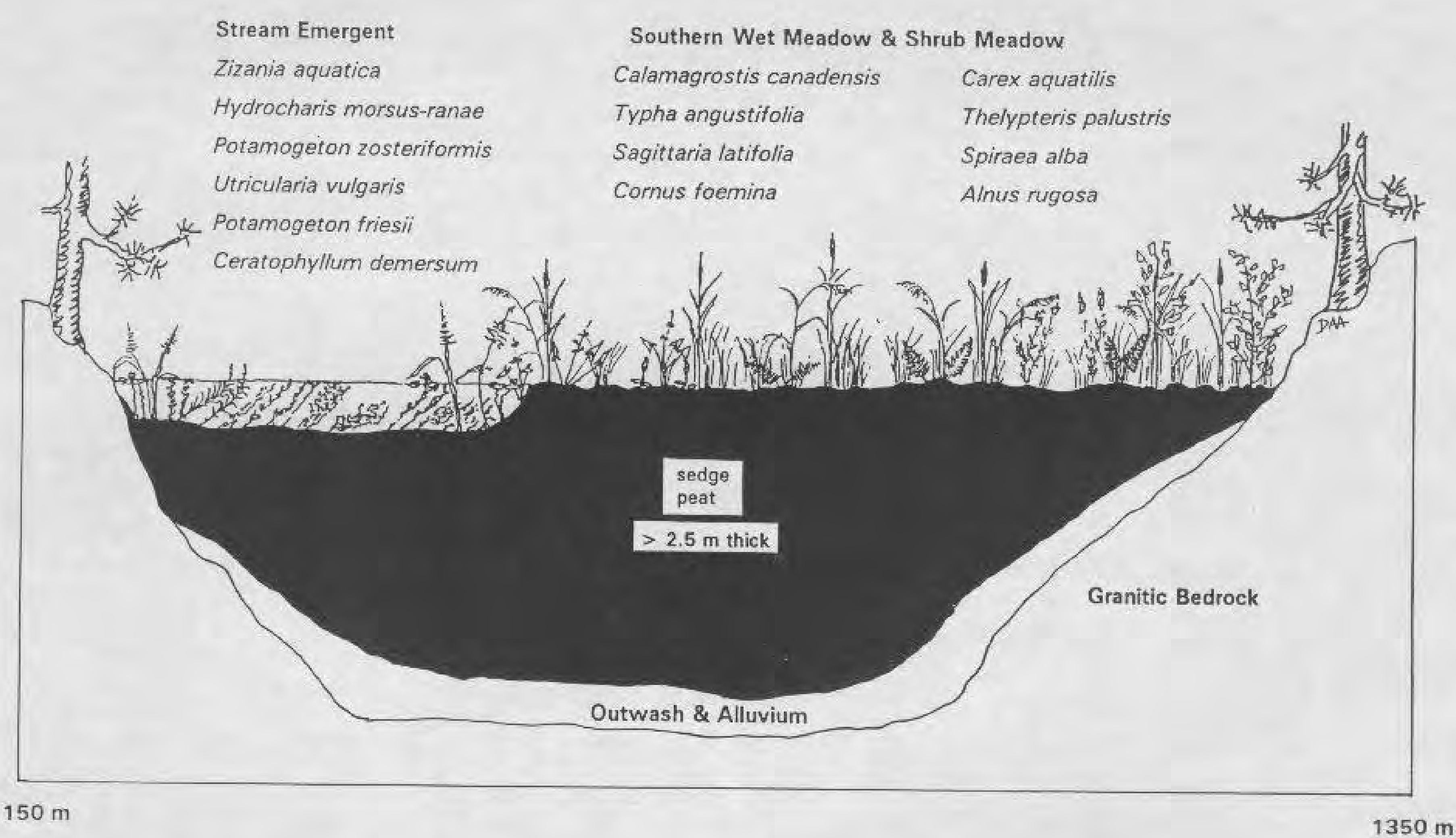


Figure 74. Detail of estuarine vegetation at Crooked Creek, St. Lawrence River.

Table 21
Vegetative Classification of Great Lakes Marsh Sites based on TWINSPAN Ordinations

Marsh	Location	Site Type	Classification of Marsh Zones		
			Emergent	Herbaceous	Shrub
Lake Superior Poor Fen					
Au Train	Superior	Estuary	N. Open	Poor Fen	N. Shrub Meadow
Bad River A	Superior	Barrier-beach lagoon	---	---	---
Bad River B	Superior	Barrier-beach lagoon	N. Open	Poor Fen	Poor Fen
Bark Bay A	Superior	Barrier-beach lagoon	N. Open	Poor Fen	---
Bark Bay B	Superior	Barrier-beach lagoon	---	---	Poor Fen
Fond du Lac A	Superior	Estuary	N. Open	---	---
Grand Island	Superior	Barrier-beach lagoon	N. Open	Poor Fen	---
Honest John A	Superior	Barrier-beach lagoon	N. Open	Poor Fen	N. Shrub Meadow
Honest John B	Superior	Barrier-beach lagoon	---	---	Poor Fen
Independence Lake	Superior	Barrier-beach lagoon	---	---	Poor Fen
Lac la Belle	Superior	Estuary	N. Open	Poor Fen	Poor Fen
Pequaming	Superior	Barrier-beach lagoon	---	Poor Fen	Poor Fen
Portage R.	Superior	Estuary	---	Poor Fen	---
Raspberry A	Superior	Barrier-beach lagoon	---	Poor Fen	Poor Fen
Siskewit Bay	Superior	Barrier-beach lagoon	N. Open	Poor Fen	Poor Fen
Stockton Is.	Superior	Barrier-beach lagoon	N. Open	Poor Fen	---
Sturgeon R.	Superior	Tributary delta	N. Open	---	Poor Fen
Northern Rich Fen					
Big Shoal Cove	Huron	Bay-Protected	N. Open	Rich Fen	---
Cheboygan A	Huron	Bay-Protected	N. Open	---	Rich Fen
Cheboygan B	Huron	Bay-Protected	---	Rich Fen	---
Cheboygan C	Huron	Bay-Protected	N. Open	Rich Fen	Rich Fen
Epoufette Bay	Michigan	Bay-Open	Marly	Rich Fen	Rich Fen
El Cajon Bay	Huron	Bay-Protected	Marly	Rich Fen	---
Kenyon Bay	Michigan	Bay-Protected	Marly	Rich Fen	---
Peck Bay	Huron	Bay-Protected	Marly	Rich Fen	---
Voight Bay	Huron	Bay-Protected	Marly	Rich Fen	---
Waugoshance Pt.	Michigan	Sand-spit swale	Marly	Rich Fen	---
Carp/Pine	Huron	Bay-Open	N. Open	N. Meadow	Rich Fen
False Presque Isle	Huron	Estuary	Marly	S. Meadow	---
Mud Lake	Michigan	Barrier-beach lagoon	Marly	N. Meadow	---

Marsh	Location	Site Type	Classification of Marsh Zones		
			Emergent	Herbaceous	Shrub
B Northern Shrub Meadow					
Duck Bay	Huron	Bay-Protected	N. Open	N. Meadow	---
Mackinac	Huron	Bay-Protected	N. Open	N. Meadow	---
Mismer Bay	Huron	Bay-Open	N. Open	N. Meadow	---
Scott Pt.	Huron	Bay-Open	N. Open	N. Meadow	---
Squaw Bay	Huron	Bay-Open	N. Open	---	---
St. Martins	Huron	Bay-Open	N. Open	N. Meadow	---
Tobico	Huron	Barrier-beach lagoon	N. Open	N. Meadow	---
Chippewa Pt.	Michigan	Bay-Open	---	N. Meadow	---
Indian Pt. A	Michigan	Bay-Open	---	---	N. Shrub Meadow
Indian Pt. B	Michigan	Bay-Open	Depauperate	N. Meadow	---
Little Fishdam	Michigan	Bay-Open	N. Open	N. Meadow	---
Mink River A	Michigan	Estuary	N. Open	N. Meadow	---
Mink River B	Michigan	Tributary delta	N. Open	N. Meadow	---
Baie de Wasai A	St. Marys R.	Channel embayment	N. Open	N. Meadow	---
Baie de Wasai C	St. Marys R.	Channel embayment	N. Open	N. Meadow	---
Churchville A	St. Marys R.	Channel-side	N. Open	N. Meadow	---
Churchville B	St. Marys R.	Channel-side	N. Open	---	---
Gogomain A	St. Marys R.	Channel-side	N. Open	N. Meadow	---
Gogomain D	St. Marys R.	Channel embayment	N. Open	N. Meadow	---
Hog Is. A	St. Marys R.	Channel embayment	---	N. Meadow	N. Shrub Meadow
Hog Is. B	St. Marys R.	Channel-side	N. Open	N. Meadow	---
Hursley B	St. Marys R.	Channel-side	N. Open	N. Meadow	N. Shrub Meadow
Hursley A	St. Marys R.	Channel-side	N. Open	---	N. Shrub Meadow
Kemps Pt.	St. Marys R.	Channel-side	N. Open	N. Meadow	---
Munuscong	St. Marys R.	Channel embayment	N. Open	N. Meadow	---
Roach Pt.	St. Marys R.	Channel embayment	N. Open	N. Meadow	---
Sand Island	St. Marys R.	Channel-side	N. Open	N. Meadow	N.Shrub Meadow
Shingle B	St. Marys R.	Channel embayment	N. Open	N. Meadow	---
Shingle C	St. Marys R.	Channel embayment	N. Open	N. Meadow	---
Sugar Is. A	St. Marys R.	Channel-side	N. Open	N. Meadow	N. Shrub Meadow
Sugar Is. B	St. Marys R.	Channel-side	N. Open	N. Meadow	---
Whipple A	St. Marys R.	Channel-side	N. Open	N. Meadow	---
Whipple B	St. Marys R.	Channel-side	N. Open	N. Meadow	---

Marsh	Location	Site Type	Classification of Marsh Zones		
			Emergent	Herbaceous	Shrub
Northern Shrub Meadow (cont.)					
Bad River M	Superior	Estuary	N. Open	N. Meadow	---
Fond du Lac B	Superior	Estuary	N. Open	N. Meadow	---
Kakagon	Superior	Estuary	N. Open	N. Meadow	N. Shrub Meadow
Long Island	Superior	Sand-spit swale	N. Open	N. Meadow	---
Pokegama A	Superior	Estuary	N. Open	S. Meadow	---
Pokegama B	Superior	Estuary	---	N. Meadow	---
Raspberry B	Superior	Estuary	N. Open	N. Meadow	---
S. Green Bay/W. Lake Michigan					
Dead Horse	Michigan	Sand-spit embayment	S. (western)	S. Meadow	---
Little Tail	Michigan	Sand-spit embayment	S. (western)	S. Meadow	---
Oconto River	Michigan	Tributary delta	S. (western)	S. Meadow	---
Peshtigo River	Michigan	Tributary delta	S. (western)	N. Meadow	---
West Twin A	Michigan	Estuary	---	N. Meadow	S. Shrub Meadow
West Twin B	Michigan	Estuary	---	N-S Meadow	---
Lake Michigan Estuaries					
Bar Lake	Michigan	Barrier-beach lagoon	N. Open	---	S. Shrub Meadow
Betsie River	Michigan	Estuary	S.-N.	S. Meadow	---
Big Sable R.	Michigan	Estuary	N. Open	---	S. Shrub Meadow
Galien River	Michigan	Estuary	S. Western	S. Meadow	---
Kalamazoo R.	Michigan	Estuary	S. Western	S. Meadow	---
Kalamazoo R.	Michigan	Estuary	S. Western	S. Meadow	---
Muskegon R.	Michigan	Estuary	S. Western	---	---
Paw Paw R.	Michigan	Estuary	---	S. Meadow	---
Pentwater R.	Michigan	Estuary	S. Western	S. Meadow	---
Pottawattomi	Michigan	Estuary	S. Western	S. Meadow	S. Shrub Meadow
S. Lloyd Is.	Michigan	Estuary	S. Western	---	---
Stoney Creek	Michigan	Estuary	---	S. Meadow	---
White River A	Michigan	Estuary	---	S. Meadow	S. Shrub Meadow
White River B	Michigan	Estuary	S. Western	S. Disturbed	---

Marsh	Location	Site Type	Classification of Marsh Zones		
			Emergent	Herbaceous	Shrub
6 Saginaw Bay Disturbed					
Coryeon A	Huron	Bay-Open	N. Open	S. Disturbed	---
Hardwood Pt.	Huron	Bay-Open	N. Open	S. Disturbed	---
Pinconning A	Huron	Sand-spit embayment	Depauperate	S. Meadow	---
Pinconning B	Huron	Bay-Open	Depauperate	---	---
Pine River	Huron	Bay-Open	N. Open	S. Disturbed	---
Saganing	Huron	Bay-Protected	Depauperate	---	S. Shrub Meadow
Whiskey Harbor	Huron	Bay-Open	Depauperate	S. Disturbed	---
Wigwam Bay	Huron	Tributary delta	N. Open	S. Disturbed	---
Wildfowl I-A	Huron	Bay-Open	---	S. Disturbed	---
Wildfowl I-B	Huron	Bay-Protected	N. Open	S. Disturbed	---
Wildfowl I-E	Huron	Bay-Protected	N. Open	S. Disturbed	---
Wildfowl Bay	Huron	Sand-spit embayment	Depauperate	S. Disturbed	---
7 Lakes St. Clair/Erie					
St. Clair R.	St. Clair R.	Connecting Chan. Delta	N. Open	S. Meadow	---
Clinton R.	St. Clair	Tributary delta	S. (western)	S. Meadow	---
Erie Bay	Erie	Sand-spit embayment	S. (western)	S. Disturbed	---
Huron River	Erie	Estuary	S. (western)	S. Meadow	---
Old Woman Cr.	Erie	Estuary	S. (western)	---	---
Otter Cr.	Erie	Estuary	---	S. Disturbed	---
Pt. Mouillee	Erie	Tributary delta	N.-S.	S. Meadow	---
Presque Isle	Erie	Sand-spit swale	S.	S. Meadow	---
Sheldon Marsh	Erie	Barrier-beach lagoon	---	S. Meadow	---
Swan Cr.	Erie	Estuary	N.-S.	S. Disturbed	---
Thompson Harbor	Erie	Sand-spit swale	N.-S.	S. Meadow	S. Shrub Meadow

Marsh	Location	Site Type	Classification of Marsh Zones		
			Emergent	Herbaceous	Shrub
8 Lake Ontario					
Black Cr. A	Ontario	Barrier-beach lagoon	---	---	Poor Fen
Black Cr. B	Ontario	Barrier-beach lagoon	S. (eastern)	---	Buttonbush Thicket
Deer Cr.A&B	Ontario	Barrier-beach lagoon	S. (eastern)	N-S Meadow	Poor Fen
Dexter Marsh	Ontario	Tributary delta	S. (eastern)	N-S Meadow	---
East Bay	Ontario	Barrier-beach lagoon	S. (eastern)	---	Buttonbush Thicket
Lakeview Pond	Ontario	Barrier-beach lagoon	S. (western)	N-S Meadow	---
Pt. Peninsula	Ontario	Barrier-beach lagoon	---	S. Meadow	Buttonbush Thicket
S. Colwell	Ontario	Barrier-beach lagoon	S. (eastern)	S. Meadow	---
Sterling Cr.	Ontario	Barrier-beach lagoon	S. (eastern)	N-S Meadow	Buttonbush Thicket
9 St. Lawrence					
Barnett	St. Lawrence	Estuary	S. (eastern)	N-S Meadow	---
Chippewa A	St. Lawrence	Tributary delta	S. (eastern)	N-S Meadow	---
Chippewa B	St. Lawrence	Estuary	S. (eastern)	N-S Meadow	---
Cranberry Cr	St. Lawrence	Estuary	S. (eastern)	N-S Meadow	---
Crooked A&B	St. Lawrence	Estuary	S. (eastern)	N-S Meadow	---
Crooked C	St. Lawrence	Estuary	S. (eastern)	S. Meadow	---
Delaney Bay	St. Lawrence	Estuary	S. (eastern)	S. Meadow	---
Flynn Bay C	St. Lawrence	Estuary	S. (eastern)	S. Meadow	---

APPENDIX I:

SITE DESCRIPTIONS FOR WETLANDS SAMPLED IN

MINNESOTA,

WISCONSIN,

OHIO,

PENNSYLVANIA,

&

NEW YORK

ST. LOUIS RIVER (Minnesota/Wisconsin border)

1. Fond du Lac

Location: T48N R15W, SW 1/4 of Sec. 8
Lake: Superior
Site type: lacustrine estuary/estuarine meander on St. Louis River
Landform: lacustrine reworked glacial till/clay lakeplain
Substrate: silt loam
Water clarity: turbid
Surveyors: D. Pomroy-Petry and M. Broschart

The Fond du Lac wetland site is located on an estuarine meander of the St. Louis River, at a distance of approximately 10 miles inland from Lake Superior, downstream from the Fond du Lac dam, southwest of Duluth, Minnesota. At this point, the river occupies a deep, steeply walled valley within the clay lakeplain; the channel is approximately 60 m below the elevation of surrounding uplands. Between the Fond du Lac dam and Lake Superior, the St. Louis River takes on a braided appearance and forms numerous active channels. The stream ranges up to 200 m wide, and forms a floodplain 1.2 k wide, most of it covered by old meander loops and channels.

Two parallel sampling transects (**A** and **B**) were placed within the wetland which has developed where a large, crescent-shaped natural levee has partially cut off an old meander. Marsh vegetation occupies the old meander behind the bar. The soil texture is sand on the levee, and is silt loam elsewhere.

The levee itself contains a dense shrub growth of *Salix bebbiana* and *Alnus rugusa*, with an undergrowth of *Urtica dioica*, *Onoclea sensibilis*, and *Impatiens capensis*. Toward the river side, the shoreline vegetation is predominately *Lythrum salicaria*. Progressing towards Fond du Lac Bay on the back side of the levee, *Typha angustifolia*, *Equisetum fluviatile*, and *Carex lacustris* predominate, before entering a zone of *Sagittaria latifolia* and *Scirpus validus* along the meander edge. As water depth increases, *Nuphar advena*, *Nyphaea odorata*, and submergent aquatic plants are common in pockets surrounded by *Sagittaria*, *Scirpus*, and *Sparganium eurycarpum*. The deeper water is free of all but submergent plants.

2. Pokegama

Location: T48N R14W, NW 1/4 of Sec. 4
Lake: Superior
Site type: lacustrine estuary
Landform: lacustrine reworked glacial till/clay lakeplain
Substrate: clay
Water clarity: turbid
Surveyors: D. Pomroy-Petry and M. Broschart

The Pokegama wetland site is located along the west side of the Pokegama River, south of Superior, Wisconsin. Downstream from the site, the river enters the St. Louis River, approximately 2-3 miles inland from Lake Superior. Land ownership is public, and the wetland is managed by the City of Superior as a recreational area.

At this point, the river channel itself is approximately 50 m wide. However, the Pokegama River has eroded down more than 15 m through the glacial clay lakeplain, creating a steeply-sided drainage and narrow floodplain less than 300 m across. The soil texture of this wetland is clay, although sand was locally present along the river channel. Visibility in the river is limited to a few centimeters due to the suspension of clay.

Sampling focused on an old meander now separated from the present river channel by a natural levee; two parallel transects (**A** and **B**) extended from the main channel, over the levee, and west across the meander to the adjacent uplands.

Along the river channel the vegetation is predominately *Sparganium eurycarpum* with some *Typha angustifolia* and *Sagittaria latifolia* present; no submergent vegetation was present along the river channel. Trees and shrubs were present on the levee, including *Fraxinus nigra*, *Cornus stolonifera*, and *Crateagus*. At mid-point along the levee, a rise contains *Betula papyrifera*, *Viburnum rafinesquianum*, and *Amelanchier*. Immediately west of the levee, the old meander is edged with *Typha angustifolia* and *Sparganium eurycarpum*, which grade into a zone of *Typha* mixed with *Carex lacustris* and *C. stricta*. On the west side of the wetland, the forest is primarily *Betula papyrifera* and *Populus tremuloides*.

WISCONSIN (Lake Superior shoreline)

1. Bark Bay

Location: T50N R7W, Sec. 1, Bayfield County, WI
Lake: Superior
Site type: barrier-beach lagoon
Landform: clayey till bluffs
Substrate: muck/peat
Water clarity: clear
Surveyor: Jim Meeker

Bark Bay is a relatively undisturbed wetland, managed by the Wisconsin DNR as a State Natural Area. It is an embayment or lagoon separated from Lake Superior by a narrow sand bar. The wetland complex is divided into two distinct areas, with the W half dominated by open water peatland and the E half influenced by sediment deposition from the Bark River. The total vegetation component is nearly half represented by sedge meadow, with only small percentages of ericacious shrubs, emergent and submergent vegetation. The bottom substrate includes fine muck, sedge-created peat, and sphagnum-created peat of 1-3 m in depth.

Transect A extended from a narrow area of open water behind the barrier beach inland across a wide area of floating and grounded sedge mat with organic accumulations exceeding 3 m. The emergent marsh of the open water contained *Dulichium arundinaceum*, *Nuphar variegata*, *Sagittaria latifolia*, and *Sparganium eurycarpum*, while the sedge mat was dominated by *Carex lasiocarpa* and *Dulichium arundinaceum*. **Transect B** crossed a narrow sedge mat (< 60 m wide) near the upland edge, this time containing *Carex lasiocarpa* mixed with poor fen species (including *Drosera rotundifolia*, *Pogonia ophioglossoides*, *Sarracenia purpurea*, and *Sphagnum* spp.); the shrubs *Chamaedaphne calyculata*, *Andromeda glaucophylla*, and *Myrica gale* were present throughout the zone.

2. Siskewit Bay

Location: T51N R6W, Sec. 32, Bayfield County, WI
Lake: Superior
Site type: barrier-beach lagoon
Landform: clayey till bluffs
Substrate: muck and peat
Water clarity: clear
Surveyor: Jim Meeker

The Siskewit Bay wetland is protected from Lake Superior by a broad sand spit that has been highly developed with vacation homes. The wetland complex behind this barrier beach is a relatively undisturbed peatland, with only a small amount of open water. There is no major drainage contributing sediment into this wetland, although several small streams (Lost Creek No. 1, No. 2, and No. 3) meander into it and join before flowing into Siskewit Bay. The bottom substrate includes muck, and sedge- and sphagnum-derived peat.

A single transect was placed near the W edge of this wetland, extending NW from the confluence of the Lost Creeks. The transect crossed an emergent zone with water depths of less than 1 m, and dominated by *Nuphar variegata* and *Sparganium eurycarpum*. A narrow (60 m wide) herbaceous zone paralleled the channel with water depths up to 13 cm; the most frequently encountered species here were *Carex lasiocarpa*, *Cladium mariscoides*, *Eleocharis smallii*, and *Utricularia intermedia*. The upland edge was bordered with a shrubby zone of *Chamaedaphne calyculata*, *Myrica gale*, and *Sphaghum* spp.

3. Raspberry Bay

Location: T52N, R4W, Sec. 35, Bayfield County, WI
Lake: Superior
Site type: A. barrier-beach lagoon; B. stream-side wetland
Landform: clayey till bluffs
Substrate: peat/clay
Water clarity: clear
Surveyor: Jim Meeker

This site is a relatively undisturbed wetland, adjacent to the Raspberry River where it flows into Raspberry Bay. The lagoon itself represents an old embayment closed off by a narrow barrier beach, which protects it from Lake Superior. The Raspberry River currently bypasses the lagoon; thus there is no major drainage contributing water flow or sediment into this wetland.

The site was sampled with two transects representing ecologically distinct areas. **Transect A** extends S from the open sands of the barrier beach near the W end of the wetland. It crosses a broad (140 m wide) sedge meadow characterized by *Carex lasiocarpa*, *C. limosa*, *Cladium mariscoides*, *Menyanthes trifoliata*, and *Utricularia intermedia*. A narrow shrub zone, containing *Chamaedaphne calyculata*, *Myrica gale*, and *Sphagnum* spp., borders the upland edge. The bottom substrate along the transect is predominately peat in excess of 1 m thick.

Transect B, in contrast, crosses zones of wet meadow and emergent marsh adjacent to the main channel of the Raspberry River as is flows around the coastal lagoon feature.

Characteristic vegetation of the herbaceous zone includes *Calla palustris*, *Carex lacustris*, *C. rostrata*, *Sparganium eurycarpum*, and *Typha latifolia*, while *Sparganium fluctuans*, *Sagittaria rigida*, and *Nuphar variegata* occur in the emergent zone. Substrate in the herbaceous zone is sedge-derived peat, while clay underlies the emergent zone.

4. Stockton Island

Location: T52N, R2W, Sec. 36
Lake: Superior
Site type: barrier-beach lagoon
Landform: clayey till bluffs
Substrate: peat/sand
Water clarity: clear
Surveyor: Jim Meeker

The Stockton Island site is administered by the National Park Service as part of Apostle Islands National Lakeshore. This undisturbed wetland site consists of a former embayment now separated from Lake Superior by a narrow sand beach. A small stream flows into the wetland, and replenishes the small pond or lagoon formed behind the barrier beach. A narrow band of sedge meadow parallels the course of this stream. Much of the site, however, consists of broad areas of sphagnum bog.

A single transect was placed near the middle of the wetland to cross both the open water behind the sand spit and the sphagnum bog. The shallow water of the pond (10-50 cm deep) contained submergent, emergent, and floating-leaved species, including *Potamogeton natans*, *Scirpus subterminalis*, and *Brasenia schreberi*. The sphagnum bog contained a mix of *Juncus canadensis*, *Cladium mariscoides*, *Rhynchospora alba*, *R. fusca*, along with *Sphagnum* spp., and the shrubs *Chamaedaphne calyculata*, *Myrica gale*, and *Vaccinium macrocarpon*. Substrates in the emergent zone were sands covered with shallow organics, while those of the herbaceous zone were peat.

5. Chequamegon Point (Long Island)

Location: T49N R3W S28
Lake: Superior
Site type: sand spit swale
Landform: sand spit
Substrate: sand
Water clarity: clear
Surveyor: Jim Meeker

Chequamegon Point is a narrow sand spit that projects approximately 8 miles from the shoreline and protects the mouth of Chequamegon Bay from the open water of Lake Superior. The Lake Superior side of the spit is open sand and beach grass, while a growth of shrubs has developed in places along the more protected side facing Chequamegon Bay. Here, substrates are bare sand or sand with a very thin veneer of organic material. Movement of sands along the spit has enclosed several shallow swales which contain wetland vegetation.

A single transect was placed near the middle of the peninsula, extending from a shallow embayment on the south side and continuing inland across a swale to a dry dune area. Emergent marsh of the embayment contained *Scirpus americanus*, *S. validus*, *Eleocharis smallii*, *Juncus pelocarpus*, and *Carex viridula*, and the submergents *Najas flexilis* and *Potamogeton spirillus*. The swale contained a wet meadow with *Carex lasiocarpa*, *C. stricta*, *Juncus balticus*, and a far too healthy stand of *Lythrum salicaria*.

6. Kakagon

Location: T49N, R3W, Sec. 11
Lake: Superior
Site type: estuary and tributary river delta
Landform: clay lakeplain
Substrate: clay
Water clarity: clear
Surveyor: Jim Meeker

The Kakagon wetland, along with the Bad River Slough and Honest John Lake wetlands, comprises a 10,000+ acre wetland complex at the base of Chequamegon Point and extending SE along the Lake Superior shoreline. The Kakagon wetland is formed by the deltas of the three streams (Kakagon River, Beartrap Creek, and Wood Creek), all of which flow into Chequamegaon Bay, and is crossed by multiple wandering channels and old meanders of the three streams. Within the channels, substrates are a thin veneer of organic muck overlaying stratified lake deposits. Due to seiche activity in adjacent Chequamegon Bay, the water currents of the Kakagon River fluctuate from downstream to upstream flow with short periods of still water in between.

The Kakagon wetland was sampled across the main channel of the Kakagon River approximately 1.5 miles from its mouth. **Transect A** began in the channel-side emergent marsh where water depths were less than 75 cm. Submergents included *Ceratophyllum demersum*, *Najas flexilis*, and *Potamogeton zosteriformis*, while common emergents were *Pontederia cordata*, *Scirpus americanus*, and a dense stand of *Zizania aquatica*; the duckweed *Spirodela polyrhiza* was consistently present as well. The emergent marsh is bordered by a fairly narrow (60 m) zone of wet meadow, dominated by *Carex lasiocarpa* and *C. lacustris*, with *Campanula aparinoides*, *Lysimachia thyrsiflora*, *Sagittaria latifolia*, and *Typha latifolia*. **Transect B** is a continuation of Transect A; it began within the wet meadow zone, and extended into a shrub zone dominated by *Chamaedaphne calyculata*, *Myrica gale*, *Alnus rugosa*, and *Sphagnum* spp. Substrates were shallow organics (< 50 cm) over clay in the emergent zone, sedge-peat in the emergent zone, and sphagnum peat in the shrub zone.

7. Bad River Slough

Location: T49N, R2W, Secs. 17 & 20
Lake: Superior
Site type: barrier-beach lagoon
Landform: clay lakeplain
Substrate: sand
Water clarity: clear
Surveyor: Jim Meeker

Bad River Slough is formed by an old channel of the Bad River blocked behind a barrier beach to form a large lagoon or slough of open water. The main channel of the Bad River now flows directly into Lake Superior and although connected, bypasses the slough. During high flow times, however, some sediment from the Bad River is deposited within the NW end of the slough. A second smaller stream (Demonie Creek) drains directly into the slough.

The first transect (**Bad River Mouth**) was placed perpendicular to the barrier beach, near the mouth of the channel connecting the slough with the Bad River. This transect began on the shoreline spit or barrier beach that separates Bad River Slough from Lake Superior and extended into the emergent marsh of the slough. The barrier beach, consisting of a firm sandy substrate with a thin veneer of organic material, is vegetated by rushes and spike rushes. The emergent marsh has a similar sand substrate, with organic accumulations of less than 35 cm; water depth was less than a meter. Here, *Eleocharis smallii* and *Sparganium eurycarpum* dominated, along with patches of *Pontederia cordata* and *Sagittaria* spp.; the submergents *Ceratophyllum demersum*, *Elodea canadensis*, and *Vallisneria americana* were well represented in deeper water.

A second pair of transects (**Bad River Slough A & B**) were situated well in the interior of the slough, near the inflow of Demonie Creek. Transect A sampled intensively within the emergent marsh zone of the slough, while Transect B extended from the emergent marsh inland across a narrow herbaceous zone (50 m wide) and into a shrub zone. The emergent zone contained the submergents *Ceratophyllum demersum*, *Elodea canadensis*, and three species of pondweed, along with *Zizania aquatica* and *Megalodonta beckii*. The herbaceous zone was a sedge meadow dominated by *Carex lasiocarpa* and *Menyanthes trifoliata*, and containing the shrubs *Betula pumila*, *Myrica gale*, *Potentilla palustris*, and *Vaccinium oxycoccos*. These shrubs increased in dominance in the shrub zone, as did the cover values for *Sphagnum* spp. Organic deposits of greater than a meter were encountered in the emergent zone, and generally greater than 50 cm in the herbaceous and shrub zones.

8. Honest John Lake

Location: T49N, R2W, Sec. 21
Lake: Superior
Site type: barrier-beach lagoon
Landform: clay lakeplain
Substrate: sand
Water clarity: clear
Surveyor: Jim Meeker

Honest John Lake, like Bad River Slough, occupies a depression behind a barrier beach that separates it from Lake Superior; however, this wetland receives little direct influx of water or sediment. As a result, Honest John is a classic bog lake with tannin-stained waters surrounded by a floating wiregrass mat.

Transect A was situated perpendicular to the shoreline adjacent to the barrier beach. The transect begins within a shrub zone along the inner side of the barrier beach and extends into the emergent marsh of the lagoon. The sand spit contained *Chamaedaphne calyculata*, *Myrica gale*, *Rosa palustris*, and *Spiraea alba*, along with a ground cover of *Carex lacustris*. The emergent zone of the shallow lagoon contained fairly dense stands of the emergents *Scirpus subterminalis*, *Sparganium fluctuans*, and *Sagittaria* sp., along with the floating

Pontederia cordata and *Megalodonta beckii*. Submergents recorded included *Myriophyllum exalbescens* and several species of pondweed. Substrates consistently were a thin veneer of organics (< 30 cm) over sand along the transect, although deeper accumulations (1.5 m) were recorded on the opposite (inland) side of the lagoon.

Transect B was placed in the interior of the depression, extending from the edge of the lagoon inland. This transect crossed a broad (220 m) herbaceous zone and ended in a shrubby *Alnus/Larix* community. Soils were saturated and consisted of peat deposits in excess of 1 meter thick. Both zones contained a ground cover of *Carex lasiocarpa* and *Sphagna*, mixed with the shrubs *Chamaedaphne calyculata*, *Myrica gale*, *Rosa palustris*, and *Vaccinium macrocarpon*. Other bog species consistently present included *Drosera rotundifolia*, *Sarracenia purpurea*, and *Menyanthes trifoliata*.

WISCONSIN (Green Bay and Lake Michigan shoreline)

1. Peshtigo River

Location: Peshtigo Harbor State Wildlife Area, Marinette County, WI
Site type: tributary river delta
Lake: Upper Green Bay, Lake Michigan
Landform: poorly drained sand lakeplain
Substrate: sand
Water clarity: clear
Surveyor: Dennis Albert

The Peshtigo River site is a broad river delta, over 4 miles across. The delta extends 2 miles inland from the present shoreline and is crossed by numerous meandering channels. The delta is presently constrained by roads on both sides of the river channel and locally by dikes. The main channel is nearly 150 m wide near the mouth and contains boat ramps and a harbor. Sampling was conducted along a minor, active channel near the north edge of the delta, just west of Slough Bridge. This channel is approximately 25 m wide with a water depth of < 1 m. Substrates are sand, with relatively shallow organic soils (30-45 cm).

The channel contains a diverse submergent and shallow emergent flora, including *Elodea canadensis*, *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Potamogeton nodosus*, *Nymphaea odorata*, *Sagittaria rigida*, and *S. latifolia*. The adjacent, broad (250 m wide) wet meadow zone was dominated by *Calamagrostis canadensis*, *Carex lacustris*, and *C. stricta*, with *Lythrum salicaria* and *Polygonum amphibium*. Again, the entire wet meadow zone was covered by shallow standing water (5-15 cm deep). A narrow band of alder swamp rings the upland edge of the wet meadow, but was not sampled.

2. Oconto River

Location: Oconto County, WI
Site type: tributary river delta
Lake: Upper Green Bay
Landform: poorly drained sand lakeplain
Substrate: sand
Water clarity: clear
Surveyors: Dennis Albert and M. Kost

The Oconto site is a river delta, approximately three miles wide, with one main channel and several abandoned channels snaking toward the Green Bay/Lake Michigan shoreline. The main channel (up to 100 m wide) is now rip-rapped and has a harbor of refuge near its mouth; old meanders are discontinuous and generally less than 1 m deep. The sampling transect was located within the delta and extends between two meanders. The narrower, first channel has sandy substrates covered by shallow organics (generally less than 65 cm thick), while the second, larger meander has a sand bottom. The deltaic bar between channels has sandy substrates with overlying shallow organics.

The narrow meander contained a fairly diverse submergent marsh within its protected waters and was edged by a narrow zone of emergent vegetation. The main vegetation zone, however, was a broad (180 m) wet meadow dominated by *Calamagrostis canadensis* and *Carex* spp., but also containing the emergent species *Lythrum salicaria*, *Scirpus validus*, *S. acutus*, *Typha angustifolia*, and *Sparganium eurycarpum*, reflecting the 8-12 cm of standing water throughout this zone. The second, larger channel is apparently more directly affected by lake currents and some wave activity, and contained little aquatic vegetation.

3. Little Tail Point

Location: Oconto County, WI
Site type: sand spit embayment
Lake: Lower Green Bay, Lake Michigan
Landform: poorly drained sand lakeplain
Substrate: sand
Water clarity: very turbid
Surveyors: Dennis Albert and M. Kost

4. Dead Horse Bay

Location: Brown County, Lower Green Bay, WI
Site type: sand spit embayment
Landform: poorly drained sand lakeplain
Substrate: sand
Lake: Lower Green Bay, Lake Michigan
Water clarity: very turbid
Surveyors: Dennis Albert and M. Kost

Both of these wetlands are found in narrow, funnel-shaped bays (approximately a mile wide at their outer edge) formed by sand spits. These spits were 1-2 miles long and less than a quarter mile wide, and were broken in several places by wave action. There is no river or stream flow directly into the embayments, but small streams northward of each are depositing the sands generating the sand spits. The bay water is fairly shallow (< 1 m) and highly turbid (partially as a result of high carp densities). Both sites have up to 80 cm of poorly consolidated organic material near the head of the embayments, apparently from *in situ* development.

The protective sand spits are vegetated with sandbar willow, with no emergent vegetation on the Lake Michigan shoreline. On the embayment side, vegetation is concentrated near the inner, more protected portion of the bay. At Dead Horse Bay, the shoreline contains a narrow zone of wet meadow dominated by *Calamagrostis canadensis*, with a broader emergent marsh (extending over 100 m) of *Sagittaria latifolia*, *Scirpus validus*, *Typha angustifolia*, *Sparganium eurycarpum*, and *Ceratophyllum demersum* grading into open, submergent marsh. At Little Tail Point, a fairly broad zone of wet meadow (again dominated by *Calamagrostis canadensis*) covers the sandspit, but *Typha angustifolia* becomes dominate near the waters edge. The emergent zone is similar in composition to that at Dead Horse Bay, but with a greater diversity of submergent species.

5. Mud Lake

Location: Door Peninsula, Door County, WI
Site type: barrier-beach lagoon
Lake: Lake Michigan
Landform: sand over low bedrock plain
Substrate: sand
Water clarity: fairly clear
Surveyors: Dennis Albert and M. Kost

This wetland is located on the northern tip of the Door Peninsula, just south of the Mink River site. Mud Lake appears to be a large swale separated from Moonlight Bay on Lake Michigan by numerous sand ridges; a small stream flows out of the swale and meanders across the many beach ridges to connect with Lake Michigan. This wetland appears similar in origin to a barrier-beach lagoon, that is, the sand dunes have largely blocked the flow of the small stream creating a shallow lake with water less than 30 cm deep. Substrates are sand, covered by deep organics (up to 2 m thick); the water is fairly clear. During sampling, strong winds from Lake Michigan reversed the stream flow back into Mud Lake; the force of the winds was so strong that the stream flowed upstream over a beaver dam.

The upland edges of the wetland are dominated by cedar swamp, which gradually changes into shrub swamp/wet meadow dominated by *Carex stricta* and *Calamagrostis canadensis*, and containing *Myrica gale*. The pond itself supports submergent vegetation, including *Chara* spp. and *Najas flexilis*, and the emergents *Nuphar variegata* and *Zizania aquatica*, which is quite abundant.

6. Mink River

Location: Door Peninsula, Door County, WI
Site type: A. lacustrine estuary; B. tributary river delta
Lake: Lake Michigan
Landform: sand over low bedrock plain
Substrate: sand
Water clarity: clear
Surveyors: Dennis Albert and M. Kost

The Mink River occupies an old glacial melt-water channel that cuts N-S across the northern tip of the Door Peninsula for a distance of approximately 4 miles. This system is fed by springs in the Niagaran dolomite, the bedrock forming the upland peninsula; spring water entering the Mink River system is highly alkaline, from the dissolving limestone (Keough 1987, 1990). The northern (Green Bay) extent of this channel contains discontinuous wetlands separated by upland forests. The Mink River then begins in a broad, mile-long swamp and flows only a little more than 2 miles to Rowley Bay on Lake Michigan.

Transect A is located near the stream's head waters, approximately 1.25 miles inland from Lake Michigan, where the channel flows between till uplands and is sheltered from wave activity of the bay. The transect extends between a narrow, shallow feeder stream (12 m wide and generally less than 1 m deep), across a wet meadow zone, to the larger, main stream. Within the feeder channel, substrates were shallow organics over marl, while marl was at the surface along the main channel. Within the wet meadow zone, fairly deep organics (2-2.5 m) were encountered over silt or marl. These marls are developed on the silty soils that overlay the local limestone bedrock.

The feeder-stream channel supports fairly dense submergent marsh, including *Myriophyllum verticillatum*, *M. exalbescens*, *Potamogeton natans*, *Utricularia vulgaris*, *Vallisneria americana*, and some floating-leaf species (*Nuphar variegata*). The herbaceous zone is a standard *Calamagrostis canadensis* and sedge wet meadow. The larger, marly channel is largely unvegetated. Swamp forest and shrub swamp ring the edges of the wetland, but were not sampled.

Transect B is very near the mouth of the river where it meets the bay, and extends across the stream mouth and into the bay. Here, organic soils are not very deep (< 65 cm); substrate is sand across the entire transect. This transect crossed a broad zone of cedar-tamarack swamp, a zone of alder shrub swamp, which grades into a narrow wet meadow dominated by *Calamagrostis canadensis* and *Carex stricta*, and then into a *Scirpus acutus*-dominated emergent marsh with abundant *Nuphar variegata*. For detailed analyses of the Mink River estuary vegetation, see Keough (1987, 1990).

7. West Twin River

Location: Manitowoc County, WI
Site type: stream-side wetland associated with lacustrine estuary
Lake: Lake Michigan
Landform: clayey till plain
Substrate: deep organics over clay
Water clarity: turbid
Surveyors: Dennis Albert and M. Kost

This is the western of the two rivers that run through and give name to the town of Two Rivers, Wisconsin. It is a relatively large river (approximately 40-50 m wide, and 1.5 m deep at mid-stream) which occupies a channel dissected down through deep till deposits. The channel is bounded by 200-300 m of flood plain on either side and steep upland bluffs (20-25 m high). The mouth of the river is now a harbor, so sites inland from the mouth were selected for sampling. **Transect A** is located approximately 1.25 miles from the mouth, while **Transect B** is further upstream at 1.6 miles from the outlet. At both transect locations, the floodplain was saturated and deep organic soils (up to 4 m) were encountered. The river itself is quite turbid, with only 15 cm of visibility.

The flood plain contains swamp forest along the edge of the bluffs, with a fairly broad (240 m) shrub swamp zone in which alder dominates. A narrow zone (60-80 m wide) of wet meadow (dominated by *Calamagrostis canadensis* and *Carex lacustris*) parallels the river. Little emergent vegetation was encountered, although scattered hybrid cat-tail (*Typha glauca*) occur across the entire wetland.

OHIO

1. Sheldon Marsh

Location: Erie County, OH
Lake: Lake Erie
Site type: barrier-beach lagoon
Landform: lacustrine plain
Substrate: silt and sand over deep organics
Water clarity: very turbid
Surveyor: Dennis Albert

Sheldon Marsh occupies a long, shallow lagoon parallel to the shoreline that is separated from Lake Erie by a low sand spit (60-70 cm high). The water of the lagoon is generally less than 70 cm deep, and is very turbid and occupied by large numbers of carp. The sand spit is vegetated by sandbar willow; almost no vegetation occurs within the marsh itself, with the exception of some localized clones of spatterdock (*Nuphar advena*), with its leaves above the water. Along the inland edge, a narrow zone of sandbar willow extends along a low sandbar, with wet meadow species (including *Calamagrostis canadensis*, *Phragmites australis*, *Typha angustifolia*, *Calystegia sepium*, and *Hibiscus moeschutos*) continuing inland to the edge of the upland.

The upland is now largely a residential area, but agriculture use persists to within several hundred meters of the shoreline. Sediment studies (Bray 1988) reveal a thick layer of organics beneath the sand bar and extending across the lagoon, probably indicating the previous existence of a stable marsh with organic soils which was later covered by silt and sand, as a result of increased agriculture as well as shoreline destabilization through dredging, etc. The lagoon presently has silt substrates with no organic deposits; shallow organics (< 15 cm) were encountered in the wet meadow zone. Historic aerial photographs indicate considerable change in the configuration of the barrier beach over time. Between 1939 and 1968, the beach was a continuous barrier. In contrast, between 1972 and 1986, the barrier beach was broken and shifted inland. At the time of sampling in 1994, the beach once again provided a continuous barrier to Lake Erie.

2. Old Woman Creek

Location: Old Woman Creek National Estuarine Research Reserve, Erie County, OH
Lake: Lake Erie
Site type: lacustrine estuary
Landform: lacustrine plain
Substrate: silt
Water clarity: very turbid
Surveyors: Dennis Albert

Old Woman Creek is a small tributary to the southwestern margin of Lake Erie. The creek, its estuary, and a large portion of its drainage basin have been designated as a National Estuarine Research Reserve. As a result, the site has been intensively studied and reported in the literature (e.g. Herdendorf 1990; Matisoff and Eaker 1992; Heath 1992; Klarer and Miller 1992).

The Old Woman Creek estuary is formed by a barrier beach across the mouth of the stream where it enters Lake Erie. The presence of the barrier beach, and hence water flow through OWC, changes seasonally (Heath 1992). During seasons of high flow and storm activity on Lake Erie (usually November through April), the mouth is open and flow progresses rapidly through the wetland marsh. During relatively quiescent times, the mouth is closed by a barrier beach, and water flow is limited to percolation through that barrier.

This barrier beach is probably of recent origin, and may be the product of increased sediment loading in rivers to the west such as the Sandusky River and Huron River. Its development has permitted an acceleration of deposition within the estuary by slowing the water flow rate (Buchanan 1982). As a result, the deep muck soils characteristic of many Great Lakes estuaries appear to have been buried at OWC by silts and clays derived from agricultural run-off. Sediment core stratigraphy indicates a change in sediment composition from peat to sandy clay mixed with peat at a depth of 130 cm; this change is associated with a C-14 date of 180± 20 (ca. 1830 A.D.) and a sharp increase in *Ambrosia* pollen resulting from deforestation and cultivation by European settlers (Reeder 1990). MNFI field observations indicate that the waters of OWC continue to be highly silt laden with very low visibility, presumably owing to the extent of agricultural activity in its immediate watershed.

The MNFI sampling transect crossed OWC at a point approximately .75 km inland from Lake Erie. The transect extended from Star Island to the eastern shore of the stream. Soils along the transect were fine-textured and silty, and banks of the river were fairly steep and highly eroded. Water depths ranged from 45-70 cm across the channel, but visibility was low (< 15 cm with the Sechi disc). The dominant species along the transect was *Nelumbo lutea*, with coverage values of 40-100%; *Lemna minor* occurred throughout as well.

3. Huron River

Location: Erie County, OH
Lake: Lake Erie
Site type: old meander of lacustrine estuary
Landform: lacustrine plain
Substrate: silt
Water clarity: very turbid
Surveyors: Dennis Albert and Greg Schneider

The Huron River is a larger river located just west of Old Woman Creek. In its lower reaches, the main channel of the Huron River is approximately 100 m wide, and occupies a floodplain .75 km wide. The river flows 10 m below the adjacent uplands. The river has heavy agricultural land use surrounding it, and other urban use near its banks, including a golf course. There are also major marinas located near the mouth of the river and the floodplain is highly degraded, with common signs of bank manipulation. The river is highly silt laden, with high turbidity.

Sampling was conducted in a broad, protected meander separated from the largely unvegetated main channel, within 2 miles of the mouth of the river. This meander loop has relatively shallow water (< 30 cm deep) and very little current. The substrate is silt throughout and the water extremely turbid. The transect begins within the swamp forest of the floodplain and continues east across a narrow wet meadow zone containing *Phalaris*, *Calystegia sepium*, and *Typha angustifolia*. A similarly narrow zone (20 m wide) of emergent marsh zone dominated by cat-tails and *Sagittaria latifolia* parallels the shore. The edges of the channel contain a 90 m-wide zone of submergent and floating species, dominated by *Nuphar advena* (40-80% cover), but a large portion of the meander is unvegetated.

PENNSYLVANIA

1. Thompson Harbor, Presque Isle

Location: Presque Isle peninsula, Erie County, PA
Lake: Lake Erie
Site type: sand spit lagoon
Landform: compound sand spit
Substrate: sand
Water clarity: clear
Surveyors: Dennis Albert and Will MacKinnon

Presque Isle is a 12 mile sand spit extending northeast out into Lake Erie, which forms a large (3 miles across) embayment south of the spit. The sampling site for 1994 was a small embayment or swale between two low beach ridges (1.25-1.75 m high) near the outer end of the sand spit. This embayment is quite small (only 70 m across) and quite shallow, and is connected to Thompson Bay on Lake Erie by a small channel. Water levels fluctuate with the wind direction. This wetland appears to be fairly dynamic, subjected to seiche events as well as sand deposition and withdrawal near its mouth.

The deepest portion of the embayment supports a relatively diverse submergent aquatic community, with *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Najas flexilis*, *Potamogeton* spp., and *Vallisneria americana*, as well as scattered patches of *Nymphaea odorata*. A stand of *Phragmites australis* dominates the emergent zone. Substrates are sand with shallow organics near the edges of the embayment, and exposed sand in the center, where the current resulting from seiche events is strongest.

Wet meadow (dominated by *Calamagrostis canadensis*), shrub swamp, and tree swamp surround the swale. The shrub and tree swamp have shallow organic soils, with no standing water by late summer. For details on successional trends in the sandspit lagoons of Presque Isle, see Kormondy (1969, 1984).

2. Presque Isle, Lagoons

Location: Presque Isle peninsula, Erie County, PA
Lake: Lake Erie
Site type: sand-spit lagoon
Landform: compound sand spit
Substrate: shallow organics (< 50 cm) over sand
Water clarity: clear
Surveyor: Dennis Albert

The Lagoons are connected to Erie Bay (the large inner bay protected by Presque Isle) by a smaller embayment, Misery Bay. Several long, linear swales (including Long Pond, Big

Pond, Cranberry Pond, and Ridge Pond) connect to Misery Bay by channels, creating a boatable wetland locally known as the Lagoons. Many of the channels are quite shallow (with water depths less than 1.5 m), but the main channels are up to 3 m deep. The substrate is sand throughout, as the entire peninsula is a series of parallel sand spits or sand dunes. Shallow organic deposits, generally less than 50 cm, overlie the sand within the channels.

The major channels support primarily submergent species, while the shallower channels are densely vegetated with submergents in deeper water, emergent vegetation in shallow water, and shrubs near the water's edge. The shallowest swales are completed dominated by buttonbush.

A single sampling transect was placed across the channel of Long Pond. Here the channel contained *Brasenia schreberi*, *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Najas minor*, *Heteranthera dubia*, *Nuphar advena*, *Nymphaea odorata*, and *Pontederia cordata*. The channel was edged with a wet meadow zone of *Calamagrostis canadensis*, *Carex stricta*, and *Sparganium eurycarpum*, and including the shrubs *Myrica pensylvanica* and *Populus deltoides*.

NEW YORK DRUMLIN FIELD

1. East Bay

Location: 5 miles E of Sodus Point, Wayne County
Lake: Ontario
Site type: barrier-beach lagoon/barred lacustrine estuary
Landform: sandy till plain/drumlin field
Substrate: muck or peat
Water clarity: turbid
Surveyor: Don Cameron

East Bay is located on the southern shore of Lake Ontario approximately 5 miles E of the village of Sodus Point, Wayne County. The several-hundred acre marsh is held in an embayment behind a narrow, undeveloped barrier beach, and sits between various N-S oriented drumlin ridges. It is fed by two warm-water, low gradient streams. Maximum water depth does not exceed 3.3 m. Substrate is muck or peat 3 m or more in depth.

East Bay marsh was sampled with a single transect that began in the deep emergent marsh of the embayment, crossed an island of alder-dominated shrub swamp, proceeded into a zone of shallow emergent marsh, and ended in a moderately sloped wooded upland. The deep emergent marsh had water depths less than 1.0 m and contained patches of floating-leaved aquatics. The shallow emergent zone with saturated soils was a mat dominated by *Typha glauca* and *Thelypteris palustris*. This mat was separated from the upland by a moat.

2. Black Creek

Location: 3 miles E of Port Bay, Wayne County
Lake: Ontario
Site type: barrier-beach lagoon
Landform: sandy till plain/drumlin field
Substrate: sand covered by 2-3 m of peat

Water clarity:
Surveyor: Don Cameron

Black Creek Marsh is located on the SE shore of Lake Ontario, approximately 3 miles E of Port Bay, Wayne County. The 500-acre marsh occurs in bands and pockets between N-S oriented drumlins behind a continuous barrier beach. Black Creek meanders through the marsh and splits into dead ends without reaching the lake, creating narrow (4-25 m wide) pools of open water behind the barrier.

Transect B was located along the long axis of the pool about 10 m behind the barrier beach and extend from the pool, across a bar of shrub swamp, and into a broad zone of shallow emergent marsh which occupies the major part of this drumlin-defined cove. Water depth in the pool was less than 2 m; substrates were sand covered by 2-3 m of peat.

Although not sampled, the barrier beach itself was *Salix* dominated. The open-water pool contained a deep emergent marsh with *Nymphaea odorata*, *Ceratophyllum demersum*, and *Potamogeton zosteriformis*, and was edged with a shrub swamp of *Alnus* and *Decodon*. The shallow emergent marsh was dominated by a mat of *Typha glauca* and *Thelypteris palustris*, and was relatively species poor.

Transect A sampled an inland poor fen or dwarf shrubby bog community on the eastern end of the site. Soils were saturated at the surface and consisted of peat accumulations greater than 3 meters in thickness. Common species encountered include *Chamaedaphne calyculata*, *Sphagnum magellanicum*, *Vaccinium macrocarpon*, *V. corymbosum*, and *Sarracenia purpurea*.

3. Sterling Creek

Location: Cayuga County
Lake: Ontario
Site type: barrier-beach lagoon/barred lacustrine estuary
Landform: sandy till plain/drumlin field
Substrate: deep organics
Water clarity: turbid
Surveyor: Don Cameron

Sterling Creek Marsh is located approximately 1 mile NE of the village of Fair Haven, Cayuga County, on the south shore of Lake Ontario. Sterling Creek winds through the marsh and the surrounding drumlins emptying into a lake-side pond (The Pond) behind a barrier beach, which in turn enters the lake through a stabilized outlet. The Pond is contained within Fair Haven State Park and receives a considerable amount of recreational fishing and swimming.

Sampling at this site focused on the area directly behind the main beach/pool area of Fair Haven State Park. Where sampled, water depths were shallow (less than 80 cm), over deep accumulations of organics (in excess of 3 m). The main portion of this wide pool had no emergent vegetation, though submerged aquatics (*Ceratophyllum demersum*) heavily laden with algae were abundant. The broad mouth of the channel which entered the back of the pool additionally contained *Lemna trisulca* and *Wolffia columbiana*. A shallow emergent marsh occurred in the form of a *Typha glauca* mat, which gradually gave way to a *Alnus-Decodon* shrub swamp.

EAST END OF LAKE ONTARIO

1. Lakeview Pond, Lakeview Marshes

Location: N end of Lakeview Marsh, Jefferson County
Lake: Ontario
Site type: barrier-beach lagoon
Landform: sand deposition over till plain
Substrate: sands covered by < 2 m of organics
Water clarity:
Surveyor: Don Cameron

Lakeview Marsh is a 3400 acre wetland complex located behind a 5-mile barrier beach on the eastern shore of Lake Ontario, at a point approximately 4 miles W of Ellisburg, Jefferson County. It is fed by two cold water streams, Sand Creek and South Sandy Creek. Some areas adjacent to the barrier beach are ponded and include open water and deep emergent marsh communities. The majority of the site is occupied by extensive shallow emergent marsh communities.

Lakeview Pond is at the N end of Lakeview Marsh attached to a dead-end branch of Sandy Creek. Formerly the creek probably flowed through a gap in the beach adjacent to this pond, but there was no opening in the beach at the time of sampling. The pond is shallow, with water generally less than 1 m deep. Substrates are sands, covered by up to 2 m of organic deposits.

The sampling transect first crossed a narrow zone of deep emergent marsh, with *Nuphar advena*, *Elodea canadensis*, and *Ceratophyllum demersum*, and then a broader zone of shallow emergent marsh, in which *Typha glauca* gave way to *Carex lacustris* with scattered stands of *Alnus rugosa*.

2. South Colwell Pond, Lakeview Marshes

Location: S. end of Lakeview Marsh, Jefferson County
Lake: Ontario
Site type: barrier-beach lagoon
Landform: sand deposition over till plain
Substrate: muck (clayey peat)
Water clarity:
Surveyor: Don Cameron

This area was located at the southern end of the Lakeview Marsh complex, within a ponded area of open water. At the time of sampling, the pool had a shallow outlet (probably seasonal) to Lake Ontario. The pool is fairly shallow, with water depths less than 1.5 m. Soil texture where sampled was muck (clayey peat).

Throughout the pool were abundant submerged aquatics, particularly *Ceratophyllum demersum* and *Elodea canadensis*, while floating-leaved aquatics occurred along the shore. A shallow emergent marsh in the form of a *Typha glauca* mat extended for 80-100 m before gradually giving way to *Calamagrostis canadensis*.

3. Deer Creek

Location: 5 miles NW of Pulaski, Oswego County
Lake: Ontario
Site type: barrier-beach lagoon
Landform: sand deposition over till plain
Substrate: peat
Water clarity: clear
Surveyor: Don Cameron

Deer Creek Marsh is located on the E shore of Lake Ontario approximately 5 miles NW of the city of Pulaski, Oswego County. It occupies 1200 acres behind a 1 mile strip of barrier beach. It is fed by Deer Creek, a slow moving, warm-water stream which enters Lake Ontario through a well developed channel. The marsh is primarily vegetated having only 2% of its area in open water.

The site was sampled with two transects. **Transect A** sampled a large fen community in the NE corner of the site. Here, soils were saturated at the surface and consisted of peat deposits ranging from 2.5 m to greater than 4 m thick. The transect first crossed a shrubby poor fen dominated by *Myrica gale* with some *Osmunda regalis* and *Chamaedaphne calyculata;* toward the stream channel, this community gradually gave way to a medium fen dominated by *Carex lasiocarpa* and *Sphagnum contortum* in areas that increasingly had areas of shallow standing water.

Transect B sampled shallow and deep emergent marsh in the NW corner of the site behind the barrier beach. Here, soils were also deep accumulations of peat (2.5 to 3.0+ m in thickness). Very shallow water (< 40 cm) in the shallow emergent water contained a relatively species-poor *Typha glauca* mat, while the deeper waters (up to 80 cm) of the deep emergent marsh contained a mix of *Typha glauca* and *Scirpus validus*.

TRENTON LIMESTONE

1. Point Peninsula

Location: S. of Cape Vincent, Jefferson County
Lake: Ontario
Site type: barrier-beach lagoon
Landform: limestone tableland
Substrate: muck
Water clarity:
Surveyor: Don Cameron

Point Peninsula marsh is located on the SW side of a 7 square mile peninsula into Lake Ontario, approximately 8 miles south of Cape Vincent, Jefferson County. At the time of sampling, the 300-acre site consisted of a wide, shallow lagoon behind a narrow strip of sand-cobble beach. The entire wetland had no visible outlet to the lake and had no pooled areas or channels. Soils behind the barrier were saturated at the surface; soils were muck covered by 70-200+ cm of organics.

The wetland was sampled with a single transect beginning on the upland edge and extending east across the depression toward the barrier beach. The substrate was a sticky muck across the entire transect, but was poorly consolidated within the depression. The upland vegetation consisted of a dense shrub swamp dominated by *Decodon verticillatus* and *Cephalanthus occidentalis*. The shallow emergent marsh was patchily dominated, with *Calamagrostis canadensis* dominating the interior of the marsh, and *Sparganium eurycarpus* having higher cover values near the beach. Frequent depressions contained *Eleocharis acicularis* and *Sagittaria latifolia*. *Salix discolor* dominated the barrier beach.

2. Dexter Marsh/Black River Bay

Location: Black River Bay, 9 miles W of Watertown, Jefferson County
Lake: Ontario
Site type: delta of Black River estuary
Landform: limestone tableland
Substrate: sandy clay
Water clarity: turbid
Surveyor: Don Cameron

Dexter Marsh is located at the mouth of the Black River at the upper end of Black River Bay, approximately 9 miles W of Watertown, Jefferson County. Several other small rivers and streams in addition to the Black River feed into this 2000-acre marsh and have wide channels that are bordered by both deep and shallow emergent marshes. The Black River is a lacustrine estuary whose mouth has been drowned by post-glacial rise in lake level. Substrate was a sandy clay covered by very shallow (5-40 cm) organics in the terrestrial zones, and muck overlaid with up to 1.5 m of organics in the deep aquatic zones.

A single transect was located on the south side of the marsh adjacent to an unnamed creek emptying into Muskalonge Bay (a small embayment of the Black River Bay). The transect crossed three zones: shrub swamp, shallow emergent marsh, and deep emergent marsh. The narrow strip of shrub swamp contained patches of *Spiraea latifolia* and *Cornus amomum*, with a ground cover of *Calamagrostis canadensis* and *Carex stricta*. The transition to shallow emergent marsh was gradual, as the shrubs and graminoids declined in density over a distance of 30-60 m, and were eventually replaced by a dense mat of *Typha glauca*. This mat ended abruptly and the deep emergent marsh began when water depths reached 80 cm.; this zone contained scattered *Sagittaria latifolia* and *Nymphaea odorata*, along with the submerged *Ceratophyllum demersum* and *Potamogeton zosteriformis*.

ST. LAWRENCE RIVER GRANITIC SHORELINE

1. Flynn Bay

Location: Grindstone Island, Jefferson County, NY
Lake/Channel: St. Lawrence River
Site type: embayment and small lacustrine estuary
Landform: glacially modified bedrock
Substrate: deep organics over clay
Water clarity: clear
Surveyors: Dennis Albert and Will MacKinnon

Flynn Bay is located on the SW corner of Grindstone Island, and opens to the St. Lawrence River to the SW. The embayment is formed and bordered by bedrock knobs and ridges that rise 3-30 m above the water. The relatively open bay receives heavy wave action from the St. Lawrence.

The sampling transect was placed in the upper reaches of a small stream flowing into the NE corner of Flynn Bay. The transect began within a narrow shrub swamp, and continued across a broad wet meadow zone, to the open water of the stream. Substrates along the terrestrial portion of the transect were .30-1.5 m of organics over clay, while organics in excess of 2 m underlay the stream channel. The shrub swamp was dominated by *Cornus foemina* and *Viburnum lentago*, with a ground cover of sedges and *Calamagrostis canadensis*; soils were saturated at the surface. *Carex comosa* and *Calamagrostis canadensis* (along with *Impatiens capensis*) continued to dominate in the wet meadow zone, but gave way to a dense stand of *Typha angustifolia* near the stream edge. The stream itself contained a diversity of pondweeds, with *Ceratophyllum demersum*, *Myrioplyllum exalbescens*, *Najas flexilis*, and *Vallisneria americana*, as well as the duckweeds *Lemna trisulca* and *Spirodela polyrhiza*.

A second transect was placed in the emergent and submergent marsh at the SW end of the bay, but was not used in the analyses. This transect was characterized by a narrow emergent marsh, with a broad, low diversity submergent marsh on deep organic substrates stretching across the entire shallow west end of the bay. The vegetation of the bay appeared to have been highly modified by boat traffic.

2. Delaney Bay

Location: Grindstone Island, Jefferson County, NY
Lake/Channel: St. Lawrence River
Site type: embayment and small lacustrine estuary
Landform: glacially modified bedrock
Substrate: deep organics over silt/clay
Water clarity: clear
Surveyors: Dennis Albert and Will MacKinnon

Delaney Bay is a long, irregular embayment near the NE end of Grindstone Island that opens to the N toward the St. Lawrence River. Like Flynn Bay, this bay is shaped and constrained by the irregular bedrock topography of the island. No major rivers or large streams flow into the bay.

The sampling transect was placed N-S across a small stream flowing into the W side of the bay just under a mile from the mouth. Vegetation zones noted here included (1) a narrow shrub zone, (2) a narrow cat-tail-dominated emergent marsh, (3) a narrow sedge and grass dominated emergent marsh near the headwaters, and (4) submergent/floating marsh within the stream. The transect began within the wet meadow zone, dominated by *Calamagrostis canadensis* and sedges, and continued into the stream, containing the submergents *Ceratophyllum demersum*, *Myriophyllum exalbescens*, *Potamogeton* spp., and *Vallisneria americana*, as well as the duckweeds *Lemna trisulca* and *Spirodela polyrhiza*. Inland substrates consisted of deep organics (1-2+ m) over clayey silt; the stream bottom was poorly consolidated organic material.

3. Barnett Marsh (Wellesley Island)

Location: Wellesley Island, NY
Lake/Channel: St. Lawrence River
Site type: embayment and small lacustrine estuary
Landform: glacially modified bedrock
Substrate: deep organics
Water clarity: clear
Surveyor: Dennis Albert

Wellesley Island is a large, hook-shaped island belonging to the Thousand Islands group of the St. Lawrence River; large granitic bedrock exposures occur along much of the shoreline. Lake of the Isles occupies the inner curve of the hook, which opens to the NE.

The Barnett Marsh wetland lies in the center of the lower, southern curve of the above-mentioned hook and drains via a small stream north into Lake of the Isles. A small bedrock island protects the mouth of the stream and knobs of bedrock occur along the wetland margin. A beaver dam and lodges were noted on the upper reaches of the stream. MNFI sampling focused on the lower portions of the stream, and crossed the submergent marsh within the bay, as well as the wet meadow paralleling both sides of the lower stream course. The bay had organic accumulations of greater than 2.25 m, while organics in excess of 3 m were encountered within the wet meadow zone.

The shallow waters of the bay contained the submergents *Ceratophyllum demersum*, *Elodea canadensis*, *Myriophyllum spicatum*, along with the floaters *Nymphaea odorata* and *Lemna trisulca*. The wet meadow zone was dominated by *Typha angustifolia*, but consistently contained *Calamagrostis canadensis*, *Carex aquatilis*, *Bidens cernua*, *Lycopus uniflorus*, *Polygonum amphibium*, *Scutellaria lateriflora*, *Thelypteris palustris*, and *Triadenum virginicum* as well. Adjacent upland forest contained mature white pine, red oak, and red maple.

4. Cranberry Creek

Location: Jefferson County, NY
Lake/Channel: St. Lawrence River
Site type: lacustrine estuary with delta
Landform: glacially modified bedrock
Substrate: deep organics
Water clarity: clear
Surveyors: Dennis Albert and Will MacKinnon

Cranberry Creek flows NE through rounded bedrock knobs and ridges, and empties into Goose Bay on the St. Lawrence River. The lower reaches of the stream (within 2 miles of the mouth) are bordered by stretches of wetland, at times .5 miles wide. The mouth of the creek forms a broader delta almost a mile across.

MNFI sampling focused on wetlands near the mouth of the stream. The transect began near the center of the stream and continued inland. The stream had a bottom of poorly consolidated organic matter 1-2 m thick beneath the water surface; deep organics (1.5-3 m thick) were encountered beneath the emergent marsh and wet meadow.

The zonation along the transect included (1) open stream channel with submergent vegetation (*Ceratophyllum demersum*, *Myriophyllum exalbscens*, *Potamogeton* spp., *Heteranthera dubia*, *Najas flexilis*) covering most of the bottom and floating vegetation (*Nymphaea odorata*, *Nuphar variegatum*, *Lemna trisulca*, *Spirodela polyrhiza*, *Utricularia vulgaris*) nearer the shoreline; (2) a broad emergent marsh dominated by *Typha angustifolia* from the water's edge to near the upland edge; and (3) a narrow sedge-grass wet meadow dominated by *Carex lacustris* and *Calamagrostis canadensis*. The wetland was bordered by a narrow shrub swamp of *Alnus rugosa* and *Cornus foemina*, and surrounded by a second-growth upland forest on silty soil or bedrock.

6. Chippewa Creek

Location: St. Lawrence County, NY
Lake/Channel: St. Lawrence River
Site type: lacustrine estuary with delta
Landform: glacially modified bedrock and outwash
Substrate: thick organics over clay
Water clarity: clear
Surveyors: Dennis Albert and Will MacKinnon

Chippewa Creek is a large creek than flows SW into Chippewa Bay on the St. Lawrence River. The creek occupies an apparent pre-glacial valley cut through rounded bedrock knobs and ridges which has been partially filled in by outwash deposits to form a fairly broad, flat basin. Extensive wetlands (up to .4 mi wide) line the lower 5 miles of the stream as it flows through this basin; a delta over .6 mi wide has formed at the mouth.

Transect A was located at the mouth of Chippewa Creek on deltaic deposits and extended inland across a broad wet meadow zone (400 m wide). Thick organic deposits (in excess of 3 m) were encountered along the transect; these appear to be underlain by clay. Wave action was high along the St. Lawrence shore, and aquatic vegetation within the creek mouth was largely limited to the exotics *Potamogeton crispus* and *Myriophyllum spicatum*. The shoreline was dominated by *Typha angustifolia*, along with *Impatiens capensis*. The *Typha* continued into the wet meadow zone, and gradually gave way to *Calamagrostis canadensis* and *Carex lacustris* as co-dominants.

Transect B was placed along a small tributary stream to Chippewa Creek at a distance of approximately 2 miles inland from Chippewa Bay at a point still under influence of Great Lakes water levels. Substrates again were deep organics, with gravel and bedrock encountered near the edges of the marsh. The small stream was diverse, containing a range of submergent and floating species (*Ceratophyllum demersum*, *Myriophyllum exalbescens*, *Potamogeton zosteriformis*, *Nymphaea odorata*, *Lemna trisulca*, *Spirodela polyrhiza*, *Utricularia vulgaris*), and was edged with a broad *Typha angustifolia* dominated emergent marsh. The adjacent narrow shrub zone contained dense *Cornus foemina*. The surrounding uplands contained a mature second growth of northern hardwoods with white pine and hemlock.

7. Crooked Creek

Location: St. Lawrence County, NY
Lake/Channel: St. Lawrence River
Site type: lacustrine estuary
Landform: glacially modified bedrock
Substrate: deep organics over clay or bedrock
Water clarity: clear
Surveyors: Dennis Albert and Will MacKinnon

The broad, meandering stream of Crooked Creek flows north into the St. Lawrence river between rounded bedrock uplands. Valleys between the knobs are occupied by backwaters of the stream and by stream-side wetlands up to .5 miles wide.

Transects A and **B** were placed within one such backwater wetland area, approximately .25 miles from the main stream channel and slightly over a mile inland from the mouth of the creek. Here, the wetland was surrounded by bedrock uplands vegetated with mature white pine, red pine, pitch pine, and red oak, and bordered by a shrubby zone dominated by alder. Sampling began within the shrubby zone and continued across a broad wet meadow zone to the open water of a small tributary stream. Substrates along the transect were deep organics (> 3 m) over bedrock or clay.

The wet meadow zone was dominated by *Calamagrostis canadensis*, *Carex aquatilis*, and *C. lacustris*, with *Sagittaria latifolia*, *Thelypteris palustris*, and *Typha latifolia* frequently present. The open water of the channel (ca. 60 cm deep) was dominated by wild rice with patches of spatterdock and water lily, and contained a diversity of pondweeds (*Potamogeton* spp), along with *Ceratophyllum demersum* and *Myriophyllum exalbescens*. *Eleocharis smallii* and *Glyceria borealis* were common along the stream edges. The exotic *Hydrocharis morsus-ranae* was widely present.

A single transect, **Transect C**, was placed within a small bay at the mouth of Crooked Creek and extended from the shoreline shrub zone into the open waters of the bay. Substrates again consisted of deep organics over silt or gravel. The sparse shrub zone was dominated by *Cornus foemina* and *Viburnum lentago*, with a ground cover of *Calamagrostis canadensis* and *Carex stricta*. Typha angustifolia dominated the edges of the bay; deeper waters contained a diversity of submergents, including *Ceratophyllum demersum*, *Myrioplyllum exalbescens*, *Najas flexilis*, *Potamogeton* spp., and *Vallisneria americana*, as well as patches of *Nyphaea odorata* and the duckweeds *Lemna trisulca* and *Spirodela polyrhiza*. The exotic *Hydrocharis morsus-ranae* was present throughout.

Appendix II
Species Codes used in TWINSPAN

Species	Code
Abies balsamea	abie bal
Abutilon theophrastis	abut the
Acer negundo	acer neg
Acer rubrum	acer rub
Acer saccharinum	acer sac
Achillea millefolium	achi mil
Acorus calamus	acor cal
Agrimonia gryposepala	agri gry
Agropyron repens	agro rep
Agrostis stolonifera	agrs sto
Alisma plantago-aquatica	alis pla
Alnus rugosa	alnu rug
Alopecurus aequalis	alop aeq
Amphicarpa bracteata	amph bra
Andromeda glaucophylla	andr gla
Anemone canadensis	anem can
Apios americana	apio ame
Apocynum sibiricum	apoc sib
Aronia melanocarpa	aron mel
Asclepias incarnata	ascl inc
Asclepias syriaca	ascl syr
Aster dumosus	aste dum
Aster junciformis	aste jun
Aster puniceus	aste pun
Aster umbellatus	aste umb
Aulucomnium palustre	aulu pal
Betula papyifera	betu pap
Bidens cernua	bide cer
Boehmeria cylindrica	boeh cyl
Brasenia schreberi	bras sch
Brassica nigra	brss nig
Bromus ciliatus	brom cil
Bromus tectorium	brom tec
Calamagrostis canadensis	cala can
Calamagrostis inexpansa	cala ine
Calla palustris	call pal
Callitriche hermaphroditica	cali her
Caltha palustris	calt pal
Calystegia sepium	caly sep
Campanula aparinoides	camp apa
Carex aquatilis	carx aqu
Carex bebbii	carx beb
Carex buxbaumii	carx bux
Carex comosa	carx com
Carex crinita	carx cri
Carex cristatella	carx crs
Carex diandra	carx dia
Carex eburnea	carx ebu
Carex exilis	carx exi
Carex flava	carx fla
Carex gracillima	carx gra
Carex gynandra	carx gyn
Carex hystericina	carx hys
Carex interior	carx int
Carex lacutris	carx lac
Carex lanuginosa	carx lan
Carex lasiocarpa	carx las
Carex limosa	carx lim
Carex lupulina	carx lup
Carex lurida	carx lur
Carex michauxiana	carx mic
Carex oligosperma	carx oli
Carex ovata	carx ova
Carex prairea	carx pra
Carex retrorsa	carx ret
Carex rostrata	carx ros
Carex scoparia	carx sco
Carex sterilis	carx ste
Carex stipata	carx sti
Carex stricta	carx str
Carex trisperma	carx tri
Carex viridula	carx vir
Carex vulpinoidea	carx vul
Celastrus scandens	cela sca
Cephalanthus occidentalis	ceph occ
Ceratophyllum demersum	cera dem
Chamaedaphne calyculata	cham cal
Chara aspera	char asp
Chara globularis	char glo
Chara vulgaris	char vul
Chara/nitella	char nit
Chelone glabra	chel gla
Chenopodium albidum	chen alb
Cicuta bulbifera	cicu bul
Cicuta maculata	cicu mac
Cinna arundinacea	cinn aru
Circaea alpina	circ alp
Circaea lutetiana	circ lut
Cirsium arvense	cirs arv
Cirsium muticum	cirs mut
Cladium mariscoides	clad mar
Clematis virginiana	clem vir
Commandra umbellata	comm umb
Convolvulus arvense	conv arv

Species	Code
Cornus amomum	corn amo
Cornus drummondii	corn dru
Cornus racemosa	corn rac
Cornus rugosa	corn rug
Cornus stolonifera	corn sto
Corylus cornuta	cory cor
Crataegus crus-galli	crat cru
Cyperus diandrus	cype dia
Cyperus odoratus	cype odo
Cyperus strigosus	cype str
Daucus carota	dauc car
Decodon verticillatus	deco ver
Deschampsia cespitosa	desc ces
Desmodium glutinosum	desm glu
Diervilla lonicera	dier lon
Dioscoria villosa	dios vil
Drepanocladus sp	drep sp.
Drosera intermedia	dros int
Drosera rotundifolia	dros rot
Dryopteris cristata	dryo cri
Dryopteris intermedia	dryo int
Dulichium arundinaceum	duli aru
Echinocloe walteri	echi wal
Eleocharis acicularis	eleo aci
Eleocharis elliptica	eleo ell
Eleocharis erythropoda	eleo ery
Eleocharis obtusa	eleo obt
Eleocharis rostellata	eleo ros
Eleocharis smallii	eleo sma
Elodea canadensis	elod can
Elodea nuttallii	elod nut
Elymus virginicus	elym vir
Epilobium coloratum	epil col
Epilobium hirsutum	epil hir
Epilobium strictum	epil str
Equisetum arvense	equi arv
Equisetum fluviatile	equi flu
Equisetum hyemale	equi hye
Equisetum variegatum	equi var
Eriocaulon septangulare	eric sep
Eriophorum angustifolium	erio ang
Eriophorum spissum	erio spi
Eriophorum virginiana	erio vir
Eupatorium maculatum	eupa mac
Eupatorium perfoliatum	eupa per
Eupatorium rugosum	eupa rug
Fragaria virginiana	frag vir
Fraxinus americana	frax ame
Fraxinus nigra	frax nig
Fraxinus pennsylvanica	frax pen
Galium aparine	gali apa
Galium boreal	gali bor
Galium palustre	gali pal
Galium trifidum	gali tri
Geum aleppicum	geum ale
Geum canadense	geum can
Geum rivale	geum riv
Glyceria canadensis	glyc can
Glyceria striata	glyc str
Hamamelis virginiana	hama vir
Heteranthera dubia	hete dub
Hibiscus palustris	hibi pal
Hieracium aurietinum	hier aur
Hippuris vulgaris	hipp vul
Hypericum boreale	hype bor
Hypericum kalmianum	hype kal
Hypericum majus	hype maj
Ilex verticillata	ilex ver
Impatiens capensis	impa cap
Iris versicolor	iris ver
Iris virginica	iris vir
Juncus balticus	junc bal
Juncus canadensis	junc can
Juncus dudleyi	junc dud
Juncus effusus	junc eff
Juncus greenei	junc gre
Juncus nodosus	junc nod
Juncus pelocarpus	junc pel
Juncus tenuis	junc ten
Juniperus communis	juni com
Kalmi polifolia	kalm pol
Lactuca canadensis	lact can
Larix laricina	lari lar
Lathyrus palustris	lath pal
Ledum groenlandicum	ledu gro
Leersia oryzoides	leer ory
Leersia virginica	leer vir
Lemna minor	lemn min
Lemna trisulca	lemn tri
Liatris spicata	liat spi
Lindernia dubia	lind dub
Lobelia dortmanna	lobe dor
Lobelia kalmii	lobe kal
Lobelia siphilitica	lobe sip
Lobelia spicata	lobe spi
Ludwegia palustris	ludw pal
Lycopus americanus	lycp ame
Lycopus uniflorus	lycp uni
Lysimachia nummularia	lysi num
Lysimachia quadriflora	lysi qua

Species	Code	Species	Code
Lysimachis terrestris	lysi ter	Pogonia ophioglossoides	pogo oph
Lysimachis thyrsiflora	lysi thy	Polygonum amphibium	poly amp
Lythrum alatum	lyth ala	Polygonum hydropiperoides	poly hyd
Lythrum salicaria	lyth sal	Polygonum lapathifolium	poly lap
Maianthemum canadense	maia can	Polygonum persicaria	poly per
Megalodonta beckii	mega bec	Polygonum punctatum	poly pun
Melilotus alba	meli alb	Polygonum sagittatum	poly sag
Mentha arvensis	ment arv	Polygonum scandens	poly sca
Mentha piperita	ment pip	Polytrichumm var. alpinum	polt alp
Menyanthes trifoliata	meny tri	Pontederia cordata	pont cor
Mimulus ringens	mimu rin	Populus balsamifera	popu bal
Monards fistulosa	mona fis	Populus deltoides	popu del
Muhlenbergia glomerata	muhl glo	Populus tremuloides	popu tre
Muhlenbergia unifloris	muhl uni	Potamogeton alpinus	pota alp
Myosotis scorpioides	myos sco	Potamogeton amplilfolius	pota amp
Myrica gale	myrc gal	Potamogeton berchtoldii	pota ber
Myriophyllum alterniflorum	myri alt	Potamogeton crispus	pota cri
Myriophyllum exalbescens	myri exa	Potamogeton epihydrus	pota epi
Myriophyllum heterohyllum	myri het	Potamogeton filiformis	pota fil
Myriophyllum spicatum	myri spi	Potamogeton foliosus	pota fol
Myriophyllum tenellum	myri ten	Potamogeton friesii	pota fri
Myriophyllum verticillatum	myri ver	Potamogeton gramineus	pota gra
Najas flexilis	naja fle	Potamogeton illinoensis	pota ill
Nelumbo lutea	nelu lut	Potamogeton natans	pota nat
Nemopanthus mucronata	nemo muc	Potamogeton nodosus	pota nod
Nitella flexilis	nite fle	Potamogeton obtusifolius	pota obt
Nuphar advena	nuph adv	Potamogeton pectinatus	pota pec
Nuphar variegata	nuph var	Potamogeton praelongus	pota pra
Nymphaea odorata	nymp odo	Potamogeton richardsonii	pota ric
Oenothera biennis	oeno bie	Potamogeton robbinsii	pota rob
Oenothera perennis	oeno per	Potamogeton strictifolius	pota str
Onoclea sensibilis	onoc sen	Potamogeton zosteriformis	pota zos
Osmunda regalis	osmu reg	Potentilla anserina	pote ans
Panicum columbianum	pani col	Potentilla fruticosa	pote fru
Panicum implicatum	pani imp	Potentilla norvegica	pote nor
Panicum virgatum	pani vir	Potentilla palustris	pote pal
Parietaria pensylvanica	pari pen	Proserpinaca palustris	pros pal
Parthenocissus inserta	part ins	Prunella vulgaris	prue vul
Parthenocissus quinquefoli	part qui	Prunus virginiana	prun vir
Pedicularis lanceolata	pedi lan	Pyrola elliptica	pyro ell
Peltandra virginica	pelt vir	Quercus bicolor	quer bic
Penthorum sedoides	pent sed	Quercus macrocarpa	quer mac
Phalaris arundinacea	phal aru	Quercus palustris	quer pal
Phleum pratense	phle pra	Quercus velutina	quer vel
Phragmites australis	phra aus	Ranunculus abortivus	ranu abo
Physostegia virginiana	phys vir	Ranunculus hispidus	ranu his
Picea mariana	pice mar	Ranunculus longirostris	ranu lon
Plea pumila	pile pum	Ranunculus pensylvanicus	ranu pen
Pinus strobus	pinu str	Ranunculus sceleratus	ranu sce
Poa compressa	poacom	Rhus typhina	rhus typ

Species	Code	Species	Code
Rhynchospora alba	rhyn alb	Scutellaria lateriflora	scut lat
Ribes americanum	ribe ame	Senecio pauperculus	sene pau
Ribes triste	ribe tri	Sium suave	sium sua
Ricciacarpus natans	ricc nat	Smilacina stellata	smil ste
Rorippa palustris	rori pal	Solanum dulcamara	sola dul
Rosa palustris	rosa pal	Solidago altissima	soli alt
Rubus allegheniensis	rubu all	Solidago caesia	soli cae
Rubus flagellaris	rubu fla	Solidago canademsis	soli can
Rubus idaeus	rubu ida	Solidago ohioensis	soli ohi
Rubus hispidus	rubu his	Solidago uliginosa	soli uli
Rubus pubescens	rubu pub	Sonchus arvensis	sonc arv
Rudbeckia hirta	rudb hir	Sphagnum spp.	sphag sp.
Rumex crispus	rume cri	Sparganium americanum	spar ame
Rumex maritimus	rume mar	Sparganium chlorocarpum	spar chl
Rumex orbiculatus	rume orb	Sparganium chloro-eury	spar che
Sagittaris cuneata	sagi cun	Sparganium eurycarpum	spar eur
Sagittaria graminea	sagi gra	Sparganium fluctuans	spar flu
Sagittaria latifolia	sagi lat	Sparganium minimum	spar min
Sagittaria montevidensis	sagi mon	Spartina pectinata	sprt pec
Salix amygdaloides	salx amy	Spiraea alba	spir alb
Salix bebbiana	salx beb	Spiraea tomentosa	spir tom
Salix candida	salx can	Spiranthes cernua	sprn cer
Salix cordata	salx cor	Spiranthes romanzoffiana	sprn rom
Salix discolor	salx dis	Spirodela polyrhiza	sprd pol
Salix eryocephala	salx ery	Stachys palustris	stac pal
Salix exigua	salx exi	Symplocarpus foetidus	symp foe
Salix fragilis	salx fra	Taraxacum officinale	tara off
Salix glaucophylloides	salx gla	Teucrium canadense	teuc can
Salix interior	salx int	Thalictrum dasycarpum	thal das
Salix lucida	salx luc	Thalictrum dioicum	thal dio
Salix pedicellaris	salx ped	Thelypteris noveboracensis	thel nov
Salix petiolaris	salx pet	Thelypteris palustris	thel pal
Salix pyrifloia	salx pyr	Thuja occidentalis	thuj occ
Salix sericea	salx ser	Tofieldia glutinosa	tofi glu
Salix serissima	salx ser	Toxicodendron radicans	toxi rad
Sambucus canadensis	samb can	Triadenum fraseri	tria fra
Sarracenia purpurea	sarr pur	Triadenum virginicum	tria vir
Sassafras albidum	sass alb	Trifolium repens	trif rep
Satureja vulgaris	satu vul	Triglochin maritimum	trig mar
Saururus cernuus	saur cer	Triglochin palustre	trig pal
Scheuchzeria palustris	sche pal	Typha angustifolia	typh ang
Scirpus acutus	scir acu	Typha x glauca	typh gla
Scirpus americanus	scir ame	Typha latifolia	typh lat
Scirpus atrovirens	scir atr	Ulmus americana	ulmu ame
Scirpus cespitosus	scir ces	Ulmus rubra	ulmu rub
Scirpus cyperinus	scir cyp	Urtica dioica	urti dio
Scirpus fluviatilis	scir flu	Utricularia cornuta	utri cor
Scirpus subterminalis	scir sub	Utricularia gibba	utri gib
Scirpus validus	scir val	Utricularia intermedia	utri int
Scutellaria galericulata	scut gal	Utricularia vulgaris	utri vul

Species	Code
Vaccinium macrocarpon	vacc mac
Vaccinium oxycoccos	vacc oxy
Vallisneria americana	vall ame
Verbena hastata	verb has
Verbena urticifolia	verb urt
Viburnum lentago	vibu len
Viola sp.	viol sp.
Virgulus novae-angliae	virg nov
Vitis riparia	viti rip
Wolffia columbiana	wolf col
Wolffia punctata	wolf pun
Xanthium sstrumarium	xant str
Zannichellia palustris	zann pal
Zizania aquatica	ziza aqu
Zizania aquatica var. aqua	ziza var

Appendix III-A
Frequency and Ubiquity of Species Occurring in Emergent Zones

Species	#	%
acer sac	1.0	0.9
acer rub	1.0	0.9
agal pur	1.0	0.9
agrs hye	1.0	0.9
agrs sto	1.0	0.9
alop aeq	1.0	0.9
andr gla	1.0	0.9
aron mel	1.0	0.9
ascl inc	1.0	0.9
boeh cyl	1.0	0.9
call pal	1.0	0.9
call her	1.0	0.9
caly sep	1.0	0.9
carx dis	1.0	0.9
carx fla	1.0	0.9
carx ten	1.0	0.9
carx dia	1.0	0.9
carx ros	1.0	0.9
carx pra	1.0	0.9
carx pcy	1.0	0.9
carx lan	1.0	0.9
carx beb	1.0	0.9
carx int	1.0	0.9
carx sco	1.0	0.9
carx pau	1.0	0.9
cham cal	1.0	0.9
chel gla	1.0	0.9
cicu mac	1.0	0.9
cirs mut	1.0	0.9
cirs arv	1.0	0.9
clad mar	1.0	0.9
corn sto	1.0	0.9
cype dia	1.0	0.9
cype odo	1.0	0.9
dros rot	1.0	0.9
dryo mar	1.0	0.9
echi wal	1.0	0.9
eleo ell	1.0	0.9
elod nut	1.0	0.9
elym vir	1.0	0.9
erio vir	1.0	0.9
erio ten	1.0	0.9
erio sep	1.0	0.9
euth gra	1.0	0.9
glyc bor	1.0	0.9
hama vir	1.0	0.9

Species	#	%
hibi mos	1.0	0.9
ilex ver	1.0	0.9
junc ten	1.0	0.9
junc eff	1.0	0.9
junc acu	1.0	0.9
lath pal	1.0	0.9
lind dub	1.0	0.9
ludw pal	1.0	0.9
lysi qua	1.0	0.9
lysi ter	1.0	0.9
meli alb	1.0	0.9
meny tri	1.0	0.9
mimu rin	1.0	0.9
myri sp.	1.0	0.9
myso sco	1.0	0.9
naja min	1.0	0.9
nelu lut	1.0	0.9
osmu reg	1.0	0.9
pale pra	1.0	0.9
pani lin	1.0	0.9
pogo oph	1.0	0.9
poly alp	1.0	0.9
popu bal	1.0	0.9
pota per	1.0	0.9
pota spi	1.0	0.9
pota fil	1.0	0.9
rhyn alb	1.0	0.9
rubu all	1.0	0.9
rume cri	1.0	0.9
salx pet	1.0	0.9
salx eri	1.0	0.9
salx ser	1.0	0.9
salx amy	1.0	0.9
salx cor	1.0	0.9
sarr pur	1.0	0.9
saur cer	1.0	0.9
sche pal	1.0	0.9
scir atr	1.0	0.9
scut lat	1.0	0.9
sola dul	1.0	0.9
soli can	1.0	0.9
spar min	1.0	0.9
spar che	1.0	0.9
sprn cer	1.0	0.9
thuj occ	1.0	0.9
utri gib	1.0	0.9

Species	#	%
utri min	1.0	0.9
utri res	1.0	0.9
vacc oxy	1.0	0.9
vero ana	1.0	0.9
viol sp.	1.0	0.9
zann pal	1.0	0.9
ziza var	1.0	0.9
armo lac	2.0	1.8
cala ine	2.0	1.8
carx ves	2.0	1.8
carx pse	2.0	1.8
drep sp.	2.0	1.8
eleo ros	2.0	1.8
eleo pau	2.0	1.8
eleo int	2.0	1.8
eleo obt	2.0	1.8
epil hir	2.0	1.8
frax pen	2.0	1.8
gera pur	2.0	1.8
junc nod	2.0	1.8
junc dud	2.0	1.8
junc alp	2.0	1.8
lobe kal	2.0	1.8
lobe dor	2.0	1.8
lycp uni	2.0	1.8
ment arv	2.0	1.8
muhl glo	2.0	1.8
nuph mic	2.0	1.8
pile pum	2.0	1.8
poly hyd	2.0	1.8
popu del	2.0	1.8
pota pus	2.0	1.8
pote nor	2.0	1.8
ricc flu	2.0	1.8
rosa pal	2.0	1.8
rume orb	2.0	1.8
sagi mon	2.0	1.8
salx gla	2.0	1.8
salx can	2.0	1.8
salx beb	2.0	1.8
salx dis	2.0	1.8
scut gal	2.0	1.8
spir alb	2.0	1.8
vacc mac	2.0	1.8
verb has	2.0	1.8
vibu len	2.0	1.8
alnu rug	3.0	2.7
ceph occ	3.0	2.7
eleo ery	3.0	2.7
eupa mac	3.0	2.7

Species	#	%
gali tri	3.0	2.7
hipp vul	3.0	2.7
isoe sp.	3.0	2.7
junc bal	3.0	2.7
lysi thy	3.0	2.7
myri alt	3.0	2.7
pota pra	3.0	2.7
pota epi	3.0	2.7
pota str	3.0	2.7
pota fol	3.0	2.7
pote ans	3.0	2.7
ranu sce	3.0	2.7
ricc nat	3.0	2.7
sagi cun	3.0	2.7
spar ame	3.0	2.7
tria fra	3.0	2.7
trig mar	3.0	2.7
urti dio	3.0	2.7
utri cor	3.0	2.7
wolf pun	3.0	2.7
algae sp	4.0	3.6
camp apa	4.0	3.6
cype str	4.0	3.6
myri ten	4.0	3.6
phal aru	4.0	3.6
poly pun	4.0	3.6
poly per	4.0	3.6
pota nod	4.0	3.6
rume mar	4.0	3.6
thel pal	4.0	3.6
acor cal	5.0	4.5
carx str	5.0	4.5
carx com	5.0	4.5
carx hys	5.0	4.5
deco ver	5.0	4.5
junc bre	5.0	4.5
junc pel	5.0	4.5
lyth sal	5.0	4.5
sium sua	5.0	4.5
spar flu	5.0	4.5
wolf col	5.0	4.5
bras sch	6.0	5.4
carx vir	6.0	5.4
carx aqu	6.0	5.4
carx lac	6.0	5.4
duli aru	6.0	5.4
eupa per	6.0	5.4
pelt vir	6.0	5.4
scir cyp	6.0	5.4
alis pla	7.0	6.3

Species	#	%	
carx las	7.0	6.3	
eleo aci	7.0	6.3	
impa cap	7.0	6.3	
pota amp	7.0	6.3	
scir flu	7.0	6.3	
junc can	8.0	7.2	
myri ver	8.0	7.2	
phra aus	8.0	7.2	
ranu lon	8.0	7.2	
cala can	9.0	8.1	
myrc gal	9.0	8.1	
lycp ame	10.0	9.0	
sagi gra	10.0	9.0	
nite fle	11.0	9.9	5
poly lap	11.0	9.9	6
pota cri	11.0	9.9	[illegible]
pota ber	11.0	9.9	4
sagi rig	11.0	9.9	6
cicu bul	12.0	10.8	5
mega bec	12.0	10.8	10
pota fri	12.0	10.8	6
pota rob	12.0	10.8	10
pote pal	12.0	10.8	7
rori pal	12.0	10.8	1
bide cer	13.0	11.7	3
leer ory	13.0	11.7	3
spar chl	13.0	11.7	6
utri int	13.0	11.7	10
nuph adv	14.0	12.6	8
pota obt	14.0	12.6	10
myri het	15.0	13.5	6
typh gla	15.0	13.5	*
pota ill	16.0	14.4	5
lemn tri	18.0	16.2	6
myri spi	18.0	16.2	*
ziza aqu	19.0	17.1	9
lemn min	21.0	18.9	5
scir sub	21.0	18.9	8
equi flu	23.0	20.7	7
hete dub	23.0	20.7	6
sprd pol	25.0	22.5	6
typh lat	25.0	22.5	1
pota pec	26.0	23.4	3
scir ame	26.0	23.4	5
typh ang	28.0	25.2	*
spar eur	29.0	26.1	5
poly amp	30.0	27.0	6
pota nat	30.0	27.0	5
myri exa	31.0	27.9	10
scir val	31.0	27.9	4

Species	#	%	
char sp.	33.0	29.7	
nuph var	34.0	30.6	7
pota zos	34.0	30.6	5
pota ric	35.0	31.5	5
pont cor	40.0	36.0	
pota gra	40.0	36.0	5
sagi lat	41.0	36.9	1
vall ame	41.0	36.9	7
elod can	43.0	38.7	1
utri vul	43.0	38.7	6
cera dem	44.0	39.6	1
naja fle	44.0	39.6	5
eleo sma	48.0	43.2	5
nymp odo	49.0	44.1	6
scir acu	50.0	45.0	5

Appendix III-B
Frequency and Ubiquity of Species Occurring in Herbaceous Zones

Species	#	%
abie bal	1.0	0.9
abut the	1.0	0.9
acer sac	1.0	0.9
agro gig	1.0	0.9
agro par	1.0	0.9
agro sto	1.0	0.9
andr gra	1.0	0.9
apoc can	1.0	0.9
apoc and	1.0	0.9
apoc sib	1.0	0.9
aste pta	1.0	0.9
aste nem	1.0	0.9
aste nov	1.0	0.9
astr bor	1.0	0.9
astr lan	1.0	0.9
athy fel	1.0	0.9
brom cil	1.0	0.9
cala ine	1.0	0.9
calt pal	1.0	0.9
card pen	1.0	0.9
carp car	1.0	0.9
carx ath	1.0	0.9
carx ten	1.0	0.9
carx con	1.0	0.9
carx pri	1.0	0.9
carx lur	1.0	0.9
carx bux	1.0	0.9
carx sco	1.0	0.9
carx cry	1.0	0.9
carx ebu	1.0	0.9
carx gyn	1.0	0.9
carx pau	1.0	0.9
carx pau	1.0	0.9
carx oli	1.0	0.9
carx lep	1.0	0.9
carx ova	1.0	0.9
cast coc	1.0	0.9
ceon ame	1.0	0.9
circ lut	1.0	0.9
cirs can	1.0	0.9
cirs pal	1.0	0.9
comm umb	1.0	0.9
conv arv	1.0	0.9
crat cru	1.0	0.9
cusc gro	1.0	0.9
cype dia	1.0	0.9

Species	#	%
cyst bul	1.0	0.9
drep sp.	1.0	0.9
dros ang	1.0	0.9
dros lin	1.0	0.9
dryo mar	1.0	0.9
elym vir	1.0	0.9
epil str	1.0	0.9
epil cil	1.0	0.9
equi hye	1.0	0.9
equi var	1.0	0.9
erio vir	1.0	0.9
erio ang	1.0	0.9
frax ame	1.0	0.9
gale tet	1.0	0.9
gali asp	1.0	0.9
geoc liv	1.0	0.9
geum mac	1.0	0.9
hama vir	1.0	0.9
hype vir	1.0	0.9
hype maj	1.0	0.9
junc buf	1.0	0.9
junc acu	1.0	0.9
kalm pol	1.0	0.9
liat spi	1.0	0.9
lind dub	1.0	0.9
lycp sp.	1.0	0.9
lyth ala	1.0	0.9
matr mat	1.0	0.9
medi sat	1.0	0.9
mona fis	1.0	0.9
muhl uni	1.0	0.9
myos lax	1.0	0.9
myos sco	1.0	0.9
myri ver	1.0	0.9
myri het	1.0	0.9
myri spi	1.0	0.9
oeno bie	1.0	0.9
orig vul	1.0	0.9
osmu cla	1.0	0.9
part qui	1.0	0.9
part ins	1.0	0.9
pent sed	1.0	0.9
phys vir	1.0	0.9
pice mar	1.0	0.9
pinu str	1.0	0.9
plan lan	1.0	0.9

Species	#	%
plat cla	1.0	0.9
poly vir	1.0	0.9
pota alp	1.0	0.9
pota spi	1.0	0.9
pter aqu	1.0	0.9
quer pal	1.0	0.9
quer vel	1.0	0.9
ranu lon	1.0	0.9
rham cat	1.0	0.9
rhyn fus	1.0	0.9
ribe ame	1.0	0.9
ribe cyn	1.0	0.9
rubu all	1.0	0.9
rubu fla	1.0	0.9
sagi mon	1.0	0.9
sagi cun	1.0	0.9
salx cor	1.0	0.9
salx fra	1.0	0.9
salx nig	1.0	0.9
salx gla	1.0	0.9
salx amy	1.0	0.9
salx myr	1.0	0.9
salx sp.	1.0	0.9
salx pyr	1.0	0.9
sass alb	1.0	0.9
sene pau	1.0	0.9
soli pat	1.0	0.9
soli hou	1.0	0.9
sonc arv	1.0	0.9
sprn cer	1.0	0.9
sprn rom	1.0	0.9
toxi rad	1.0	0.9
trif rep	1.0	0.9
typh gla	1.0	0.9
vall ame	1.0	0.9
vero off	1.0	0.9
vibu raf	1.0	0.9
wolf col	1.0	0.9
xant str	1.0	0.9
zann pal	1.0	0.9
zant ame	1.0	0.9
ziza var	1.0	0.9
ziza aqu	1.0	0.9
acer neg	2.0	1.8
agro rep	2.0	1.8
agro hye	2.0	1.8
alop aeq	2.0	1.8
apio ame	2.0	1.8
ascl syr	2.0	1.8
astr lon	2.0	1.8

Species	#	%
betu pop	2.0	1.8
buto umb	2.0	1.8
calo tub	2.0	1.8
carx pra	2.0	1.8
carx pcy	2.0	1.8
carx lan	2.0	1.8
carx cra	2.0	1.8
carx ret	2.0	1.8
carx cho	2.0	1.8
carx vul	2.0	1.8
carx cri	2.0	1.8
carx lup	2.0	1.8
chel gla	2.0	1.8
cicu mac	2.0	1.8
cirs vul	2.0	1.8
corn cor	2.0	1.8
corn dru	2.0	1.8
cype odo	2.0	1.8
dauc car	2.0	1.8
echi wal	2.0	1.8
eleo int	2.0	1.8
epil hir	2.0	1.8
erio sep	2.0	1.8
erio ten	2.0	1.8
gali bor	2.0	1.8
glyc bor	2.0	1.8
junc ten	2.0	1.8
junc bra	2.0	1.8
juni com	2.0	1.8
ledu gro	2.0	1.8
lemn tri	2.0	1.8
lysi num	2.0	1.8
lysi qua	2.0	1.8
ment pip	2.0	1.8
myri pen	2.0	1.8
nemo muc	2.0	1.8
pani vir	2.0	1.8
parn gla	2.0	1.8
phle pra	2.0	1.8
pile fon	2.0	1.8
poly sca	2.0	1.8
poly pen	2.0	1.8
prun vul	2.0	1.8
pycn vir	2.0	1.8
ranu his	2.0	1.8
rhyn cap	2.0	1.8
rume ver	2.0	1.8
rume cri	2.0	1.8
sagi rig	2.0	1.8
sela ecl	2.0	1.8

Species	#	%
soli ohi	2.0	1.8
soli alt	2.0	1.8
spar min	2.0	1.8
symp foe	2.0	1.8
tara off	2.0	1.8
tofi glu	2.0	1.8
wolf pun	2.0	1.8
agal pur	3.0	2.7
aron mel	3.0	2.7
aste umb	3.0	2.7
aste pun	3.0	2.7
aste jun	3.0	2.7
bide con	3.0	2.7
carx pse	3.0	2.7
carx fla	3.0	2.7
carx ves	3.0	2.7
carx exi	3.0	2.7
carx mic	3.0	2.7
cera dem	3.0	2.7
cirs arv	3.0	2.7
desc ces	3.0	2.7
eleo ros	3.0	2.7
equi pal	3.0	2.7
frag vir	3.0	2.7
frax nig	3.0	2.7
gali apa	3.0	2.7
ludw pal	3.0	2.7
muhl glo	3.0	2.7
myri exa	3.0	2.7
nuph adv	3.0	2.7
nuph var	3.0	2.7
osmu reg	3.0	2.7
pani col	3.0	2.7
pani imp	3.0	2.7
poacom	3.0	2.7
poly hyd	3.0	2.7
popu del	3.0	2.7
prim mis	3.0	2.7
quer bic	3.0	2.7
rhyn cpt	3.0	2.7
rubu pub	3.0	2.7
rudb hir	3.0	2.7
soli can	3.0	2.7
spar chl	3.0	2.7
spar pec	3.0	2.7
stac pal	3.0	2.7
thal das	3.0	2.7
trig pal	3.0	2.7
achi mil	4.0	3.6
andr gla	4.0	3.6

Species	#	%
betu pum	4.0	3.6
bide fro	4.0	3.6
call pal	4.0	3.6
char sp.	4.0	3.6
cirs mut	4.0	3.6
dros int	4.0	3.6
eleo pau	4.0	3.6
eleo obt	4.0	3.6
glyc str	4.0	3.6
hibi mos	4.0	3.6
ilex ver	4.0	3.6
lysi cil	4.0	3.6
mimu rin	4.0	3.6
pota ill	4.0	3.6
pota nat	4.0	3.6
ranu pen	4.0	3.6
rubu str	4.0	3.6
salx eri	4.0	3.6
sche pal	4.0	3.6
scir ces	4.0	3.6
sprd pol	4.0	3.6
betu pap	5.0	4.5
cala ark	5.0	4.5
ceph occ	5.0	4.5
cype str	5.0	4.5
eleo aci	5.0	4.5
elod can	5.0	4.5
hype kal	5.0	4.5
iris vir	5.0	4.5
junc nod	5.0	4.5
junc pel	5.0	4.5
pani lin	5.0	4.5
pota obt	5.0	4.5
salx luc	5.0	4.5
salx ser	5.0	4.5
salx beb	5.0	4.5
scut lat	5.0	4.5
utri min	5.0	4.5
vacc mac	5.0	4.5
vibu len	5.0	4.5
acer rub	6.0	5.5
carx dia	6.0	5.5
carx sti	6.0	5.5
dros rot	6.0	5.5
eleo ery	6.0	5.5
epil lep	6.0	5.5
pota gra	6.0	5.5
pros pal	6.0	5.5
rume mar	6.0	5.5
salx exi	6.0	5.5

Species	#	%
scir sub	6.0	5.5
tria vir	6.0	5.5
utri cor	6.0	5.5
vacc oxy	6.0	5.5
viol sp.	6.0	5.5
viti rip	6.0	5.5
acor cal	7.0	6.4
anem can	7.0	6.4
boeh cyl	7.0	6.4
carx int	7.0	6.4
corn foe	7.0	6.4
euth gra	7.0	6.4
junc eff	7.0	6.4
lari lar	7.0	6.4
pogo oph	7.0	6.4
popu tre	7.0	6.4
rhyn alb	7.0	6.4
sola dul	7.0	6.4
soli uli	7.0	6.4
carx lim	8.0	7.3
deco ver	8.0	7.3
gali pal	8.0	7.3
junc dud	8.0	7.3
junc bre	8.0	7.3
meny tri	8.0	7.3
pelt vir	8.0	7.3
popu bal	8.0	7.3
salx dis	8.0	7.3
scir atr	8.0	7.3
spha sp.	8.0	7.3
corn amo	9.0	8.2
eleo ell	9.0	8.2
glyc can	9.0	8.2
lobe kal	9.0	8.2
nymp odo	9.0	8.2
teuc can	9.0	8.2
carx hys	10.0	9.1
cham cal	10.0	9.1
epil col	10.0	9.1
equi arv	10.0	9.1
pile pum	10.0	9.1
poly pun	10.0	9.1
poly sag	10.0	9.1
thuj occ	10.0	9.1
trig mar	10.0	9.1
alis pla	11.0	10.0
carx com	11.0	10.0
lysi ter	11.0	10.0
pote nor	11.0	10.0
scir cyp	11.0	10.0

Species	#	%
urti dio	11.0	10.0
caly sep	12.0	10.9
duli aru	12.0	10.9
lemn min	12.0	10.9
poly per	12.0	10.9
rosa pal	12.0	10.9
sarr pur	12.0	10.9
tria fra	12.0	10.9
carx vir	13.0	11.8
pote fru	13.0	11.8
salx ped	13.0	11.8
scir flu	13.0	11.8
scir ame	13.0	11.8
ascl inc	14.0	12.7
iris ver	14.0	12.7
ment arv	14.0	12.7
carx ros	15.0	13.6
junc bal	15.0	13.6
ranu sce	15.0	13.6
salx can	15.0	13.6
rume orb	16.0	14.5
clad mar	17.0	15.5
eleo sma	17.0	15.5
frax pen	17.0	15.5
junc can	17.0	15.5
leer ory	17.0	15.5
onoc sen	17.0	15.5
poly lap	17.0	15.5
pont cor	17.0	15.5
utri vul	17.0	15.5
carx beb	18.0	16.4
lath pal	18.0	16.4
pote ans	18.0	16.4
sium sua	18.0	16.4
verb has	18.0	16.4
equi flu	20.0	18.2
lyth sal	20.0	18.2
bide cer	21.0	19.1
corn sto	21.0	19.1
phra aus	23.0	20.9
lycp uni	24.0	21.8
eupa mac	25.0	22.7
scir acu	26.0	23.6
thel pal	26.0	23.6
salx pet	28.0	25.5
myrc gal	30.0	27.3
scir val	30.0	27.3
eupa per	31.0	28.2
phal aru	31.0	28.2
lysi thy	32.0	29.1

Species	#	%
rori pal	32.0	29.1
utri int	32.0	29.1
carx las	34.0	30.9
lycp ame	35.0	31.8
spir alb	35.0	31.8
spar eur	36.0	32.7
alnu rug	37.0	33.6
gali tri	40.0	36.4
sagi lat	41.0	37.3
scut gal	43.0	39.1
carx aqu	44.0	40.0
cicu bul	46.0	41.8
pote pal	46.0	41.8
typh ang	46.0	41.8
typh lat	48.0	43.6
camp apa	52.0	47.3
carx lac	53.0	48.2
impa cap	53.0	48.2
poly amp	56.0	50.9
carx str	61.0	55.5
cala can	90.0	81.8

Appendix III-C
Frequency and Ubiquity of Species Occurring in Shrub Zones

Species	#	%	Species	#	%
acor cal	1.0	2.8	nuph adv	1.0	2.8
anem can	1.0	2.8	nuph var	1.0	2.8
apoc and	1.0	2.8	pani lin	1.0	2.8
aste jun	1.0	2.8	part qui	1.0	2.8
aste nem	1.0	2.8	poli jun	1.0	2.8
aula sub	1.0	2.8	poly pun	1.0	2.8
boeh cyl	1.0	2.8	popu del	1.0	2.8
caly sep	1.0	2.8	pota obt	1.0	2.8
carx con	1.0	2.8	pote ric	1.0	2.8
carx cri	1.0	2.8	prim mis	1.0	2.8
carx fla	1.0	2.8	pros pal	1.0	2.8
carx hys	1.0	2.8	pros rot	1.0	2.8
carx lep	1.0	2.8	rhyn fus	1.0	2.8
carx mic	1.0	2.8	rori pal	1.0	2.8
carx oli	1.0	2.8	rubu all	1.0	2.8
carx pau	1.0	2.8	rubu fla	1.0	2.8
carx ret	1.0	2.8	rubu his	1.0	2.8
carx sti	1.0	2.8	rubu str	1.0	2.8
carx vir	1.0	2.8	salx dis	1.0	2.8
cast coc	1.0	2.8	salx myr	1.0	2.8
cera dem	1.0	2.8	scir ame	1.0	2.8
char sp.	1.0	2.8	scir atr	1.0	2.8
cirs mut	1.0	2.8	scir sub	1.0	2.8
desc ces	1.0	2.8	sene pau	1.0	2.8
drep sp.	1.0	2.8	smil ste	1.0	2.8
dros ang	1.0	2.8	smil tri	1.0	2.8
dros lin	1.0	2.8	spar chl	1.0	2.8
dryo cri	1.0	2.8	spar flu	1.0	2.8
eleo ell	1.0	2.8	spir tom	1.0	2.8
elod can	1.0	2.8	sprd pol	1.0	2.8
epil cil	1.0	2.8	teuc can	1.0	2.8
epil col	1.0	2.8	toxi rad	1.0	2.8
erio sep	1.0	2.8	vero off	1.0	2.8
erio ten	1.0	2.8	viol sp.	1.0	2.8
frax nig	1.0	2.8	xyri mon	1.0	2.8
geum can	1.0	2.8	abie bal	2.0	5.6
hype kal	1.0	2.8	acer rub	2.0	5.6
junc can	1.0	2.8	ascl inc	2.0	5.6
junc nod	1.0	2.8	bide cer	2.0	5.6
junc ten	1.0	2.8	bide con	2.0	5.6
lobe kal	1.0	2.8	call pal	2.0	5.6
loni obl	1.0	2.8	carx bux	2.0	5.6
mela lin	1.0	2.8	carx cho	2.0	5.6
ment tri	1.0	2.8	carx com	2.0	5.6
muhl glo	1.0	2.8	carx ebu	2.0	5.6
myri pen	1.0	2.8	carx exi	2.0	5.6

Species	#	%
carx liv	2.0	5.6
carx pau	2.0	5.6
carx tri	2.0	5.6
carx ves	2.0	5.6
corn amo	2.0	5.6
cusc gro	2.0	5.6
equi arv	2.0	5.6
erio spi	2.0	5.6
eupa mac	2.0	5.6
junc pel	2.0	5.6
phra aus	2.0	5.6
pice gla	2.0	5.6
pice mar	2.0	5.6
pile fon	2.0	5.6
pile pum	2.0	5.6
pinu str	2.0	5.6
plat cla	2.0	5.6
pont cor	2.0	5.6
pote ans	2.0	5.6
pote nor	2.0	5.6
salx luc	2.0	5.6
salx ser	2.0	5.6
scir ces	2.0	5.6
spar eur	2.0	5.6
vacc ang	2.0	5.6
vibu rec	2.0	5.6
betu pap	3.0	8.3
carx ros	3.0	8.3
ceph occ	3.0	8.3
corn can	3.0	8.3
duli aru	3.0	8.3
eleo sma	3.0	8.3
equi pal	3.0	8.3
erio vir	3.0	8.3
glyc can	3.0	8.3
kalm pol	3.0	8.3
leer ory	3.0	8.3
lyth sal	3.0	8.3
pote fru	3.0	8.3
salx beb	3.0	8.3
salx pyr	3.0	8.3
scir acu	3.0	8.3
scir cyp	3.0	8.3
sium sua	3.0	8.3
trig mar	3.0	8.3
typh ang	3.0	8.3
utri cor	3.0	8.3
viti rip	3.0	8.3
aron mel	4.0	11.1
bide fro	4.0	11.1

Species	#	%
dros int	4.0	11.1
gali pal	4.0	11.1
ilex ver	4.0	11.1
junc bal	4.0	11.1
ledu gro	4.0	11.1
ment arv	4.0	11.1
rume orb	4.0	11.1
salx can	4.0	11.1
sche pal	4.0	11.1
typh gla	4.0	11.1
betu pum	5.0	13.9
carx int	5.0	13.9
deco ver	5.0	13.9
frax pen	5.0	13.9
gali tri	5.0	13.9
lemn min	5.0	13.9
nemo muc	5.0	13.9
phal aru	5.0	13.9
poly amp	5.0	13.9
soli uli	5.0	13.9
thuj occ	5.0	13.9
tria vir	5.0	13.9
urti dio	5.0	13.9
carx lim	6.0	16.7
eupa per	6.0	16.7
iris ver	6.0	16.7
pelt vir	6.0	16.7
sola dul	6.0	16.7
utri vul	6.0	16.7
vacc oxy	6.0	16.7
equi flu	7.0	19.4
lycp uni	7.0	19.4
onoc sen	7.0	19.4
osmu reg	7.0	19.4
pogo oph	7.0	19.4
rhyn alb	7.0	19.4
sagi lat	7.0	19.4
salx pet	7.0	19.4
scut gal	7.0	19.4
carx aqu	8.0	22.2
dros rot	8.0	22.2
tria fra	8.0	22.2
vacc mac	8.0	22.2
cicu bul	9.0	25.0
corn sto	9.0	25.0
lysi ter	9.0	25.0
clad mar	10.0	27.8
meny tri	10.0	27.8
salx ped	10.0	27.8
thel pal	10.0	27.8

Species	#	%
typh lat	10.0	27.8
andr gla	11.0	30.6
lycp ame	11.0	30.6
lysi thy	11.0	30.6
rosa pal	11.0	30.6
sarr pur	11.0	30.6
spir alb	11.0	30.6
carx lac	12.0	33.3
impa cap	12.0	33.3
lari lar	12.0	33.3
spha sp.	12.0	33.3
cham cal	13.0	36.1
camp apa	15.0	41.7
carx las	15.0	41.7
carx str	15.0	41.7
utri int	15.0	41.7
pote pal	19.0	52.8
cala can	20.0	55.6
myrc gal	22.0	61.1
alnu rug	29.0	80.6

APPENDIX IV

TWINSPAN Ordination of Emergent Zones

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EMERGENT ZONES:  Aquatic species in 3 or more transects

 NUMBER OF SAMPLES    111
 NUMBER OF SPECIES     88

 LENGTH OF RAW DATA ARRAY  2997


 SPECIES NAMES
    1 acor  cal!   2 algae  sp!   3 alis  pla!   4 bras  sch!   5 carx  com!   6 carx  hys!   7 carx  lac!   8 carx  las
    9 cera  dem!  10 char  sp.!  11 deco  ver!  12 duli  aru!  13 eleo  ery!  14 eleo  sma!  15 elod  can!  16 equi  flu
   17 hete  dub!  18 hipp  vul!  19 isoe  sp.!  20 junc  bal!  21 junc  bre!  22 junc  can!  23 junc  pel!  24 leer  ory
   25 lemn  min!  26 lemn  tri!  27 mega  bec!  28 myri  alt!  29 myri  exa!  30 myri  het!  31 myri  spi!  32 myri  ten
   33 myri  ver!  34 naja  fle!  35 nite  fle!  36 nuph  adv!  37 nuph  var!  38 nymp  odo!  39 pelt  vir!  40 phra  aus
   41 poly  amp!  42 pont  cor!  43 pota  amp!  44 pota  ber!  45 pota  cri!  46 pota  epi!  47 pota  fol!  48 pota  fri
   49 pota  gra!  50 pota  ill!  51 pota  nat!  52 pota  nod!  53 pota  obt!  54 pota  pec!  55 pota  pra!  56 pota  ric
   57 pota  rob!  58 pota  str!  59 pota  zos!  60 pote  pal!  61 ranu  lon!  62 ricc  nat!  63 sagi  cun!  64 sagi  gra
   65 sagi  lat!  66 sagi  rig!  67 scir  acu!  68 scir  ame!  69 scir  cyp!  70 scir  flu!  71 scir  sub!  72 scir  val
   73 sium  sua!  74 spar  ame!  75 spar  chl!  76 spar  eur!  77 spar  flu!  78 sprd  pol!  79 typh  ang!  80 typh  gla
   81 typh  lat!  82 utri  cor!  83 utri  int!  84 utri  vul!  85 vall  ame!  86 wolf  col!  87 wolf  pun!  88 ziza  agu


 SAMPLE-UNIT NAMES
    1 AUTRAIN  !   2 BAIEDEWA !   3 BAIEDEWC !   4 BARLAKE  !   5 BETSIE   !   6 BIGSABLE !   7 BIGSHOAL !   8 CARPPINE
    9 CHEBOYGA !  10 CHEBOYGC !  11 CHURCH_A !  12 CHURCH_B !  13 CLINTON  !  14 CORYEON  !  15 DUCKBAY  !  16 ELCAJON
   17 EPOUFE   !  18 ERIEBAY  !  19 FALSE_PR !  20 FISHDAM  !  21 GALIEN   !  22 GOGOMAIA !  23 GOGOMAID !  24 GRAND
   25 HARDWOOD !  26 HOGISND  !  27 HURSLEYA !  28 HURSLEYB !  29 INDIAN_B !  30 KALAMAZA !  31 KALAMAZD !  32 KEMPS_PT
   33 KENYON   !  34 LACLABEL !  35 MACKINAC !  36 MISMER   !  37 MUNUSCON !  38 MUSKEGON !  39 PECKBAY  !  40 PENTWATR
   41 PINCONA  !  42 PINCONB  !  43 PINE_RIV !  44 POTAWATT !  45 PTMOULLE !  46 ROACH    !  47 SAGANING !  48 SANDISND
   49 SCOTT    !  50 SHINGLEB !  51 SHINGLEC !  52 S.LLOYD  !  53 SQUAW    !  54 STCLAIR  !  55 STMARTIN !  56 STURGEON
   57 SUGAR_A  !  58 SUGAR_B  !  59 SWANCR   !  60 TOBICO   !  61 VOIGHT   !  62 WAUGOSHA !  63 WHIPPLEA !  64 WHIPPLEB
   65 WHISKEY  !  66 WHITEB   !  67 WIGWAM   !  68 WILDFBAY !  69 WILDISA  !  70 WILDISB  !  71 WILDISE  !  72 FONDULA
   73 FONDULB  !  74 POKEGAMA !  75 POKEGAMB !  76 BARNETT  !  77 BLACKB   !  78 CHIPPEWA !  79 CHIPPEWB !  80 S.COLWEL
   81 CRANBERR !  82 CROOKEDA !  83 CROOKEDC !  84 DEERCR_B !  85 DELANEY  !  86 DEXTER   !  87 EASTBAY  !  88 FLYNNC
   89 LAKEVIEW !  90 STERLING !  91 HURON    !  92 OLDWOMAN !  93 PRESQUE  !  94 THOMPSON !  95 BADRIVA  !  96 BADRIVB
   97 BADRIVM  !  98 BARKBAYA !  99 DEADHORS ! 100 HONJOHNA ! 101 KAKAGON  ! 102 LITTLE   ! 103 LONGISND ! 104 MINKA
  105 MINKB    ! 106 MUDLAKE  ! 107 OCONTO   ! 108 PESHTIGO ! 109 RASPBERR ! 110 SISKEWIT ! 111 STOCKTON !

 CUT LEVELS:       0.00   10.00   20.00   40.00   60.00

  MAXIMUM NUMBER OF PSEUDOSPECIES POSSIBLE:    2562
  LENGTH OF DATA ARRAY AFTER DEFINING PSEUDOSPECIES:    2149
  TOTAL NUMBER OF PSEUDOSPECIES AND SPECIES:    222
  NUMBER OF SPECIES (EXCLUDING NO OCCURANCES):     88

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     DIVISION    1  (N= 111)    I.E. GROUP *

  EIGENVALUE 0.433  AT ITERATION   2

  INDICATORS, TOGETHER WITH THEIR SIGN
  cera  dem1(+)   sprd  poll(+)   cera  dem2(+)   scir  acu1(-)   eleo  smal(-)   lemn  tri1(+)

  MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    2

  ITEMS IN NEGATIVE GROUP   2  (N=   75)          I.E. GROUP *0
  AUTRAIN   BAIEDEWA  BAIEDEWC  BARLAKE   BIGSABLE  BIGSHOAL  CARPPINE  CHEBOYGA  CHEBOYGC  CHURCH_A  CHURCH_B  CORYEON
  DUCKBAY   ELCAJON   EPOUFE    FALSE_PR  FISHDAM   GOGOMAIA  GOGOMAID  GRAND     HARDWOOD  HOGISND   HURSLEYA  HURSLEYB
  INDIAN_B  KEMPS_PT  KENYON    LACLABEL  MACKINAC  MISMER    MUNUSCON  PECKBAY   PINCONA   PINCONB   PINE_RIV  PTMOULLE
  ROACH     SAGANING  SANDISND  SCOTT     SHINGLEB  SHINGLEC  SQUAW     STCLAIR   STMARTIN  STURGEON  SUGAR_A   SUGAR_B
  SWANCR    TOBICO    VOIGHT    WAUGOSHA  WHIPPLEA  WHIPPLEB  WHISKEY   WIGWAM    WILDISA   WILDISB   WILDISE   FONDULA
  FONDULB   POKEGAMA  THOMPSON  BADRIVB   BADRIVM   BARKBAYA  HONJOHNA  KAKAGON   LONGISND  MINKA     MINKB     MUDLAKE
  RASPBERR  SISKEWIT  STOCKTON

  BORDERLINE NEGATIVES      (N=    5)
  PINCONA   PTMOULLE  SWANCR    WIGWAM    THOMPSON

  MISCLASSIFIED NEGATIVES (N=    1)
  POKEGAMA

  ITEMS IN POSITIVE GROUP   3  (N=   36)          I.E. GROUP *1
  BETSIE    CLINTON   ERIEBAY   GALIEN    KALAMAZA  KALAMAZD  MUSKEGON  PENTWATR  POTAWATT  S.LLOYD   WHITEB    WILDFBAY
  POKEGAMB  BARNETT   BLACKB    CHIPPEWA  CHIPPEWB  S.COLWEL  CRANBERR  CROOKEDA  CROOKEDC  DEERCR_B  DELANEY   DEXTER
  EASTBAY   FLYNNC    LAKEVIEW  STERLING  HURON     OLDWOMAN  PRESQUE   BADRIVA   DEADHORS  LITTLE    OCONTO    PESHTIGO

  BORDERLINE POSITIVES      (N=    1)
  POKEGAMB

  MISCLASSIFIED POSITIVES (N=    9)
  BETSIE    ERIEBAY   GALIEN    POTAWATT  WILDFBAY  DEERCR_B  HURON     OLDWOMAN  PESHTIGO

  NEGATIVE PREFERENTIALS
  char  sp.1( 28,  5) eleo  smal( 41,  6) equi  flu1( 23,  0) nuph  var1( 28,  6) pota  gra1( 37,  3) pota  ill1( 16,  0)
  pota  nat1( 25,  5) pota  ric1( 31,  4) scir  acu1( 45,  4) scir  ame1( 25,  1) scir  sub1( 20,  1) typh  lat1( 22,  3)
  scir  acu2( 25,  0)

  POSITIVE PREFERENTIALS
  cera  dem1( 15, 29) lemn  min1(  7, 14) lemn  tri1(  1, 17) myri  spi1(  7, 11) nuph  adv1(  0, 14) nymp  odo1( 24, 25)
  pota  cri1(  2,  9) spar  eur1( 14, 15) sprd  pol1(  2, 23) cera  dem2(  2, 21) elod  can2(  7, 14) lemn  min2(  0,  8)
  lemn  tri2(  0, 14) myri  exa2(  3,  8) nuph  adv2(  0,  9) nymp  odo2(  2, 14) pota  zos2(  1,  8) sprd  pol2(  0, 12)
  utri  vul2(  5, 10) vall  ame2(  6,  9) cera  dem3(  0, 16) nymp  odo3(  0,  9) sprd  pol3(  0, 10) utri  vul3(  1,  8)
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NON-PREFERENTIALS
elod  canl( 25, 18) hete  dubl( 12, 11) myri  exal( 18, 13) naja  flel( 35,  9) poly  ampl( 24,  6) pont  corl( 29, 11)
pota  pecl( 14, 12) pota  zosl( 19, 15) sagi  latl( 28, 13) scir  vall( 17, 14) typh  angl( 19,  9) utri  vull( 30, 13)
vall  amel( 28, 12) ziza  aqul( 10,  9)

 END OF LEVEL   1

************************************************************************************************************************
     DIVISION    2  (N=  75)    I.E. GROUP *0

EIGENVALUE 0.326  AT ITERATION   3

INDICATORS, TOGETHER WITH THEIR SIGN
eleo  smal(+)   char  sp.1(-)   char  sp.2(-)   char  sp.3(-)   pota  ricl(+)   utri  vull(+)

MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP   4  (N=   14)         I.E. GROUP *00
ELCAJON   EPOUFE    FALSE_PR  INDIAN_B  KENYON    PECKBAY   PINCONA   PINCONB   SAGANING  VOIGHT    WAUGOSHA  WHISKEY
WILDISA   MUDLAKE

BORDERLINE NEGATIVES    (N=    4)
KENYON    SAGANING  WAUGOSHA  MUDLAKE

MISCLASSIFIED NEGATIVES (N=    2)
INDIAN_B  PINCONA

ITEMS IN POSITIVE GROUP   5  (N=   61)         I.E. GROUP *01
AUTRAIN   BAIEDEWA  BAIEDEWC  BARLAKE   BIGSABLE  BIGSHOAL  CARPPINE  CHEBOYGA  CHEBOYGC  CHURCH_A  CHURCH_B  CORYEON
DUCKBAY   FISHDAM   GOGOMAIA  GOGOMAID  GRAND     HARDWOOD  HOGISND   HURSLEYA  HURSLEYB  KEMPS_PT  LACLABEL  MACKINAC
MISMER    MUNUSCON  PINE_RIV  PTMOULLE  ROACH     SANDISND  SCOTT     SHINGLEB  SHINGLEC  SQUAW_    STCLAIR   STMARTIN
STURGEON  SUGAR_A   SUGAR_B   SWANCR    TOBICO    WHIPPLEA  WHIPPLEB  WIGWAM    WILDISB   WILDISE   FONDULA   FONDULB
POKEGAMA  THOMPSON  BADRIVB   BADRIVM   BARKBAYA  HONJOHNA  KAKAGON   LONGISND  MINKA     MINKB     RASPBERR  SISKEWIT
STOCKTON

BORDERLINE POSITIVES    (N=    2)
CHEBOYGC  HOGISND

MISCLASSIFIED POSITIVES (N=    1)
SHINGLEC

NEGATIVE PREFERENTIALS
char  sp.1( 12, 16) junc  canl(  3,  5) char  sp.2(  9,  4) char  sp.3(  6,  1)
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POSITIVE PREFERENTIALS
cera  dem1(  0, 15) eleo  sma1(  1, 40) elod  can1(  0, 25) equi  flu1(  0, 23) myri  exa1(  1, 17) myri  het1(  0, 15)
naja  fle1(  3, 32) nymp  odo1(  1, 23) pont  cor1(  1, 28) pota  gra1(  1, 36) pota  ill1(  0, 16) pota  nat1(  2, 23)
pota  pec1(  1, 13) pota  ric1(  1, 30) pota  zos1(  0, 19) sagi  lat1(  1, 27) scir  sub1(  0, 20) spar  eur1(  1, 13)
typh  ang1(  0, 19) typh  lat1(  0, 22) utri  vul1(  1, 29) eleo  sma2(  0, 15)

NON-PREFERENTIALS
nuph  var1(  3, 25) poly  amp1(  4, 20) scir  acu1(  5, 40) scir  ame1(  7, 18) scir  val1(  4, 13) vall  ame1(  3, 25)
scir  acu2(  3, 22)


**************************************************************************************************************************
      DIVISION    3  (N=  36)    I.E. GROUP *1

EIGENVALUE 0.441  AT ITERATION   2

INDICATORS, TOGETHER WITH THEIR SIGN
cera  dem2(-)   elod  can1(-)

MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP   6  (N=   25)          I.E. GROUP *10
BETSIE    CLINTON   PENTWATR  WHITEB    POKEGAMB  BARNETT   BLACKB    CHIPPEWA  CHIPPEWB  S.COLWEL  CRANBERR  CROOKEDA
CROOKEDC  DELANEY   DEXTER    EASTBAY   FLYNNC    LAKEVIEW  STERLING  PRESQUE   BADRIVA   DEADHORS  LITTLE    OCONTO
PESHTIGO

BORDERLINE NEGATIVES    (N=    2)
WHITEB    DEADHORS

ITEMS IN POSITIVE GROUP   7  (N=   11)          I.E. GROUP *11
ERIEBAY   GALIEN    KALAMAZA  KALAMAZD  MUSKEGON  POTAWATT  S.LLOYD   WILDFBAY  DEERCR_B  HURON     OLDWOMAN

BORDERLINE POSITIVES    (N=    1)
DEERCR_B

NEGATIVE PREFERENTIALS
cera  dem1( 25,  4) elod  can1( 18,  0) hete  dub1( 10,  1) lemn  tri1( 16,  1) myri  exa1( 13,  0) myri  spi1( 10,  1)
naja  fle1(  9,  0) nuph  var1(  6,  0) pota  cri1(  8,  1) pota  fri1(  7,  0) pota  pec1( 10,  2) pota  zos1( 15,  0)
utri  vul1( 12,  1) vall  ame1( 12,  0) ziza  aqu1(  8,  1) cera  dem2( 21,  0) elod  can2( 14,  0) lemn  tri2( 13,  1)
myri  exa2(  8,  0) pota  zos2(  8,  0) utri  vul2(  9,  1) vall  ame2(  9,  0) cera  dem3( 16,  0) lemn  tri3(  6,  1)
pota  zos3(  6,  0) utri  vul3(  7,  1)

POSITIVE PREFERENTIALS
deco  ver1(  0,  3) leer  ory1(  1,  5) nuph  adv1(  7,  7) pelt  vir1(  0,  6) pont  cor1(  5,  6) wolf  col1(  2,  3)
lemn  min2(  3,  5) nuph  adv2(  4,  5) pelt  vir2(  0,  6) scir  val2(  1,  3) wolf  col2(  1,  3) nuph  adv3(  1,  4)
pelt  vir3(  0,  4) pelt  vir4(  0,  3) sprd  pol4(  0,  3)
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NON-PREFERENTIALS
lemn  minl(  8,  6) nymp  odo1( 19,  6) sagi  lat1( 10,  3) scir  val1(  8,  6) spar  eur1( 10,  5) sprd  pol1( 16,  7)
typh  ang1(  7,  2) nymp  odo2( 11,  3) sprd  pol2(  8,  4) nymp  odo3(  7,  2) sprd  pol3(  6,  4)

  END OF LEVEL   2

*******************************************************************************************************************
     DIVISION    4  (N=  14)    I.E. GROUP *00

EIGENVALUE 0.601  AT ITERATION   3

INDICATORS, TOGETHER WITH THEIR SIGN
scir  ame2(-)

MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP   8  (N=    2)         I.E. GROUP *000
INDIAN_B  PINCONB

ITEMS IN POSITIVE GROUP   9  (N=   12)         I.E. GROUP *001
ELCAJON   EPOUFE    FALSE_PR  KENYON    PECKBAY   PINCONA   SAGANING  VOIGHT    WAUGOSHA  WHISKEY   WILDISA   MUDLAKE

NEGATIVE PREFERENTIALS
myri  spi1(  1,  1) scir  ame1(  2,  5) scir  ame2(  2,  0) scir  ame3(  2,  0)

POSITIVE PREFERENTIALS
junc  can1(  0,  3) naja  fle1(  0,  3) nuph  var1(  0,  3) poly  amp1(  0,  4) scir  acu1(  0,  5) scir  val1(  0,  4)
vall  ame1(  0,  3) char  sp.2(  0,  9) scir  acu2(  0,  3) char  sp.3(  0,  6)

NON-PREFERENTIALS
char  sp.1(  1, 11)

*******************************************************************************************************************
     DIVISION    5  (N=  61)    I.E. GROUP *01

EIGENVALUE 0.284  AT ITERATION   3

INDICATORS, TOGETHER WITH THEIR SIGN
spar  flu1(-)   eleo  sma1(+)   scir  acu1(+)   pota  gra1(+)   naja  fle1(+)   myri  het2(-)

MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  10  (N=    4)         I.E. GROUP *010
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LACLABEL  BARKBAYA  RASPBERR  SISKEWIT

ITEMS IN POSITIVE GROUP  11  (N=   57)          I.E. GROUP *011
AUTRAIN   BAIEDEWA  BAIEDEWC  BARLAKE   BIGSABLE  BIGSHOAL  CARPPINE  CHEBOYGA  CHEBOYGC  CHURCH_A  CHURCH_B  CORYEON
DUCKBAY   FISHDAM   GOGOMAIA  GOGOMAID  GRAND     HARDWOOD  HOGISND   HURSLEYA  HURSLEYB  KEMPS_PT  MACKINAC  MISMER
MUNUSCON  PINE_RIV  PTMOULLE  ROACH     SANDISND  SCOTT     SHINGLEB  SHINGLEC  SQUAW     STCLAIR   STMARTIN  STURGEON
SUGAR_A   SUGAR_B   SWANCR    TOBICO    WHIPPLEA  WHIPPLEB  WIGWAM    WILDISB   WILDISE   FONDULA   FONDULB   POKEGAMA
THOMPSON  BADRIVB   BADRIVM   HONJOHNA  KAKAGON   LONGISND  MINKA     MINKB     STOCKTON

BORDERLINE POSITIVES    (N=    2)
KAKAGON   MINKA

NEGATIVE PREFERENTIALS
duli  aru1(  2,   4) leer  ory1(  1,   5) mega  bec1(  2,   9) myri  het1(  2, 13) pota  amp1(  1,   4) pota  epi1(  1,  1)
sagi  gra1(  1,   6) sagi  rig1(  1,   5) spar  ame1(  1,   1) spar  eur1(  2, 11) spar  flu1(  3,   2) duli  aru2(  1,  0)
hete  dub2(  1,   3) mega  bec2(  1,   2) myri  het2(  2,   0) nuph  var2(  2,   3) pota  amp2(  1,   0) sagi  gra2(  1,  2)
sagi  rig2(  1,   0) spar  eur2(  1,   5) spar  flu2(  2,   1) hete  dub3(  1,   2) nuph  var3(  1,   2) sagi  rig3(  1,  0)
spar  eur3(  1,   2) spar  flu3(  1,   0)

POSITIVE PREFERENTIALS
char  sp.1(  0, 16) eleo  sma1(  0, 40) elod  can1(  0, 25) equi  flu1(  0, 23) naja  fle1(  0, 32) nymp  odo1(  0, 23)
poly  amp1(  0, 20) pont  cor1(  0, 28) pota  gra1(  0, 36) pota  ill1(  0, 16) pota  nat1(  0, 23) pota  obt1(  0, 12)
pota  pec1(  0, 13) pota  ric1(  1, 29) sagi  lat1(  0, 27) scir  acu1(  0, 40) scir  ame1(  0, 18) scir  vall(  0, 13)
typh  ang1(  0, 19) typh  lat1(  0, 22) vall  ame1(  0, 25) eleo  sma2(  0, 15) scir  acu2(  0, 22)

NON-PREFERENTIALS
cera  dem1(  1, 14) hete  dub1(  1, 10) myri  exa1(  2, 15) nuph  var1(  3, 22) pota  zos1(  1, 18) scir  sub1(  2, 18)
utri  vul1(  1, 28) ziza  aqu1(  1,   8)


*****************************************************************************************************************************
     DIVISION    6  (N=  25)    I.E. GROUP *10

EIGENVALUE 0.331  AT ITERATION   3
INDICATORS, TOGETHER WITH THEIR SIGN
spar  eur1(+)   lemn  tri1(-)   scir  vall(+)   sagi  lat1(+)   utri  vul1(-)   nymp  odo2(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    2

ITEMS IN NEGATIVE GROUP  12  (N=   19)          I.E. GROUP *100
CLINTON   WHITEB    BARNETT   BLACKB    CHIPPEWA  CHIPPEWB  S.COLWEL  CRANBERR  CROOKEDA  CROOKEDC  DELANEY   DEXTER
EASTBAY   FLYNNC    LAKEVIEW  STERLING  PRESQUE   BADRIVA   PESHTIGO

BORDERLINE NEGATIVES    (N=    1)
WHITEB

ITEMS IN POSITIVE GROUP  13  (N=    6)          I.E. GROUP *101
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BETSIE    PENTWATR POKEGAMB DEADHORS LITTLE   OCONTO

BORDERLINE POSITIVES    (N=    1)
OCONTO

NEGATIVE PREFERENTIALS
lemn  tri1( 16,  0) pota  fri1(  7,  0) pota  nat1(  5,  0) pota  zos1( 14,  1) sagi  rig1(  5,  0) utri  vul1( 11,  1)
ziza  aqu1(  7,  1) lemn  tri2( 13,  0) myri  exa2(  7,  1) myri  spi2(  4,  0) nuph  adv2(  4,  0) nymp  odo2( 11,  0)
pont  cor2(  4,  0) pota  zos2(  8,  0) sprd  pol2(  7,  1) utri  vul2(  9,  0) vall  ame2(  8,  1) ziza  aqu2(  4,  0)
lemn  tri3(  6,  0) nymp  odo3(  7,  0) pota  zos3(  6,  0) utri  vul3(  7,  0)

POSITIVE PREFERENTIALS
char  sp.1(  3,  2) lemn  min1(  3,  5) poly  amp1(  2,  2) pota  obt1(  0,  2) pota  pec1(  5,  5) pota  ric1(  2,  2)
pota  str1(  0,  2) ranu  lon1(  1,  2) sagi  lat1(  4,  6) scir  flu1(  0,  2) scir  val1(  3,  5) spar  eur1(  4,  6)
typh  ang1(  3,  4) typh  lat1(  0,  2) lemn  min2(  1,  2) sagi  lat2(  1,  3) spar  eur2(  1,  2) spar  eur3(  1,  2)

NON-PREFERENTIALS
cera  dem1( 19,  6) eleo  sma1(  4,  1) elod  can1( 15,  3) hete  dub1(  7,  3) myri  exa1( 10,  3) myri  spi1(  8,  2)
naja  fle1(  7,  2) nuph  adv1(  5,  2) nuph  var1(  4,  2) nymp  odo1( 16,  3) pont  cor1(  4,  1) pota  cri1(  6,  2)
sprd  pol1( 11,  5) vall  ame1( 10,  2) cera  dem2( 16,  5) elod  can2( 12,  2) cera  dem3( 12,  4) sprd  pol3(  5,  1)
cera  dem4(  4,  1)

**************************************************************************************************************************
      DIVISION    7  (N=  11)    I.E. GROUP *11

EIGENVALUE 0.554  AT ITERATION   3

INDICATORS, TOGETHER WITH THEIR SIGN
nite  fle1(+)

MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    0     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    1

ITEMS IN NEGATIVE GROUP  14  (N=   10)        I.E. GROUP *110
GALIEN   KALAMAZA  KALAMAZD  MUSKEGON  POTAWATT  S.LLOYD   WILDFBAY  DEERCR_B  HURON    OLDWOMAN

ITEMS IN POSITIVE GROUP  15  (N=    1)        I.E. GROUP *111
ERIEBAY

NEGATIVE PREFERENTIALS
cera  dem1(  4,  0) deco  ver1(  3,  0) lemn  min1(  6,  0) nuph  adv1(  7,  0) nymp  odo1(  6,  0) pelt  vir1(  6,  0)
pont  cor1(  6,  0) sagi  lat1(  3,  0) spar  eur1(  5,  0) sprd  pol1(  7,  0) wolf  col1(  3,  0) lemn  min2(  5,  0)
nuph  adv2(  5,  0) nymp  odo2(  3,  0) pelt  vir2(  6,  0) sprd  pol2(  4,  0) wolf  col2(  3,  0) nuph  adv3(  4,  0)
pelt  vir3(  4,  0) sprd  pol3(  4,  0) pelt  vir4(  3,  0) sprd  pol4(  3,  0)

POSITIVE PREFERENTIALS
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leer  ory1(  4,  1) nite  fle1(  0,  1) pota  pec1(  1,  1) scir  val1(  5,  1) leer  ory2(  1,  1) nite  fle2(  0,  1)
pota  pec2(  0,  1) scir  val2(  2,  1) nite  fle3(  0,  1) pota  pec3(  0,  1)

  END OF LEVEL   3

*************************************************************************************************************************
     DIVISION    8  (N=   2)    I.E. GROUP *000

     DIVISION FAILS - THERE ARE TOO FEW ITEMS

*************************************************************************************************************************
     DIVISION    9  (N=  12)    I.E. GROUP *001

EIGENVALUE 0.577  AT ITERATION   2

INDICATORS, TOGETHER WITH THEIR SIGN
scir  val1(-)   alis  pla1(-)   char  sp.3(+)

MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  18  (N=    3)         I.E. GROUP *0010
PINCONA   SAGANING  WHISKEY

ITEMS IN POSITIVE GROUP  19  (N=    9)         I.E. GROUP *0011
ELCAJON   EPOUFE    FALSE_PR  KENYON    PECKBAY   VOIGHT    WAUGOSHA  WILDISA   MUDLAKE

NEGATIVE PREFERENTIALS
alis  pla1(  2,  0) hete  dub1(  1,  0) leer  ory1(  1,  0) lemn  min1(  1,  0) myri  spi1(  1,  0) poly  amp1(  2,  2)
pont  cor1(  1,  0) pota  ric1(  1,  0) scir  ame1(  2,  3) scir  cyp1(  1,  0) scir  val1(  3,  1) spar  eur1(  1,  0)
typh  gla1(  1,  0) vall  ame1(  2,  1) typh  gla2(  1,  0)

POSITIVE PREFERENTIALS
nuph  var1(  0,  3) pota  nat1(  0,  2) sagi  gra1(  0,  2) scir  acu1(  0,  5) char  sp.2(  1,  8) scir  acu2(  0,  3)
char  sp.3(  0,  6)

NON-PREFERENTIALS
char  sp.1(  2,  9) junc  can1(  1,  2) naja  fle1(  1,  2)

*************************************************************************************************************************
     DIVISION   10  (N=   4)    I.E. GROUP *010

     DIVISION FAILS - THERE ARE TOO FEW ITEMS

*************************************************************************************************************************
     DIVISION   11  (N=  57)    I.E. GROUP *011
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EIGENVALUE 0.276  AT ITERATION   3
INDICATORS, TOGETHER WITH THEIR SIGN
pota  ricl(-)   pont  corl(-)   pota  gral(-)   elod  canl(-)   scir  vall(+)   vall  amel(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  22  (N=   46)         I.E. GROUP *0110
AUTRAIN   BAIEDEWA  BAIEDEWC  BARLAKE   BIGSHOAL  CARPPINE  CHEBOYGA  CHURCH_A  CHURCH_B  DUCKBAY   FISHDAM   GOGOMAIA
GOGOMAID  GRAND     HOGISND   HURSLEYA  HURSLEYB  KEMPS_PT  MACKINAC  MISMER    MUNUSCON  PINE_RIV  ROACH     SANDISND
SCOTT     SHINGLEB  SHINGLEC  SQUAW     STCLAIR   STMARTIN  STURGEON  SUGAR_A   SUGAR_B   WHIPPLEA  WHIPPLEB  WIGWAM
WILDISB   WILDISE   THOMPSON  BADRIVM   HONJOHNA  KAKAGON   LONGISND  MINKA     MINKB     STOCKTON

BORDERLINE NEGATIVES     (N=    1)
BARLAKE

MISCLASSIFIED NEGATIVES (N=    2)
STMARTIN  LONGISND

ITEMS IN POSITIVE GROUP  23  (N=   11)         I.E. GROUP *0111
BIGSABLE  CHEBOYGC  CORYEON   HARDWOOD  PTMOULLE  SWANCR    TOBICO    FONDULA   FONDULB   POKEGAMA  BADRIVB

BORDERLINE POSITIVES     (N=    1)
CHEBOYGC

NEGATIVE PREFERENTIALS
char  sp.1( 15,  1) elod  canl( 25,  0) equi  flul( 21,  2) hete  dubl( 10,  0) myri  exal( 15,  0) myri  hetl( 12,  1)
nuph  varl( 21,  1) poly  ampl( 19,  1) pont  corl( 28,  0) pota  gral( 33,  3) pota  illl( 15,  1) pota  natl( 22,  1)
pota  obtl( 12,  0) pota  ricl( 29,  0) pota  robl( 11,  0) pota  zosl( 17,  1) scir  acul( 36,  4) scir  subl( 18,  0)
vall  amel( 24,  1) eleo  sma2( 14,  1) naja  fle2( 10,  0) scir  acu2( 21,  1)

POSITIVE PREFERENTIALS
alis  plal(  1,  3) carx  lacl(  3,  3) leer  oryl(  2,  3) pote  pall(  7,  4) sagi  gral(  3,  3) scir  vall(  6,  7)
spar  eurl(  6,  5) typh  angl( 12,  7) typh  glal(  5,  4) sagi  lat2(  2,  4)

NON-PREFERENTIALS
cera  deml( 10,  4) eleo  smal( 34,  6) naja  flel( 28,  4) nymp  odol( 20,  3) pota  pecl( 10,  3) sagi  latl( 20,  7)
scir  amel( 14,  4) typh  latl( 17,  5) utri  vull( 24,  4)

********************************************************************************************************************
     DIVISION   12  (N=  19)    I.E. GROUP *100

EIGENVALUE 0.331  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
pota  fril(-)   myri  exal(-)   myri  exa2(-)   utri  vul3(-)   utri  vul2(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -2     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP   -1
```

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ITEMS IN NEGATIVE GROUP  24  (N=    11)          I.E. GROUP *1000
BARNETT   BLACKB    CHIPPEWA  CHIPPEWB  CRANBERR  CROOKEDA  CROOKEDC  DELANEY   DEXTER    FLYNNC    STERLING

BORDERLINE NEGATIVES     (N=    1)
BLACKB

ITEMS IN POSITIVE GROUP  25  (N=     8)          I.E. GROUP *1001
CLINTON   WHITEB    S.COLWEL  EASTBAY   LAKEVIEW  PRESQUE   BADRIVA   PESHTIGO

NEGATIVE PREFERENTIALS
char  sp.1(  3,   0) hete  dubl(  6,   1) myri  exal(  9,   1) nuph  varl(  4,   0) pota  berl(  3,   0) pota  cril(  5,   1)
pota  fril(  7,   0) pota  pecl(  4,   1) sagi  latl(  3,   1) typh  angl(  3,   0) vall  amel(  8,   2) myri  exa2(  7,   0)
pota  zos2(  6,   2) utri  vul2(  8,   1) vall  ame2(  6,   2) ziza  aqu2(  3,   1) lemn  tri3(  6,   0) pota  zos3(  5,   1)
utri  vul3(  7,   0)

POSITIVE PREFERENTIALS
algae  spl(  0,   3) bras  schl(  0,   2) myri  spil(  2,   6) nuph  advl(  1,   4) pont  corl(  0,   4) pota  natl(  2,   3)
sagi  rigl(  2,   3) scir  acul(  1,   2) scir  vall(  0,   3) typh  glal(  1,   2) algae  sp2(  0,   3) myri  spi2(  1,   3)
nuph  adv2(  0,   4) pont  cor2(  0,   4) elod  can3(  1,   2)

NON-PREFERENTIALS
cera  deml( 11,   8) eleo  smal(  2,   2) elod  canl(  8,   7) lemn  tril( 11,   5) naja  flel(  5,   2) nymp  odol(  9,   7)
pota  zosl( 10,   4) spar  eurl(  2,   2) sprd  poll(  7,   4) utri  vull(  8,   3) ziza  aqul(  5,   2) cera  dem2(  9,   7)
elod  can2(  5,   7) lemn  tri2(  9,   4) nymp  odo2(  6,   5) sprd  pol2(  5,   2) cera  dem3(  6,   6) nymp  odo3(  4,   3)
sprd  pol3(  3,   2) cera  dem4(  2,   2)


*****************************************************************************************************************************
    DIVISION   13  (N=    6)    I.E. GROUP *101

EIGENVALUE 0.515  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
lemn  minl(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  26  (N=     5)          I.E. GROUP *1010
BETSIE    PENTWATR  DEADHORS  LITTLE    OCONTO

ITEMS IN POSITIVE GROUP  27  (N=     1)          I.E. GROUP *1011
POKEGAMB

NEGATIVE PREFERENTIALS
char  sp.1(  2,   0) elod  canl(  3,   0) hete  dubl(  3,   0) lemn  minl(  5,   0) myri  exal(  3,   0) myri  spil(  2,   0)
naja  flel(  2,   0) nuph  advl(  2,   0) nuph  varl(  2,   0) nymp  odol(  3,   0) poly  ampl(  2,   0) pota  cril(  2,   0)
pota  obtl(  2,   0) pota  pecl(  5,   0) pota  strl(  2,   0) ranu  lonl(  2,   0) scir  flul(  2,   0) scir  vall(  5,   0)
```

```
typh  angl(  4,  0) vall  ame1(  2,  0) elod  can2(  2,  0) lemn  min2(  2,  0) cera  dem3(  4,  0)

POSITIVE PREFERENTIALS
pota  ric1(  1,  1) sagi  gra1(  0,  1) spar  ame1(  0,  1) typh  lat1(  1,  1) ziza  aqu1(  0,  1) sagi  gra2(  0,  1)
sagi  lat2(  2,  1) spar  ame2(  0,  1) spar  eur2(  1,  1) sagi  gra3(  0,  1) spar  eur3(  1,  1)

NON-PREFERENTIALS
cera  dem1(  5,  1) sagi  lat1(  5,  1) spar  eur1(  5,  1) sprd  pol1(  4,  1) cera  dem2(  4,  1)

************************************************************************************************************************
     DIVISION   14  (N=  10)    I.E. GROUP *110

EIGENVALUE 0.508  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
bras  sch1(+)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    0     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    1

ITEMS IN NEGATIVE GROUP  28  (N=    9)        I.E. GROUP *1100
GALIEN    KALAMAZA  KALAMAZD  MUSKEGON  POTAWATT  S.LLOYD   WILDFBAY  HURON     OLDWOMAN

ITEMS IN POSITIVE GROUP  29  (N=    1)        I.E. GROUP *1101
DEERCR_B

NEGATIVE PREFERENTIALS
cera  dem1(  4,  0) deco  ver1(  3,  0) eleo  ery1(  2,  0) leer  ory1(  4,  0) lemn  min1(  6,  0) pelt  vir1(  6,  0)
poly  amp1(  2,  0) sagi  lat1(  3,  0) scir  flu1(  2,  0) spar  eur1(  5,  0) sprd  pol1(  7,  0) typh  ang1(  2,  0)
typh  gla1(  2,  0) wolf  col1(  3,  0) wolf  pun1(  2,  0) lemn  min2(  5,  0) pelt  vir2(  6,  0) sprd  pol2(  4,  0)
wolf  col2(  3,  0) wolf  pun2(  2,  0) pelt  vir3(  4,  0) sprd  pol3(  4,  0) nuph  adv4(  2,  0) pelt  vir4(  3,  0)
sprd  pol4(  3,  0)

POSITIVE PREFERENTIALS
bras  sch1(  0,  1) pota  gra1(  0,  1) scir  sub1(  0,  1) scir  val1(  4,  1) utri  vul1(  0,  1) bras  sch2(  0,  1)
nuph  adv2(  4,  1) nymp  odo2(  2,  1) scir  sub2(  0,  1) scir  val2(  1,  1) utri  vul2(  0,  1) bras  sch3(  0,  1)
nuph  adv3(  3,  1) nymp  odo3(  1,  1) utri  vul3(  0,  1)

NON-PREFERENTIALS
nuph  adv1(  6,  1) nymp  odo1(  5,  1) pont  cor1(  5,  1)

THIS IS THE END OF THE DIVISIONS REQUESTED
************************************************************************************************************************
************************************************************************************************************************
     DIVISION    1  (N=  88)    I.E. GROUP *

EIGENVALUE 0.819  AT ITERATION   2

ITEMS IN NEGATIVE GROUP   2  (N=   51)        I.E. GROUP *0
```

```
 acor  cal  alis  pla  carx  hys  carx  lac  carx  las  char  sp.  duli  aru  eleo  sma  equi  flu  hete  dub  hipp  vul
 isoe  sp.  junc  bal  junc  bre  junc  can  junc  pel  mega  bec  myri  alt  myri  het  myri  ten  myri  ver  naja  fle
 nite  fle  nuph  var  phra  aus  poly  amp  pont  cor  pota  amp  pota  fol  pota  gra  pota  ill  pota  nat  pota  obt
 pota  pra  pota  ric  pota  rob  pote  pal  ricc  nat  sagi  gra  sagi  lat  scir  acu  scir  ame  scir  sub  spar  chl
 spar  flu  typh  ang  typh  gla  typh  lat  utri  cor  utri  int  vall  ame

ITEMS IN POSITIVE GROUP   3  (N=   37)        I.E. GROUP *1
 algae  sp  bras  sch  carx  com  cera  dem  deco  ver  eleo  ery  elod  can  leer  ory  lemn  min  lemn  tri  myri  exa
 myri  spi  nuph  adv  nymp  odo  pelt  vir  pota  ber  pota  cri  pota  epi  pota  fri  pota  nod  pota  pec  pota  str
 pota  zos  ranu  lon  sagi  cun  sagi  rig  scir  cyp  scir  flu  scir  val  sium  sua  spar  ame  spar  eur  sprd  pol
 utri  vul  wolf  col  wolf  pun  ziza  aqu

  END OF LEVEL   1

****************************************************************************************************
     DIVISION    2  (N=  51)    I.E. GROUP *0

EIGENVALUE 0.368  AT ITERATION   1

ITEMS IN NEGATIVE GROUP   4  (N=   37)        I.E. GROUP *00
 acor  cal  carx  hys  carx  lac  carx  las  char  sp.  duli  aru  eleo  sma  equi  flu  hipp  vul  isoe  sp.  junc  bal
 junc  bre  junc  can  junc  pel  mega  bec  myri  alt  myri  het  myri  ten  myri  ver  naja  fle  phra  aus  pota  amp
 pota  fol  pota  gra  pota  ill  pota  nat  pota  obt  pota  ric  pota  rob  pote  pal  ricc  nat  scir  acu  scir  ame
 scir  sub  spar  flu  typh  lat  utri  cor

ITEMS IN POSITIVE GROUP   5  (N=   14)        I.E. GROUP *01
 alis  pla  hete  dub  nite  fle  nuph  var  poly  amp  pont  cor  pota  pra  sagi  gra  sagi  lat  spar  chl  typh  ang
 typh  gla  utri  int  vall  ame
```

```
****************************************************************************************************
     DIVISION    3  (N=  37)    I.E. GROUP *1

EIGENVALUE 0.349  AT ITERATION   3

ITEMS IN NEGATIVE GROUP   6  (N=   13)        I.E. GROUP *10
 elod  can  myri  exa  pota  ber  pota  epi  pota  pec  ranu  lon  sagi  cun  sagi  rig  scir  cyp  spar  ame  spar  eur
 utri  vul  ziza  aqu

ITEMS IN POSITIVE GROUP   7  (N=   24)        I.E. GROUP *11
 algae  sp  bras  sch  carx  com  cera  dem  deco  ver  eleo  ery  leer  ory  lemn  min  lemn  tri  myri  spi  nuph  adv
 nymp  odo  pelt  vir  pota  cri  pota  fri  pota  nod  pota  str  pota  zos  scir  flu  scir  val  sium  sua  sprd  pol
 wolf  col  wolf  pun

  END OF LEVEL   2

****************************************************************************************************
     DIVISION    4  (N=  37)    I.E. GROUP *00

EIGENVALUE 0.156  AT ITERATION   2

ITEMS IN NEGATIVE GROUP   8  (N=   29)        I.E. GROUP *000
 carx  lac  carx  las  duli  aru  eleo  sma  equi  flu  hipp  vul  isoe  sp.  junc  bal  junc  bre  junc  pel  mega  bec
 myri  alt  myri  het  myri  ten  myri  ver  phra  aus  pota  fol  pota  gra  pota  ill  pota  obt  pota  ric  pota  rob
 pote  pal  ricc  nat  scir  acu  scir  sub  spar  flu  typh  lat  utri  cor

ITEMS IN POSITIVE GROUP   9  (N=    8)        I.E. GROUP *001
 acor  cal  carx  hys  char  sp.  junc  can  naja  fle  pota  amp  pota  nat  scir  ame

****************************************************************************************************
     DIVISION    5  (N=  14)    I.E. GROUP *01

EIGENVALUE 0.386  AT ITERATION   2

ITEMS IN NEGATIVE GROUP  10  (N=    5)        I.E. GROUP *010
 alis  pla  nuph  var  poly  amp  sagi  gra  typh  gla

ITEMS IN POSITIVE GROUP  11  (N=    9)        I.E. GROUP *011
 hete  dub  nite  fle  pont  cor  pota  pra  sagi  lat  spar  chl  typh  ang  utri  int  vall  ame
```

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*****************************************************************************************************
     DIVISION    6  (N=  13)    I.E. GROUP *10

EIGENVALUE 0.324  AT ITERATION   3

ITEMS IN NEGATIVE GROUP  12  (N=   11)          I.E. GROUP *100
 elod  can  myri  exa  pota  ber  pota  epi  ranu  lon  sagi  cun  sagi  rig  scir  cyp  spar  ame  utri  vul  ziza  aqu

ITEMS IN POSITIVE GROUP  13  (N=    2)          I.E. GROUP *101
 pota  pec  spar  eur

*****************************************************************************************************
     DIVISION    7  (N=  24)    I.E. GROUP *11

EIGENVALUE 0.317  AT ITERATION   2

ITEMS IN NEGATIVE GROUP  14  (N=   18)          I.E. GROUP *110
 algae  sp  bras  sch  carx  com  cera  dem  lemn  tri  myri  spi  nuph  adv  nymp  odo  pelt  vir  pota  cri  pota  fri
 pota  nod  pota  str  pota  zos  sium  sua  sprd  pol  wolf  col  wolf  pun

ITEMS IN POSITIVE GROUP  15  (N=    6)          I.E. GROUP *111
 deco  ver  eleo  ery  leer  ory  lemn  min  scir  flu  scir  val

  END OF LEVEL   3

*****************************************************************************************************
     DIVISION    8  (N=  29)    I.E. GROUP *000

EIGENVALUE 0.094  AT ITERATION   1

ITEMS IN NEGATIVE GROUP  16  (N=   22)          I.E. GROUP *0000
 carx  lac  carx  las  duli  aru  eleo  sma  equi  flu  hipp  vul  isoe  sp.  junc  bal  junc  bre  myri  alt  myri  het
 myri  ten  phra  aus  pota  fol  pota  gra  pota  ill  pote  pal  ricc  nat  scir  sub  spar  flu  typh  lat  utri  cor

ITEMS IN POSITIVE GROUP  17  (N=    7)          I.E. GROUP *0001
 junc  pel  mega  bec  myri  ver  pota  obt  pota  ric  pota  rob  scir  acu
```

```
**************************************************************************************************
     DIVISION    9  (N=    8)    I.E. GROUP *001

EIGENVALUE 0.338  AT ITERATION    1

ITEMS IN NEGATIVE GROUP  18  (N=    5)         I.E. GROUP *0010
 acor  cal  carx  hys  naja  fle  pota  amp  pota  nat

ITEMS IN POSITIVE GROUP  19  (N=    3)         I.E. GROUP *0011
 char  sp.  junc  can  scir  ame


**************************************************************************************************
     DIVISION   10  (N=    5)    I.E. GROUP *010

EIGENVALUE 0.190  AT ITERATION    1

ITEMS IN NEGATIVE GROUP  20  (N=    4)         I.E. GROUP *0100
 alis  pla  nuph  var  poly  amp  sagi  gra

ITEMS IN POSITIVE GROUP  21  (N=    1)         I.E. GROUP *0101
 typh  gla


**************************************************************************************************
     DIVISION   11  (N=    9)    I.E. GROUP *011

EIGENVALUE 0.281  AT ITERATION    1

ITEMS IN NEGATIVE GROUP  22  (N=    7)         I.E. GROUP *0110
 hete  dub  nite  fle  sagi  lat  spar  chl  typh  ang  utri  int  vall  ame

ITEMS IN POSITIVE GROUP  23  (N=    2)         I.E. GROUP *0111
 pont  cor  pota  pra


**************************************************************************************************
     DIVISION   12  (N=   11)    I.E. GROUP *100

EIGENVALUE 0.317  AT ITERATION    1

ITEMS IN NEGATIVE GROUP  24  (N=    4)         I.E. GROUP *1000
 pota  epi  ranu  lon  scir  cyp  utri  vul

ITEMS IN POSITIVE GROUP  25  (N=    7)         I.E. GROUP *1001
 elod  can  myri  exa  pota  ber  sagi  cun  sagi  rig  spar  ame  ziza  aqu
```

```
*****************************************************************************************************************
     DIVISION   13  (N=   2)    I.E. GROUP *101

     DIVISION FAILS - THERE ARE TOO FEW ITEMS

*****************************************************************************************************************
     DIVISION   14  (N=  18)    I.E. GROUP *110

EIGENVALUE 0.206  AT ITERATION   2

ITEMS IN NEGATIVE GROUP  28  (N=   12)          I.E. GROUP *1100
 algae  sp  bras  sch  carx  com  lemn  tri  myri  spi  nymp  odo  pota  cri  pota  fri  pota  nod  pota  str  pota  zos
 sium  sua

ITEMS IN POSITIVE GROUP  29  (N=    6)          I.E. GROUP *1101
 cera  dem  nuph  adv  pelt  vir  sprd  pol  wolf  col  wolf  pun

*****************************************************************************************************************
     DIVISION   15  (N=   6)    I.E. GROUP *111

EIGENVALUE 0.364  AT ITERATION   1

ITEMS IN NEGATIVE GROUP  30  (N=    4)          I.E. GROUP *1110
 deco  ver  eleo  ery  lemn  min  scir  flu

ITEMS IN POSITIVE GROUP  31  (N=    2)          I.E. GROUP *1111
 leer  ory  scir  val

  END OF LEVEL   4

THIS IS THE END OF THE DIVISIONS REQUESTED
```

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*******************************************************************************************************
ORDER OF SPECIES INCLUDING RARER ONES
 81 typh  lat!   7 carx  lac!   8 carx  las!  12 duli  aru!  20 junc  bal!  21 junc  bre!  60 pote  pal!  77 spar  flu
 82 utri  cor!  14 eleo  sma!  30 myri  het!  49 pota  gra!  62 ricc  nat!  16 equi  flu!  18 hipp  vul!  19 isoe  sp.
 28 myri  alt!  32 myri  ten!  40 phra  aus!  47 pota  fol!  50 pota  ill!  71 scir  sub!  23 junc  pel!  67 scir  acu
 27 mega  bec!  33 myri  ver!  56 pota  ric!  57 pota  rob!  53 pota  obt!   1 acor  cal!   6 carx  hys!  43 pota  amp
 51 pota  nat!  34 naja  fle!  10 char  sp.!  22 junc  can!  68 scir  ame!   3 alis  pla!  37 nuph  var!  41 poly  amp
 64 sagi  gra!  80 typh  gla!  83 utri  int!  79 typh  ang!  17 hete  dub!  35 nite  fle!  65 sagi  lat!  75 spar  chl
 85 vall  ame!  42 pont  cor!  55 pota  pra!  46 pota  epi!  61 ranu  lon!  69 scir  cyp!  84 utri  vul!  15 elod  can
 63 sagi  cun!  66 sagi  rig!  29 myri  exa!  44 pota  ber!  74 spar  ame!  88 ziza  aqu!  54 pota  pec!  76 spar  eur
  2 algae  sp!  26 lemn  tri!  31 myri  spi!  45 pota  cri!  48 pota  fri!  52 pota  nod!  58 pota  str!  59 pota  zos
 73 sium  sua!   4 bras  sch!   5 carx  com!  38 nymp  odo!   9 cera  dem!  78 sprd  pol!  36 nuph  adv!  39 pelt  vir
 86 wolf  col!  87 wolf  pun!  11 deco  ver!  13 eleo  ery!  25 lemn  min!  70 scir  flu!  24 leer  ory!  72 scir  val


ORDER OF SAMPLE UNITS
 29 INDIAN_B !  42 PINCONB  !  41 PINCONA  !  47 SAGANING !  65 WHISKEY  !  17 EPOUFE   !  19 FALSE_PR !  33 KENYON
 16 ELCAJON  !  39 PECKBAY  !  61 VOIGHT   !  69 WILDISA  !  62 WAUGOSHA ! 106 MUDLAKE  !  34 LACLABEL !  98 BARKBAYA
109 RASPBERR ! 110 SISKEWIT !  67 WIGWAM   !  94 THOMPSON !   1 AUTRAIN  !   2 BAIEDEWA !   3 BAIEDEWC !   4 BARLAKE
  9 CHEBOYGA !  15 DUCKBAY  !  20 FISHDAM  !  22 GOGOMAIA !  23 GOGOMAID !  27 HURSLEYA !  28 HURSLEYB !  32 KEMPS_PT
 35 MACKINAC !  36 MISMER   !  37 MUNUSCON !  43 PINE_RIV !  46 ROACH    !  48 SANDISND !  49 SCOTT    !  50 SHINGLEB
 51 SHINGLEC !  53 SQUAW    !  54 STCLAIR  !  56 STURGEON !  57 SUGAR_A  !  58 SUGAR_B  !  63 WHIPPLEA !  64 WHIPPLEB
 70 WILDISB  !  71 WILDISE  !  97 BADRIVM  ! 100 HONJOHNA ! 101 KAKAGON  ! 104 MINKA    ! 105 MINKB    ! 111 STOCKTON
  7 BIGSHOAL !   8 CARPPINE !  11 CHURCH_A !  12 CHURCH_B !  24 GRAND    !  26 HOGISND  !  55 STMARTIN ! 103 LONGISND
 10 CHEBOYGC !  14 CORYEON  !  45 PTMOULLE !  59 SWANCR   !  72 FONDULA  !  73 FONDULB  !   6 BIGSABLE !  74 POKEGAMA
 96 BADRIVB  !  25 HARDWOOD !  60 TOBICO   !  82 CROOKEDA !  85 DELANEY  !  81 CRANBERR !  83 CROOKEDC !  76 BARNETT
 77 BLACKB   !  78 CHIPPEWA !  79 CHIPPEWB !  86 DEXTER   !  88 FLYNNC   !  90 STERLING !  13 CLINTON  !  66 WHITEB
 80 S.COLWEL !  87 EASTBAY  !  89 LAKEVIEW !  93 PRESQUE  ! 108 PESHTIGO !  95 BADRIVA  !  40 PENTWATR !  99 DEADHORS
102 LITTLE   ! 107 OCONTO   !   5 BETSIE   !  75 POKEGAMB !  31 KALAMAZD !  52 S.LLOYD  !  92 OLDWOMAN !  21 GALIEN
 30 KALAMAZA !  38 MUSKEGON !  44 POTAWATT !  68 WILDFBAY !  91 HURON    !  84 DEERCR_B !  18 ERIEBAY  !
```

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           000000000000000000000000000000000000000000000000000000000000000000000000001111111111111111111111111111111111111
           000000000000001111111111111111111111111111111111111111111111111111111111110000000000000000000000000001111111111
           001111111111110000111111111111111111111111111111111111111111111111111111110000000000000000000011111100000000001
             000111111111      0000000000000000000000000000000000000000000000001111111111000000000000111111110000010000000001

           [---] [*001 ] [                            *01                              ] [                 *1                 ]
           IPPSWEFKEPVWWMLBRSWTABBBCDFGGHHKMMMPRSSSSSSSSSWWWWBHKMMSBCCCGHSLCCPSFFBPBHTCDCCBBCCDFSCWSELPPBPDLOBPKSOGKMPWHDE
           NIIAHPAELEOIAUAAAIIHUAAAHUIOOUUEAIUIOACHHQTTUUHHIIAOAIITIAHHROTOHOTWOOIOAAORERRALHHELTLH.AAREAEEICEOA.LAAUOIUER
           DNNGIOLNCCILUDCRSSGOTIIRECSGGRRMCSNNANOIIUCUGGIILLDNKNNOGRUUAGMNERMANNGKDRBOLAORAIIXYEIICSKESDNATOTKLLDLLSTLREI
           ICCASUSYAKGDGLLKPKWMREELBKHOOSSPKMUECDTNNALRAAPPDDRJAKKCSPRRNIAGBYONDDSERDIOANONCPPTNRNTOTESHRTDTNSEALWIAKADORE
           AOONKFEOJBHIOAABBEAPADDAOBDMMLLSIES_HITGGWAGRRPPIIIOGABKHPCCDSRIOEUCUUAGIWCKNBKEKPPENLTELBVQTIWHLTIGMOOEMEWFNCB
           NNNIEE_NOATSSKBAEWMSIEEKYAAAAEE_NRCR S LL IE__LLSSVHO  TOIHH NTSYOLRLLBAVOOEEEETBEERCIOBWAIUIVAOEOEAAYMNAGAB RA
           _BANY P NY AHEEYRI ONWWEGYMIIYYPA OI N EE ROABEEBEMNN  OAN__ DINGNL ABLMBO DYRDT WW  NN EYEEGATR   MZDA ZOTA _Y
           B G R    A LART N AC A  ADABTC NV D BC  N  AB   A    NLEAB  NDC E   EA D A RC  AB  G  L W O RS   BD N ANTY B

81 typh lat -------------------1111-1--111---1--11--------1--11-----111-------1-1331------------------------1----1---------1--  0000
 7 carx lac ------------------------------------1-----------1-1-----------------3-21-----------------------------------------  0000
 8 carx las ----------------------3-------1-1--11------------------------------3-3------------------------------------------  0000
12 duli aru -------------12-----1-----------------1---------1----------------1-----------------------------------------------  0000
21 junc bre ----------------------1-------1---------------------1------11------------------------------------------------------  0000
60 pote pal --------------------11-----1--11---1----------1--------------------2111-----1--------------------------------------  0000
77 spar flu -------------123---------------------------1-----2-----------------------------------------------------------------  0000
82 utri cor ----------------------1-----------------------------1-------1---------------------------------------------------------  0000
14 eleo sma ------------1---------11-1-2321111-121121121-2-121-311-3-11222-121---111-2-111----------1----1-----1--------1-----  0000
30 myri het -------------2-2-----1-1-----1-1----11--1---111-------11-----------------1-------------------------------------------  0000
49 pota gra -----1---------------11--112211111111111111211111--1---12-1-14-11-11-----------------2----------1-----------1-  0000
62 ricc nat ------------------------------------1---------1----------------------1----------------------------------------------  0000
16 equi flu ---------------------1-----121111-1-11113---2221---1-----121--------11---------------------------------------------  0000
18 hipp vul ----------------------1-1-----1---------------------------------------------------------------------------------------  0000
19 isoe sp. ---------------------------------------1-------------1--2---------------------------------------------------------------  0000
32 myri ten ------------------------------1-------1----2------------2-----------------------------------------------------------------  0000
40 phra aus ------------------2---1-----------1-1-1-----1-1----------------------------1----------------------------------------  0000
50 pota ill ----------------------1----1--1-11-111-11--11111--------------1-------------------------------------------------------  0000
71 scir sub -------------11------2---111111322-214---2-------121--3----------------------------------------------------------2-  0000
23 junc pel --------1-----------------1------------------------------1-2-----1-------------------------------------------------  0001
67 scir acu -----1321---2------1121112122121222121233121 1-3211----3-3323--3-11-----1--2--1------------1-1---1-----------------  0001
27 mega bec -------------12---1--1-11-------1-1--------------221-------------------------------------------3----------------  0001
33 myri ver --------------------3---------------1-------------2----2---2----------11-------------------------------2-----------  0001
56 pota ric ---1-------------1-1-11--11-1-1111-111111-1111-1111-1--1-1-11---------------1------1-----------1-1-------------  0001
57 pota rob --------------------1-11------1----1-11--------11----1-----------1---------------------------------3----------------  0001
53 pota obt ------------------------11---1-1-1--111--12----11-----------------------------------------------1--1--------------  0001
 1 acor cal ----------------------1------1-------------------------------------------11----1-----------------------------------  0010
43 pota amp --------------2-------------------1-11--------------------1-----------------------------------1-----------------  0010
51 pota nat -------------11---------1--1-1211-112-31212-2-1-21---111-1--------------1------------12---------1--1-2-------------  0010
34 naja fle ----1--------13-----13-11-131---111111-12---22131132111-2---------2--1111------1-31----13---1---1---11--------------  0010
10 char sp. -1-21331332323---------------111---1-1-21---1--3121-------1--2-1-------------1------21---1-----------2---1-----------  0011
22 junc can ---1-12------------------1-------1---------------1-----------1--1---------------------------------------------------  0011
68 scir ame 33-111--1---1-------1--1---111--------3-1-------2---111-1--------1-121--11-------------------1------------------  0011
 3 alis pla ---11------------------------------------------------1----------12-----2----------------------1------------------  0100
37 nuph var ------1-2-----1-213--3111--1-1---1---111---1---111-11-321-1-1-----------------11-311------------------12-----------  0100
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TWINSPAN for Emergent Zones

```
41 poly  amp  --11-11----------------11---111-11111--11--11-1--1-1----1-------1------------1-1---------------1--1---1------1-2----  0100
64 sagi  gra  -----1-1------2-----------1-------------------------------------1--1--------22-1-------------------------------3------------  0100
80 typh  gla  ---2---------------1-----2--------------------11-------1-----------------131--1------1------------11------------------1-1---  0101
83 utri  int  ------------------------11-----1-----11--11-------------------------------1-------1-3-----2-----1-----------------1---------------  0110
79 typh  ang  ---------------------1--1-1---1---1-1112---11-----------1-----------11-111---441-------1-1-----------1112-----------12--  0110
17 hete  dub  ---1--------------3-412-----1---------3-1------11-----11--------------------------------11111--1-------2--1-1-1-----------1---  0110
35 nite  fle  ---------------------11--1-----------1-1-------------1------1-----------2-------------1-1------------------------------------3  0110
65 sagi  lat  -----1--------------------1---11-1-----1-11-1----11-3-----111111-12-----1---1221123--11-------1---------2-121122------11-2--  0110
75 spar  chl  ------------------------1-----1--1------1-1------1----1-------11-------------------1------3--1---------------------------------1----  0110
85 vall  ame  --11---------1------221-----2-11-111-111-11--12121-1121-1------------------1-------1222-3122---2-2------31-----------------  0110
42 pont  cor  ---1--------------------11--111111-111-11111-2-111111121-----11-----------------------------------22-22--1------11--2-1-11-  0111
55 pota  pra  -------------------------------------1--------------------1--------------------------------------------------1-----------------------  0111
61 ranu  lon  ------------------------------111--1--------1-----------------------------------------------1-----------------2---1---------------  1000
84 utri  vul  --------------1--1---4-21--11111-121--21---1---11--1-1111-1-----11-------111-23-2-33-3333--21-1------1---------------3-  1000
15 elod  can  --------------------22-21112--121--2-1-11-111111---21--1--1-1-------------------11232-2212-3222321--24-------------------  1001
66 sagi  rig  ------------------3------------------------------------11111---------------------------------32--------111----------------------  1001
29 myri  exa  -------------1--1-1--1-----12---------12-------11--1-1112111-------------------------22221222-1------1---211------------------  1001
44 pota  ber  -------------1---------1-1--1---11-1-------------------------------------------------------2-----1-1-----------3---------------------  1001
88 ziza  aqu  --------------2--1------1--1-------------------1-1--------1131----------------------------31--2--21-----------13------1-----2--------  1001
54 pota  pec  -------------1-------1-----1---------1---1-------1--2--11-----1-1-------------11--1-------1-2------112---------11112--1----------3  101
76 spar  eur  ---1-------------13-----------212-------------------------13-1-----------------11213-----11-----------3---1--411113---111-11--  101
 2 algae  sp  -------------------------------------------------------------------------2-----------------------------232------------------------  1100
26 lemn  tri  --------------------------------------1--------------------------------------------------1232133332422221------------------3------  1100
31 myri  spi  -11------------------31--------------------------1---------------1--------------1--------------2-1-----2-21112----11----1-----------  1100
45 pota  cri  ------------------------------------------------1-----------------------------3--------------12--1--11-1--------1----1-------1------  1100
48 pota  fri  --------------1-------2-----------1----------------------1-1------------------------------2114--1--11------------------------------  1100
52 pota  nod  --------------------1-------------------------1------------------------------------------------1-------------------3-----------------------  1100
59 pota  zos  -----------------1--12------1-1111111-1----1-1----1----1-1-1-----------------1-------3-121313331--312--11-----------------------  1100
 4 bras  sch  ------------------------11------------------------------------3---------------------------------------------1--3-----------------------3-  1100
 5 carx  com  --------------------------1------------------------------------------------------------------1-----11-----------------------------------1---  1100
38 nymp  odo  --------------1------1----1-1-1-------11111--11112211111-----------------1--1-1-----1--233133123122313-1--11-24--1-11-3-  1100
 9 cera  dem  ------------------1--1---2------------11---1----1---1---211-------------------1111---231123235343335241334331211--11------  1101
78 sprd  pol  ---------------------------------------------------------------1-------------------------1-----3-112-3-23-3-311--3111-111-53441----  1101
36 nuph  adv  -------------------------------------------------------------------------------------------------1---------2232--1---1---2--4113-43-  1101
39 pelt  vir  --------------------------------------------------------------------------------------------------------------------------------43-2244-----  1101
86 wolf  col  ----------------------------------------------------------------------------------------------------3----------1-----------2-22----  1101
87 wolf  pun  --------------------------------------------------------------------------------------------------------------1-----------2-2------  1101
11 deco  ver  -------------------------1----------------------------------------------------------1------------------------------------111-----  1110
13 eleo  ery  -------------------------------------------------------------------------------1---------------------------------------------11---  1110
25 lemn  min  ---1---------------------1-------------1-------1-----------------1----------1--1--------1-------1--3----------21131-22142-2-----  1110
70 scir  flu  ---------------------------------------1-------------1-------------------1-----------------------------------11---1----1-------  1110
24 leer  ory  ---1-------------1-------------------------------------------------1-------1--12-1-----------------------------------1-1-----21-1-2  1111
72 scir  val  --111-2--------------1----11-----------1---------------1----------------11-13111----1----------------2----11-11111-----111-2-22  1111

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TWINSPAN for Emergent Zones

APPENDIX V

TWINSPAN Ordination of Herbaceous Zones

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HERBACEOUS ZONES: Species in 5 or more transects (H, E, and W)

 NUMBER OF SAMPLES    109
 NUMBER OF SPECIES    140
 LENGTH OF RAW DATA ARRAY  4763

 SPECIES NAMES
    1 acer  rub!   2 acor  cal!   3 alis  pla!   4 alnu  rug!   5 anem  can!   6 ascl  inc!   7 betu  pap!   8 bide  cer
    9 boeh  cyl!  10 cala  ark!  11 cala  can!  12 caly  sep!  13 camp  apa!  14 carx  aqu!  15 carx  beb!  16 carx  com
   17 carx  dia!  18 carx  hys!  19 carx  int!  20 carx  lac!  21 carx  las!  22 carx  lim!  23 carx  ros!  24 carx  sti
   25 carx  str!  26 carx  vir!  27 ceph  occ!  28 cham  cal!  29 cicu  bul!  30 clad  mar!  31 corn  amo!  32 corn  foe
   33 corn  sto!  34 cype  str!  35 deco  ver!  36 dros  rot!  37 duli  aru!  38 eleo  aci!  39 eleo  ell!  40 eleo  ery
   41 eleo  sma!  42 epil  col!  43 epil  lep!  44 equi  arv!  45 equi  flu!  46 eupa  mac!  47 eupa  per!  48 euth  gra
   49 frax  pen!  50 gali  pal!  51 gali  tri!  52 glyc  can!  53 hype  kal!  54 impa  cap!  55 iris  ver!  56 iris  vir
   57 junc  bal!  58 junc  bre!  59 junc  can!  60 junc  dud!  61 junc  eff!  62 junc  nod!  63 junc  pel!  64 lari  lar
   65 lath  pal!  66 leer  ory!  67 lobe  kal!  68 lycp  ame!  69 lycp  uni!  70 lysi  ter!  71 lysi  thy!  72 lyth  sal
   73 ment  arv!  74 meny  tri!  75 myrc  gal!  76 onoc  sen!  77 pani  lin!  78 pelt  vir!  79 phal  aru!  80 phra  aus
   81 pile  pum!  82 pogo  oph!  83 poly  amp!  84 poly  lap!  85 poly  per!  86 poly  pun!  87 poly  sag!  88 pont  cor
   89 popu  bal!  90 popu  tre!  91 pote  ans!  92 pote  fru!  93 pote  nor!  94 pote  pal!  95 ranu  sce!  96 rhyn  alb
   97 rori  pal!  98 rosa  pal!  99 rume  mar! 100 rume  orb! 101 sagi  lat! 102 salx  beb! 103 salx  can! 104 salx  dis
  105 salx  exi! 106 salx  luc! 107 salx  ped! 108 salx  pet! 109 salx  ser! 110 sarr  pur! 111 scir  acu! 112 scir  ame
  113 scir  atr! 114 scir  cyp! 115 scir  flu! 116 scir  sub! 117 scir  val! 118 scut  gal! 119 scut  lat! 120 sium  sua
  121 sola  dul! 122 soli  uli! 123 spar  eur! 124 spha  sp.! 125 spir  alb! 126 teuc  can! 127 thel  pal! 128 thuj  occ
  129 tria  fra! 130 tria  vir! 131 trig  mar! 132 typh  ang! 133 typh  lat! 134 urti  dio! 135 vacc  mac! 136 vacc  oxy
  137 verb  has! 138 vibu  len! 139 viol  sp.! 140 viti  rip!

 SAMPLE-UNIT NAMES
    1 AUTRAIN  !   2 BAIEDAWA !   3 BAIEDEWC !   4 BETSIE   !   5 BIGSHOAL !   6 CARPPINE !   7 CHEBOYGB !   8 CHEBOYGC
    9 CHIPPEWA !  10 CHURCHA  !  11 CLINTON  !  12 CORYEON  !  13 DUCKBAY  !  14 ELCAJON  !  15 EPOUFETT !  16 ERIEBAY
   17 FALSE    !  18 FISHDAM  !  19 GALIEN   !  20 GOGOMAIA !  21 GOGOMAID !  22 GRAND    !  23 HARDWOOD !  24 HOGISNDA
   25 HOGISNDB !  26 HURSLEYB !  27 INDIAN   !  28 KALAMAZA !  29 KALAMAZD !  30 KEMPS    !  31 KENYON   !  32 LACLABEL
   33 MACKINAC !  34 MISMER   !  35 MUNUSCON !  36 OTTER    !  37 PAWPAW   !  38 PECK     !  39 PENTWATR !  40 PEQUAMIN
   41 PINCONNA !  42 PINE     !  43 PORTAGE  !  44 POTAWATT !  45 PTMOULLE !  46 ROACH    !  47 SANDIS   !  48 SCOTT
   49 SHINGLEB !  50 SHINGLEC !  51 STCLAIR  !  52 STMARTIN !  53 STONY_CR !  54 SUGAR_A  !  55 SUGAR_B  !  56 SWANCR
   57 TOBICO   !  58 VOIGHT   !  59 WAUGOSHA !  60 WHIPPLEA !  61 WHIPPLEB !  62 WHISKEY  !  63 WHITEA   !  64 WHITEB
   65 WIGWAM   !  66 WILDFBAY !  67 WILDISLA !  68 WILDISLB !  69 WILDISLE !  70 FONDULAC !  71 POKEGAMA !  72 POKEGAMB
   73 BARNETTC !  74 CHIPPEWA !  75 CHIPPEWB !  76 COLWELL  !  77 CRANBERR !  78 CROOKEDA !  79 CROOKEDC !  80 DEERB
   81 DELANEY  !  82 DEXTER   !  83 FLYNNC   !  84 LAKEVIEW !  85 PTPENIN  !  86 STERLING !  87 HURON    !  88 SHELDON
   89 PRESQUE  !  90 THOMPSON !  91 BADRIVM  !  92 BADRIVB  !  93 BARKBAYA !  94 DEADHORS !  95 HONJOHNA !  96 KAKAGON
   97 LITTLE   !  98 LONGISND !  99 MINKRIVA ! 100 MINKRIVB ! 101 MUDLAKE  ! 102 OCONTO   ! 103 PESHTIGO ! 104 RASPBERA
  105 RASPBERB ! 106 SISKEWIT ! 107 STOCKTON ! 108 W.TWIN_A ! 109 W.TWIN_B !

 CUT LEVELS:       0.00   10.00   20.00   40.00   60.00

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    DIVISION    1  (N= 109)    I.E. GROUP *

EIGENVALUE 0.446  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
cham  call(+)   meny  tril(+)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    0     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    1

ITEMS IN NEGATIVE GROUP   2  (N=   98)         I.E. GROUP *0
BAIEDAWA BAIEDEWC BETSIE   BIGSHOAL CARPPINE CHEBOYGB CHEBOYGC CHIPPEWA CHURCHA  CLINTON  CORYEON  DUCKBAY
ELCAJON  EPOUFETT ERIEBAY  FALSE    FISHDAM  GALIEN   GOGOMAIA GOGOMAID HARDWOOD HOGISNDA HOGISNDB HURSLEYB
INDIAN   KALAMAZA KALAMAZD KEMPS    KENYON   MACKINAC MISMER   MUNUSCON OTTER    PAWPAW   PECK     PENTWATR
PINCONNA PINE     POTAWATT PTMOULLE ROACH    SANDIS   SCOTT    SHINGLEB SHINGLEC STCLAIR  STMARTIN STONY_CR
SUGAR_A  SUGAR_B  SWANCR   TOBICO   VOIGHT   WAUGOSHA WHIPPLEA WHIPPLEB WHISKEY  WHITEA   WHITEB   WIGWAM
WILDFBAY WILDISLA WILDISLB WILDISLE FONDULAC POKEGAMA POKEGAMB BARNETT  CHIPPEWA CHIPPEWB COLWELL  CRANBERR
CROOKEDA CROOKEDC DEERB    DELANEY  DEXTER   FLYNNC   LAKEVIEW PTPENIN  STERLING HURON    SHELDON  PRESQUE
THOMPSON BADRIVM  DEADHORS KAKAGON  LITTLE   LONGISND MINKRIVA MINKRIVB MUDLAKE  OCONTO   PESHTIGO RASPBERB
W.TWIN_A W.TWIN_B

BORDERLINE NEGATIVES    (N=    2)
BAIEDEWC  PECK

ITEMS IN POSITIVE GROUP   3  (N=   11)         I.E. GROUP *1
AUTRAIN  GRAND    LACLABEL PEQUAMIN PORTAGE  BADRIVB  BARKBAYA HONJOHNA RASPBERA SISKEWIT STOCKTON

NEGATIVE PREFERENTIALS
bide  cer1( 21,  0) cala  can1( 85,  4) carx  lac1( 50,  2) carx  str1( 60,  1) cicu  bul1( 43,  2) corn  sto1( 20,  1)
eupa  mac1( 24,  1) eupa  per1( 31,  0) gali  tri1( 38,  2) impa  cap1( 53,  0) lyth  sal1( 20,  0) phal  aru1( 31,  0)
phra  aus1( 22,  1) poly  amp1( 55,  1) rori  pal1( 32,  0) salx  pet1( 28,  0) scir  acu1( 25,  1) scir  val1( 29,  1)
scut  gal1( 43,  0) spar  eur1( 35,  1) thel  pal1( 25,  1) typh  ang1( 46,  0) cala  can2( 60,  0) carx  lac2( 23,  0)
carx  str2( 33,  1) impa  cap2( 20,  0) typh  ang2( 24,  0) cala  can3( 35,  0)

POSITIVE PREFERENTIALS
carx  las1( 24, 10) carx  lim1(  1,  7) cham  cal1(  0, 10) clad  mar1( 10,  7) dros  rot1(  1,  5) duli  aru1(  6,  6)
eleo  sma1( 12,  5) equi  flu1( 15,  5) iris  ver1( 11,  3) junc  can1( 13,  4) lari  lar1(  4,  3) meny  tri1(  0,  8)
myrc  gal1( 20, 10) pogo  oph1(  1,  6) rhyn  alb1(  0,  7) rosa  pal1(  8,  4) sarr  pur1(  4,  8) scir  sub1(  3,  3)
soli  uli1(  4,  3) spha  sp.1(  1,  7) thuj  occ1(  7,  3) tria  fra1(  7,  5) vacc  mac1(  1,  4) vacc  oxy1(  0,  6)
carx  las2( 13,  8) clad  mar2(  4,  5) meny  tri2(  0,  3) myrc  gal2(  4,  7) rhyn  alb2(  0,  4) spha  sp.2(  0,  4)
carx  las3(  6,  5) clad  mar3(  1,  4) spha  sp.3(  0,  4)

NON-PREFERENTIALS
alnu  rug1( 32,  5) camp  apa1( 48,  3) carx  aqu1( 40,  3) lycp  ame1( 33,  2) lycp  uni1( 22,  2) lysi  thy1( 30,  2)
pote  pal1( 39,  6) sagi  lat1( 36,  5) spir  alb1( 32,  2) typh  lat1( 43,  4)

  END OF LEVEL   1
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******************************************************************************************************************
     DIVISION    2  (N=  98)    I.E. GROUP *0

EIGENVALUE 0.345  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
carx  virl(-)   clad  marl(-)   lobe  kall(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -2     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP   -1

ITEMS IN NEGATIVE GROUP   4  (N=    9)         I.E. GROUP *00
BIGSHOAL  CHEBOYGB  CHEBOYGC  ELCAJON   EPOUFETT  KENYON    PECK      VOIGHT    WAUGOSHA

ITEMS IN POSITIVE GROUP   5  (N=   89)         I.E. GROUP *01
BAIEDAWA  BAIEDEWC  BETSIE    CARPPINE  CHIPPEWA  CHURCHA   CLINTON   CORYEON   DUCKBAY   ERIEBAY   FALSE     FISHDAM
GALIEN    GOGOMAIA  GOGOMAID  HARDWOOD  HOGISNDA  HOGISNDB  HURSLEYB  INDIAN    KALAMAZA  KALAMAZD  KEMPS     MACKINAC
MISMER    MUNUSCON  OTTER     PAWPAW    PENTWATR  PINCONNA  PINE      POTAWATT  PTMOULLE  ROACH     SANDIS    SCOTT
SHINGLEB  SHINGLEC  STCLAIR   STMARTIN  STONY_CR  SUGAR_A   SUGAR_B   SWANCR    TOBICO    WHIPPLEA  WHIPPLEB  WHISKEY
WHITEA    WHITEB    WIGWAM    WILDFBAY  WILDISLA  WILDISLB  WILDISLE  FONDULAC  POKEGAMA  POKEGAMB  BARNETT   CHIPPEWA
CHIPPEWB  COLWELL   CRANBERR  CROOKEDA  CROOKEDC  DEERB     DELANEY   DEXTER    FLYNNC    LAKEVIEW  PTPENIN   STERLING
HURON     SHELDON   PRESQUE   THOMPSON  BADRIVM   DEADHORS  KAKAGON   LITTLE    LONGISND  MINKRIVA  MINKRIVB  MUDLAKE
OCONTO    PESHTIGO  RASPBERB  W.TWIN_A  W.TWIN_B

BORDERLINE POSITIVES     (N=    6)
CARPPINE  FALSE     INDIAN    MACKINAC  WILDFBAY  LONGISND

NEGATIVE PREFERENTIALS
betu  papl(  2,  3) cala  arkl(  4,  1) carx  hysl(  2,  8) carx  intl(  2,  3) carx  virl(  9,  4) clad  marl(  8,  2)
eleo  elll(  3,  6) eupa  perl(  6, 25) euth  gral(  3,  4) glyc  canl(  3,  5) hype  kall(  4,  1) junc  ball(  6,  8)
junc  brel(  3,  3) junc  canl(  3, 10) junc  nodl(  2,  3) junc  pell(  2,  1) lobe  kall(  8,  1) myrc  gall(  4, 16)
pani  linl(  5,  0) popu  ball(  2,  6) pote  ansl(  7, 11) pote  frul(  7,  4) pote  norl(  3,  8) sarr  purl(  3,  1)
scir  acul(  6, 19) scir  amel(  5,  8) soli  ulil(  3,  1) thuj  occl(  3,  4) trig  marl(  6,  3) viol  sp.1(  2,  4)
carx  vir2(  6,  0) clad  mar2(  4,  0) junc  bal2(  2,  1) pote  ans2(  2,  0) scir  acu2(  2,  1) scir  ame2(  2,  3)

POSITIVE PREFERENTIALS
bide  cerl(  0, 21) carx  lacl(  0, 50) cicu  bull(  1, 42) corn  stol(  0, 20) eupa  macl(  0, 24) gali  tril(  0, 38)
impa  capl(  0, 53) lath  pall(  0, 18) lysi  thyl(  1, 29) lyth  sall(  0, 20) phra  ausl(  0, 22) poly  ampl(  0, 55)
pote  pall(  1, 38) rori  pall(  1, 31) salx  petl(  1, 27) scir  vall(  1, 28) scut  gall(  0, 43) spar  eurl(  0, 35)
spir  albl(  1, 31) thel  pall(  0, 25) typh  angl(  2, 44) typh  latl(  2, 41) verb  hasl(  0, 18) carx  lac2(  0, 23)
carx  str2(  1, 32) impa  cap2(  0, 20) typh  ang2(  0, 24)

NON-PREFERENTIALS
alnu  rugl(  2, 30) cala  canl(  9, 76) camp  apal(  4, 44) carx  aqul(  2, 38) carx  lasl(  3, 21) carx  strl(  3, 57)
frax  penl(  2, 15) lycp  amel(  4, 29) lycp  unil(  2, 20) phal  arul(  4, 27) sagi  latl(  2, 34) salx  canl(  2, 13)
cala  can2(  3, 57) carx  las2(  2, 11) cala  can3(  2, 33) carx  str3(  1, 18) cala  can4(  2, 10)
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****************************************************************************************************************************
     DIVISION    3  (N=  11)    I.E. GROUP *1

EIGENVALUE 0.478  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
meny  tri1(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP   6  (N=    8)         I.E. GROUP *10
AUTRAIN   GRAND     LACLABEL  PEQUAMIN  BADRIVB   RASPBERA  SISKEWIT  STOCKTON

ITEMS IN POSITIVE GROUP   7  (N=    3)         I.E. GROUP *11
PORTAGE   BARKBAYA  HONJOHNA

NEGATIVE PREFERENTIALS
cala  can1(  4,  0) camp  apa1(  3,  0) carx  int1(  2,  0) carx  lim1(  6,  1) cicu  bul1(  2,  0) clad  mar1(  6,  1)
dros  rot1(  5,  0) gali  tri1(  2,  0) junc  pel1(  2,  0) lari  lar1(  3,  0) lycp  ame1(  2,  0) lycp  uni1(  2,  0)
lysi  thy1(  2,  0) meny  tri1(  8,  0) pogo  oph1(  6,  0) pote  fru1(  2,  0) rhyn  alb1(  7,  0) rosa  pal1(  4,  0)
sarr  pur1(  8,  0) soli  uli1(  3,  0) spha  sp.1(  7,  0) spir  alb1(  2,  0) thuj  occ1(  3,  0) vacc  mac1(  4,  0)
vacc  oxy1(  6,  0) carx  lim2(  2,  0) meny  tri2(  3,  0) rhyn  alb2(  4,  0) sarr  pur2(  2,  0) spha  sp.2(  4,  0)
vacc  oxy2(  2,  0) myrc  gal3(  2,  0) spha  sp.3(  4,  0)

POSITIVE PREFERENTIALS
carx  aqu1(  1,  2) carx  lac1(  1,  1) duli  aru1(  3,  3) eleo  aci1(  0,  1) junc  bre1(  1,  1) junc  can1(  1,  3)
lysi  ter1(  1,  1) ment  arv1(  1,  1) phra  aus1(  0,  1) pont  cor1(  0,  2) scir  cyp1(  0,  1) sium  sua1(  0,  1)
carx  aqu2(  0,  1) duli  aru2(  0,  2) phra  aus2(  0,  1) sagi  lat2(  0,  1) carx  las3(  2,  3) duli  aru3(  0,  2)
phra  aus3(  0,  1) sagi  lat3(  0,  1) carx  las4(  0,  1) phra  aus4(  0,  1)

NON-PREFERENTIALS
alnu  rug1(  4,  1) carx  las1(  7,  3) cham  cal1(  7,  3) eleo  sma1(  3,  2) equi  flu1(  3,  2) iris  ver1(  2,  1)
myrc  gal1(  7,  3) pote  pal1(  5,  1) sagi  lat1(  3,  2) scir  sub1(  2,  1) tria  fra1(  4,  1) typh  lat1(  3,  1)
carx  las2(  5,  3) clad  mar2(  4,  1) myrc  gal2(  5,  2) clad  mar3(  3,  1)

  END OF LEVEL   2
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**************************************************************************************************************************
     DIVISION    4  (N=   9)    I.E. GROUP *00

EIGENVALUE 0.420  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
pote  fru1(+)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    0     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    1

ITEMS IN NEGATIVE GROUP   8  (N=    2)         I.E. GROUP *000
EPOUFETT  KENYON

ITEMS IN POSITIVE GROUP   9  (N=    7)         I.E. GROUP *001
BIGSHOAL  CHEBOYGB  CHEBOYGC  ELCAJON   PECK      VOIGHT    WAUGOSHA

NEGATIVE PREFERENTIALS
cicu  bul1(  1,  0) lysi  ter1(  1,  0) pote  pal1(  1,  0) cala  can2(  2,  1) carx  str2(  1,  0) junc  bal2(  1,  1)
pote  ans2(  1,  1) cala  can3(  2,  0) carx  str3(  1,  0) clad  mar3(  1,  0) junc  bal3(  1,  0) cala  can4(  2,  0)
cala  can5(  1,  0)

POSITIVE PREFERENTIALS
alnu  rug1(  0,  2) betu  pap1(  0,  2) cala  ark1(  0,  4) carx  aqu1(  0,  2) carx  hys1(  0,  2) carx  int1(  0,  2)
carx  las1(  0,  3) clad  mar1(  1,  7) eleo  ell1(  0,  3) frax  pen1(  0,  2) glyc  can1(  0,  3) hype  kal1(  0,  4)
junc  bre1(  0,  3) junc  can1(  0,  3) junc  nod1(  0,  2) junc  pel1(  0,  2) lycp  ame1(  0,  4) lycp  uni1(  0,  2)
myrc  gal1(  0,  4) pani  lin1(  0,  5) phal  aru1(  0,  4) popu  bal1(  0,  2) pote  fru1(  0,  7) pote  nor1(  0,  3)
sagi  lat1(  0,  2) salx  can1(  0,  2) sarr  pur1(  0,  3) scir  acu1(  0,  6) soli  uli1(  0,  3) thuj  occ1(  0,  3)
typh  ang1(  0,  2) typh  lat1(  0,  2) viol  sp.1(  0,  2) carx  las2(  0,  2) scir  acu2(  0,  2) scir  ame2(  0,  2)

NON-PREFERENTIALS
cala  can1(  2,  7) camp  apa1(  1,  3) carx  str1(  1,  2) carx  vir1(  2,  7) eupa  per1(  2,  4) euth  gra1(  1,  2)
junc  bal1(  1,  5) lobe  kal1(  2,  6) pote  ans1(  1,  6) scir  ame1(  1,  4) trig  mar1(  1,  5) carx  vir2(  1,  5)
clad  mar2(  1,  3)

**************************************************************************************************************************
     DIVISION    5  (N=  89)    I.E. GROUP *01

EIGENVALUE 0.325  AT ITERATION   3
INDICATORS, TOGETHER WITH THEIR SIGN
rori  pal1(+)   pote  pal1(-)   salx  pet1(-)   scir  val1(+)   camp  apa1(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  10  (N=   50)         I.E. GROUP *010
BAIEDAWA  BAIEDEWC  CARPPINE  CHIPPEWA  CHURCHA   DUCKBAY   FISHDAM   GOGOMAIA  GOGOMAID  HOGISNDA  HOGISNDB  HURSLEYB
INDIAN    KEMPS     MACKINAC  MISMER    MUNUSCON  ROACH     SANDIS    SCOTT     SHINGLEB  SHINGLEC  STMARTIN  SUGAR_A
SUGAR_B   TOBICO    WHIPPLEA  WHIPPLEB  FONDULAC  POKEGAMA  POKEGAMB  BARNETT   CHIPPEWA  CRANBERR  CROOKEDA  DEERB
DELANEY   DEXTER    LAKEVIEW  STERLING  BADRIVM   KAKAGON   LONGISND  MINKRIVA  MINKRIVB  MUDLAKE   PESHTIGO  RASPBERB
W.TWIN_A  W.TWIN_B
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BORDERLINE NEGATIVES     (N=    4)
CHIPPEWA  CRANBERR  DELANEY   STERLING

MISCLASSIFIED NEGATIVES (N=    6)
WHIPPLEA  FONDULAC  POKEGAMA  POKEGAMB  DEXTER    BADRIVM

ITEMS IN POSITIVE GROUP  11  (N=   39)        I.E. GROUP *011
BETSIE    CLINTON   CORYEON   ERIEBAY   FALSE     GALIEN    HARDWOOD  KALAMAZA  KALAMAZD  OTTER     PAWPAW    PENTWATR
PINCONNA  PINE      POTAWATT  PTMOULLE  STCLAIR   STONY_CR  SWANCR    WHISKEY   WHITEA    WHITEB    WIGWAM    WILDFBAY
WILDISLA  WILDISLB  WILDISLE  CHIPPEWB  COLWELL   CROOKEDC  FLYNNC    PTPENIN   HURON     SHELDON   PRESQUE   THOMPSON
DEADHORS  LITTLE    OCONTO

BORDERLINE POSITIVES     (N=    2)
FALSE     PRESQUE

MISCLASSIFIED POSITIVES (N=    1)
PTPENIN

NEGATIVE PREFERENTIALS
alnu  rugl( 25,  5) camp  apal( 34, 10) carx  aqul( 29,  9) carx  lasl( 21,  0) equi  flul( 13,  1) lath  pall( 14,  4)
lysi  thyl( 22,  7) myrc  gall( 16,  0) pote  pall( 34,  4) salx  canl( 11,  2) salx  pedl( 12,  0) salx  petl( 25,  2)
spir  albl( 25,  6) carx  aqu2( 13,  4) carx  lac2( 22,  1) carx  las2( 11,  0) carx  str2( 24,  8) carx  lac3( 16,  1)
carx  str3( 15,  3)

POSITIVE PREFERENTIALS
alis  plal(  2,  9) bide  cerl(  5, 16) caly  sepl(  3,  9) epil  coll(  1,  9) eupa  perl(  9, 16) leer  oryl(  1, 15)
lycp  amel( 11, 18) lyth  sall(  7, 13) ment  arvl(  4,  8) pile  puml(  2,  8) poly  lapl(  1, 16) poly  perl(  0, 11)
poly  punl(  0, 10) pote  ansl(  3,  8) ranu  scel(  3, 12) rori  pall(  4, 27) scir  flul(  3, 10) scir  vall(  6, 22)
spar  eurl( 12, 23) typh  angl( 16, 28) urti  diol(  1,  9) verb  hasl(  2, 16) bide  cer2(  0, 10) impa  cap2(  6, 14)
rori  pal2(  0,  9) typh  ang2(  9, 15)

NON-PREFERENTIALS
ascl  incl(  6,  8) cala  canl( 43, 33) carx  bebl(  8,  9) carx  lacl( 33, 17) carx  strl( 38, 19) cicu  bull( 22, 20)
corn  stol( 13,  7) eupa  macl( 13, 11) frax  penl(  6,  9) gali  tril( 19, 19) impa  capl( 24, 29) lycp  unil( 14,  6)
onoc  senl( 11,  5) phal  arul( 13, 14) phra  ausl(  9, 13) poly  ampl( 33, 22) pont  corl(  7,  8) rume  orbl(  8,  8)
sagi  latl( 19, 15) scir  acul( 11,  8) scut  gall( 23, 20) sium  sual( 11,  6) thel  pall( 17,  8) typh  latl( 29, 12)
cala  can2( 34, 23) cala  can3( 17, 16) typh  ang3(  7,  9)
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********************************************************************************************************************
     DIVISION    6  (N=   8)    I.E. GROUP *10

EIGENVALUE 0.404  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
cicu  bull(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  12  (N=    2)         I.E. GROUP *100
GRAND     SISKEWIT

ITEMS IN POSITIVE GROUP  13  (N=    6)         I.E. GROUP *101
AUTRAIN   LACLABEL  PEQUAMIN  BADRIVB   RASPBERA  STOCKTON

NEGATIVE PREFERENTIALS
alnu  rug1(  2,  2) camp  apa1(  2,  1) carx  aqu1(  1,  0) carx  int1(  1,  1) carx  lac1(  1,  0) carx  ros1(  1,  0)
carx  str1(  1,  0) cicu  bul1(  2,  0) corn  sto1(  1,  0) eleo  sma1(  2,  1) eupa  mac1(  1,  0) gali  tri1(  2,  0)
glyc  can1(  1,  0) junc  bal1(  1,  0) junc  bre1(  1,  0) leer  ory1(  1,  0) lycp  ame1(  1,  1) lycp  uni1(  1,  1)
lysi  ter1(  1,  0) lysi  thy1(  1,  1) ment  arv1(  1,  0) onoc  sen1(  1,  0) poly  amp1(  1,  0) poly  sag1(  1,  0)
pote  fru1(  1,  1) pote  pal1(  2,  3) rosa  pal1(  2,  2) salx  ped1(  1,  0) scir  sub1(  1,  1) scir  val1(  1,  0)
spar  eur1(  1,  0) spir  alb1(  1,  1) thel  pal1(  1,  0) tria  fra1(  2,  2) trig  mar1(  1,  0) typh  lat1(  2,  1)
carx  las2(  2,  3) carx  str2(  1,  0) junc  bre2(  1,  0) scir  sub2(  1,  0)

POSITIVE PREFERENTIALS
iris  ver1(  0,  2) junc  pel1(  0,  2) soli  uli1(  0,  3) spha  sp.1(  1,  6) vacc  mac1(  0,  4) carx  lim2(  0,  2)
clad  mar2(  0,  4) meny  tri2(  0,  3) rhyn  alb2(  0,  4) sarr  pur2(  0,  2) spha  sp.2(  0,  4) vacc  oxy2(  0,  2)
carx  las3(  0,  2) clad  mar3(  0,  3) myrc  gal3(  0,  2) spha  sp.3(  0,  4)

NON-PREFERENTIALS
cala  can1(  1,  3) carx  las1(  2,  5) carx  lim1(  1,  5) cham  cal1(  2,  5) clad  mar1(  1,  5) dros  rot1(  1,  4)
duli  aru1(  1,  2) equi  flu1(  1,  2) lari  lar1(  1,  2) meny  tri1(  2,  6) myrc  gal1(  2,  5) pogo  oph1(  1,  5)
rhyn  alb1(  2,  5) sagi  lat1(  1,  2) sarr  pur1(  2,  6) thuj  occ1(  1,  2) vacc  oxy1(  1,  5) myrc  gal2(  1,  4)

********************************************************************************************************************
     DIVISION    7  (N=   3)    I.E. GROUP *11

     DIVISION FAILS - THERE ARE TOO FEW ITEMS

END OF LEVEL   3
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*****************************************************************************************************************************
     DIVISION    8  (N=    2)    I.E. GROUP *000

     DIVISION FAILS - THERE ARE TOO FEW ITEMS

*****************************************************************************************************************************
     DIVISION    9  (N=    7)    I.E. GROUP *001

EIGENVALUE 0.364  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
carx  las1(+)   eleo  ell1(+)   glyc  can1(+)   junc  bre1(+)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    0     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    1

ITEMS IN NEGATIVE GROUP  18  (N=    3)         I.E. GROUP *0010
ELCAJON   PECK      VOIGHT

ITEMS IN POSITIVE GROUP  19  (N=    4)         I.E. GROUP *0011
BIGSHOAL  CHEBOYGB  CHEBOYGC  WAUGOSHA

NEGATIVE PREFERENTIALS
acer  rub1(  1,  0) camp  apa1(  2,  1) carx  int1(  2,  0) carx  lim1(  1,  0) dros  rot1(  1,  0) eleo  aci1(  1,  0)
junc  bal1(  3,  2) junc  nod1(  2,  0) junc  pel1(  2,  0) lycp  uni1(  2,  0) pote  nor1(  2,  1) sarr  pur1(  2,  1)
soli  uli1(  2,  1) thuj  occ1(  2,  1) junc  bal2(  1,  0)

POSITIVE PREFERENTIALS
alnu  rug1(  0,  2) betu  pap1(  0,  2) carx  beb1(  0,  1) carx  hys1(  0,  2) carx  las1(  0,  3) carx  str1(  0,  2)
corn  amo1(  0,  1) eleo  ell1(  0,  3) eleo  sma1(  0,  1) equi  flu1(  0,  1) eupa  per1(  1,  3) euth  gra1(  0,  2)
glyc  can1(  0,  3) junc  bre1(  0,  3) junc  can1(  0,  3) lycp  ame1(  1,  3) lysi  thy1(  0,  1) pani  lin1(  1,  4)
phal  aru1(  1,  3) poly  per1(  0,  1) popu  bal1(  0,  2) rori  pal1(  0,  1) sagi  lat1(  0,  2) salx  can1(  0,  2)
salx  dis1(  0,  1) salx  pet1(  0,  1) salx  ser1(  0,  1) scir  ame1(  1,  3) scir  val1(  0,  1) sola  dul1(  0,  1)
spir  alb1(  0,  1) trig  mar1(  1,  4) typh  ang1(  0,  2) typh  lat1(  0,  2) urti  dio1(  0,  1) viol  sp.1(  0,  2)
cala  ark2(  0,  1) cala  can2(  0,  1) carx  las2(  0,  2) eleo  ell2(  0,  1) junc  bre2(  0,  1) junc  can2(  0,  1)
lobe  kal2(  0,  1) pani  lin2(  0,  1) pote  ans2(  0,  1) scir  ame2(  0,  2) carx  las3(  0,  1) carx  vir3(  0,  1)

NON-PREFERENTIALS
cala  ark1(  2,  2) cala  can1(  3,  4) carx  aqu1(  1,  1) carx  vir1(  3,  4) clad  mar1(  3,  4) frax  pen1(  1,  1)
hype  kal1(  2,  2) lobe  kal1(  3,  3) myrc  gal1(  2,  2) pote  ans1(  2,  4) pote  fru1(  3,  4) scir  acu1(  3,  3)
carx  vir2(  2,  3) clad  mar2(  1,  2) scir  acu2(  1,  1)
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*****************************************************************************************************
     DIVISION   10  (N=  50)    I.E. GROUP *010

EIGENVALUE 0.266  AT ITERATION   3
INDICATORS, TOGETHER WITH THEIR SIGN
camp  apal(+)   carx  lac3(-)   poly  ampl(+)   carx  ros3(-)   carx  aqul(+)   typh  lat1(+)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  20  (N=    4)        I.E. GROUP *0100
FONDULAC  POKEGAMA  POKEGAMB  BADRIVM

BORDERLINE NEGATIVES    (N=    1)
POKEGAMB

ITEMS IN POSITIVE GROUP  21  (N=   46)        I.E. GROUP *0101
BAIEDAWA  BAIEDEWC  CARPPINE  CHIPPEWA  CHURCHA   DUCKBAY   FISHDAM   GOGOMAIA  GOGOMAID  HOGISNDA  HOGISNDB  HURSLEYB
INDIAN    KEMPS     MACKINAC  MISMER    MUNUSCON  ROACH     SANDIS    SCOTT     SHINGLEB  SHINGLEC  STMARTIN  SUGAR_A
SUGAR_B   TOBICO    WHIPPLEA  WHIPPLEB  BARNETT   CHIPPEWA  CRANBERR  CROOKEDA  DEERB     DELANEY   DEXTER    LAKEVIEW
STERLING  KAKAGON   LONGISND  MINKRIVA  MINKRIVB  MUDLAKE   PESHTIGO  RASPBERB  W.TWIN_A  W.TWIN_B

NEGATIVE PREFERENTIALS
carx  int1(  1,  2) carx  ros1(  2,  8) duli  aru1(  1,  5) eleo  sma1(  1,  4) junc  eff1(  1,  1) ment  arv1(  1,  3)
scir  cyp1(  1,  5) scir  val1(  1,  5) sola  dul1(  1,  2) acor  cal2(  1,  1) alnu  rug2(  1,  3) carx  int2(  1,  0)
carx  lac2(  4, 18) carx  ros2(  2,  2) cicu  bul2(  1,  0) duli  aru2(  1,  0) eleo  sma2(  1,  0) equi  flu2(  1,  2)
impa  cap2(  2,  4) junc  eff2(  1,  0) lyth  sal2(  1,  1) ment  arv2(  1,  0) onoc  sen2(  1,  0) pote  pal2(  1,  2)
sagi  lat2(  1,  1) scir  val2(  1,  0) sola  dul2(  1,  0) acor  cal3(  1,  0) alnu  rug3(  1,  0) carx  int3(  1,  0)
carx  lac3(  4, 12) carx  ros3(  2,  0) cicu  bul3(  1,  0) duli  aru3(  1,  0) eleo  sma3(  1,  0) equi  flu3(  1,  1)
impa  cap3(  2,  0) junc  eff3(  1,  0) lyth  sal3(  1,  1) ment  arv3(  1,  0) onoc  sen3(  1,  0) pote  pal3(  1,  0)
sagi  lat3(  1,  0) scir  val3(  1,  0) sola  dul3(  1,  0) carx  lac4(  2,  5) carx  ros4(  1,  0) carx  str4(  1,  4)
onoc  sen4(  1,  0) carx  str5(  1,  1) onoc  sen5(  1,  0)

POSITIVE PREFERENTIALS
alnu  rug1(  1, 24) cala  can1(  1, 42) camp  apal(  0, 34) carx  aqul(  0, 29) carx  las1(  0, 21) corn  sto1(  0, 13)
eupa  mac1(  0, 13) gali  tri1(  0, 19) iris  ver1(  0, 10) lath  pal1(  0, 14) lycp  ame1(  0, 11) lycp  uni1(  0, 14)
lysi  thy1(  0, 22) myrc  gal1(  0, 16) phal  aru1(  0, 13) poly  ampl(  0, 33) pote  pal1(  1, 33) salx  can1(  0, 11)
salx  ped1(  0, 12) salx  pet1(  0, 25) scir  acu1(  0, 11) scut  gal1(  0, 23) sium  sua1(  0, 11) spar  eur1(  0, 12)
spir  alb1(  0, 25) thel  pal1(  0, 17) typh  ang1(  0, 16) typh  lat1(  0, 29) cala  can2(  1, 33) carx  aqu2(  0, 13)
carx  las2(  0, 11) carx  str2(  1, 23)

NON-PREFERENTIALS
acor  cal1(  1,  6) carx  lac1(  4, 29) carx  str1(  2, 36) cicu  bul1(  1, 21) equi  flu1(  1, 12) impa  cap1(  2, 22)
lyth  sal1(  1,  6) onoc  sen1(  1, 10) sagi  lat1(  1, 18) cala  can3(  1, 16) carx  str3(  1, 14)
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*************************************************************************************************************
     DIVISION   11  (N=  39)    I.E. GROUP *011

EIGENVALUE 0.266  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
poly  perl(+)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    0     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    1

ITEMS IN NEGATIVE GROUP  22  (N=   26)         I.E. GROUP *0110
BETSIE    CLINTON   FALSE     GALIEN    KALAMAZA  KALAMAZD  PAWPAW    PENTWATR  PINCONNA  POTAWATT  PTMOULLE  STCLAIR
STONY_CR  WHITEA    CHIPPEWB  COLWELL   CROOKEDC  FLYNNC    PTPENIN   HURON     SHELDON   PRESQUE   THOMPSON  DEADHORS
LITTLE    OCONTO

ITEMS IN POSITIVE GROUP  23  (N=   13)         I.E. GROUP *0111
CORYEON   ERIEBAY   HARDWOOD  OTTER     PINE      SWANCR    WHISKEY   WHITEB    WIGWAM    WILDFBAY  WILDISLA  WILDISLB
WILDISLE

BORDERLINE POSITIVES    (N=    1)
WILDISLE

MISCLASSIFIED POSITIVES (N=    2)
SWANCR    WILDFBAY

NEGATIVE PREFERENTIALS
ascl  incl(  7,  1) caly  sepl(  8,  1) camp  apal( 10,  0) carx  bebl(  8,  1) carx  coml(  6,  1) cicu  bull( 17,  3)
eupa  macl(  9,  2) lysi  thyl(  7,  0) ment  arvl(  8,  0) pelt  virl(  6,  0) rume  orbl(  7,  1) scir  flul(  8,  2)
thel  pall(  8,  0) urti  diol(  8,  1) carx  str2(  7,  1) impa  cap2( 12,  2) typh  ang2( 12,  3) cala  can3( 14,  2)
typh  ang3(  8,  1) cala  can4(  7,  0)

POSITIVE PREFERENTIALS
alis  plal(  3,  6) bide  cerl(  5, 11) cype  strl(  1,  4) eleo  eryl(  3,  3) eupa  perl(  8,  8) junc  canl(  2,  4)
junc  dudl(  3,  3) lycp  unil(  3,  3) poly  perl(  0, 11) pote  ansl(  4,  4) ranu  scel(  4,  8) rume  marl(  0,  6)
salx  exil(  2,  3) scir  vall( 11, 11) viti  ripl(  3,  3) bide  cer2(  2,  8) poly  lap2(  1,  4) rori  pal2(  2,  7)
scir  val2(  3,  3) bide  cer3(  1,  5)

NON-PREFERENTIALS
cala  canl( 24,  9) carx  aqul(  7,  2) carx  lacl( 11,  6) carx  strl( 14,  5) corn  stol(  4,  3) epil  coll(  7,  2)
frax  penl(  5,  4) gali  tril( 13,  6) impa  capl( 21,  8) leer  oryl( 10,  5) lycp  amel( 14,  4) lyth  sall( 10,  3)
phal  arul( 10,  4) phra  ausl(  7,  6) pile  puml(  6,  2) poly  ampl( 14,  8) poly  lapl( 10,  6) poly  punl(  7,  3)
pont  corl(  5,  3) rori  pall( 14, 13) sagi  latl( 11,  4) scir  acul(  5,  3) scut  gall( 14,  6) spar  eurl( 16,  7)
typh  angl( 17, 11) typh  latl(  9,  3) verb  hasl( 11,  5) cala  can2( 18,  5) poly  amp2(  4,  3)
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**********************************************************************************************************************
     DIVISION   12  (N=   2)    I.E. GROUP *100

     DIVISION FAILS - THERE ARE TOO FEW ITEMS


**********************************************************************************************************************
     DIVISION   13  (N=   6)    I.E. GROUP *101

EIGENVALUE 0.369  AT ITERATION   1
INDICATORS, TOGETHER WITH THEIR SIGN
carx  las1(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP  -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  26  (N=    5)         I.E. GROUP *1010
AUTRAIN   PEQUAMIN  BADRIVB   RASPBERA  STOCKTON

ITEMS IN POSITIVE GROUP  27  (N=    1)         I.E. GROUP *1011
LACLABEL

NEGATIVE PREFERENTIALS
alnu  rugl(  2,  0) carx  las1(  5,  0) carx  lim1(  5,  0) cham  cal1(  5,  0) dros  rot1(  4,  0) duli  aru1(  2,  0)
equi  flu1(  2,  0) iris  ver1(  2,  0) junc  pel1(  2,  0) myrc  gal1(  5,  0) pote  pal1(  3,  0) rosa  pal1(  2,  0)
sagi  lat1(  2,  0) thuj  occ1(  2,  0) tria  fra1(  2,  0) vacc  mac1(  4,  0) vacc  oxy1(  5,  0) carx  las2(  3,  0)
carx  lim2(  2,  0) clad  mar2(  4,  0) meny  tri2(  3,  0) myrc  gal2(  4,  0) rhyn  alb2(  4,  0) sarr  pur2(  2,  0)
vacc  oxy2(  2,  0) carx  las3(  2,  0) clad  mar3(  3,  0) myrc  gal3(  2,  0)

POSITIVE PREFERENTIALS
cala  can1(  2,  1) lari  lar1(  1,  1) soli  uli1(  2,  1) pogo  oph2(  0,  1) spha  sp.4(  0,  1) spha  sp.5(  0,  1)

NON-PREFERENTIALS
clad  mar1(  4,  1) meny  tri1(  5,  1) pogo  oph1(  4,  1) rhyn  alb1(  4,  1) sarr  pur1(  5,  1) spha  sp.1(  5,  1)
spha  sp.2(  3,  1) spha  sp.3(  3,  1)


  END OF LEVEL   4


**********************************************************************************************************************
     DIVISION   21  (N=  46)    I.E. GROUP *0101

EIGENVALUE 0.259  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
thel  pall(+)   typh  ang2(+)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    2
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ITEMS IN NEGATIVE GROUP  42   (N=   36)          I.E. GROUP *01010
BAIEDAWA  BAIEDEWC  CARPPINE  CHIPPEWA  CHURCHA   DUCKBAY   FISHDAM   GOGOMAIA  GOGOMAID  HOGISNDA  HOGISNDB  HURSLEYB
INDIAN    KEMPS     MACKINAC  MISMER    MUNUSCON  ROACH     SANDIS    SCOTT     SHINGLEB  SHINGLEC  STMARTIN  SUGAR_A
SUGAR_B   TOBICO    WHIPPLEA  WHIPPLEB  KAKAGON   LONGISND  MINKRIVA  MINKRIVB  MUDLAKE   PESHTIGO  RASPBERB  W.TWIN_A

BORDERLINE NEGATIVES     (N=     2)
TOBICO    W.TWIN_A

ITEMS IN POSITIVE GROUP  43   (N=   10)          I.E. GROUP *01011
BARNETTC  HIPPEWA   CRANBERR  CROOKEDA  DEERB     DELANEY   DEXTER    LAKEVIEW  STERLING  W.TWIN_B

MISCLASSIFIED POSITIVES (N=     1)
CROOKEDA

NEGATIVE PREFERENTIALS
eupa  macl( 12,  1) eupa  perl(  8,  1) iris  verl( 10,  0) myrc  gall( 15,  1) phra  ausl(  8,  1) salx  canl( 11,  0)
salx  pedl( 11,  1) scir  acul( 10,  1) typh  latl( 26,  3) carx  las2( 10,  1) carx  str2( 22,  1) cala  can3( 15,  1)
carx  lac3( 11,  1) carx  str3( 14,  0)

POSITIVE PREFERENTIALS
acor  call(  2,  4) ascl  incl(  3,  3) caly  sepl(  1,  2) carx  coml(  0,  4) corn  amol(  1,  2) corn  foel(  0,  3)
deco  verl(  0,  4) duli  arul(  2,  3) eleo  smal(  1,  3) epil  lepl(  1,  4) gali  pall(  2,  3) impa  capl( 14,  8)
iris  virl(  1,  2) lycp  amel(  7,  4) lycp  unil(  9,  5) lysi  thyl( 12, 10) onoc  senl(  5,  5) pelt  virl(  0,  2)
pile  puml(  0,  2) poly  sagl(  2,  4) popu  trel(  2,  2) rori  pall(  2,  2) rume  orbl(  5,  3) sagi  latl( 11,  7)
scir  cypl(  3,  2) scir  flul(  1,  2) scir  vall(  3,  2) sium  sual(  7,  4) sola  dull(  0,  2) spar  eurl(  7,  5)
teuc  canl(  2,  2) thel  pall(  7, 10) tria  virl(  1,  4) typh  angl(  6, 10) vibu  lenl(  1,  2) gali  pal2(  0,  3)
impa  cap2(  2,  2) lysi  thy2(  3,  4) poly  amp2(  3,  4) thel  pal2(  1,  3) tria  vir2(  0,  2) typh  ang2(  0,  9)
typh  ang3(  0,  7) typh  ang4(  0,  2)

NON-PREFERENTIALS
alnu  rugl( 19,  5) cala  canl( 33,  9) camp  apal( 25,  9) carx  aqul( 23,  6) carx  lacl( 21,  8) carx  lasl( 18,  3)
carx  strl( 31,  5) cicu  bull( 14,  7) corn  stol( 10,  3) equi  flul(  9,  3) gali  tril( 14,  5) lath  pall( 11,  3)
lyth  sall(  4,  2) phal  arul(  9,  4) poly  ampl( 24,  9) pote  pall( 25,  8) salx  petl( 21,  4) scut  gall( 16,  7)
spir  albl( 21,  4) tria  fral(  5,  2) cala  can2( 28,  5) carx  aqu2( 11,  2) carx  lac2( 15,  3) spir  alb2(  4,  2)

*****************************************************************************************************************
     DIVISION   22  (N=  26)    I.E. GROUP *0110

EIGENVALUE 0.268  AT ITERATION   3
INDICATORS, TOGETHER WITH THEIR SIGN
rori  pall(-)   caly  sepl(+)   spar  eurl(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  44   (N=   20)          I.E. GROUP *01100
BETSIE    CLINTON   FALSE     GALIEN    KALAMAZA  KALAMAZD  PAWPAW    PENTWATR  PINCONNA  POTAWATT  PTMOULLE  STCLAIR
STONY_CR  WHITEA    CHIPPEWB  COLWELL   PTPENIN   PRESQUE   DEADHORS  OCONTO
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BORDERLINE NEGATIVES     (N=    3)
CLINTON   CHIPPEWB  COLWELL

ITEMS IN POSITIVE GROUP  45  (N=    6)         I.E. GROUP *01101
CROOKEDC  FLYNNC    HURON     SHELDON   THOMPSON  LITTLE

NEGATIVE PREFERENTIALS
ascl  incl(  7,  0) bide  cer1(  5,  0) camp  apal( 10,  0) carx  agul(  7,  0) carx  beb1(  8,  0) carx  lacl( 10,  1)
eleo  smal(  5,  0) eupa  macl(  8,  1) eupa  perl(  7,  1) junc  eff1(  5,  0) leer  ory1( 10,  0) lyth  sall(  9,  1)
pelt  virl(  6,  0) poly  lapl( 10,  0) rori  pall( 14,  0) rume  orb1(  7,  0) sagi  lat1( 11,  0) scir  acul(  5,  0)
scir  vall( 11,  0) spar  eurl( 15,  1) thel  pall(  7,  1) typh  lat1(  8,  1) verb  has1( 10,  1) cala  can4(  7,  0)

POSITIVE PREFERENTIALS
caly  sepl(  3,  5) corn  foel(  2,  2) lycp  unil(  1,  2) onoc  sen1(  2,  3) scir  flu1(  5,  3) sium  sual(  2,  2)
teuc  canl(  2,  3) vibu  lenl(  0,  2) caly  sep2(  0,  3) corn  foe2(  1,  2) phal  aru2(  2,  2) phra  aus2(  0,  2)
vibu  len2(  0,  2) typh  ang3(  5,  3)

NON-PREFERENTIALS
cala  canl( 19,  5) carx  coml(  5,  1) carx  strl( 11,  3) cicu  bull( 14,  3) epil  coll(  5,  2) gali  tril(  9,  4)
impa  capl( 15,  6) lycp  ame1( 11,  3) lysi  thyl(  5,  2) ment  arvl(  6,  2) phal  arul(  7,  3) phra  ausl(  5,  2)
pile  puml(  5,  1) poly  ampl( 12,  2) poly  punl(  6,  1) scut  gall( 11,  3) typh  angl( 12,  5) urti  diol(  6,  2)
cala  can2( 13,  5) carx  str2(  6,  1) impa  cap2(  9,  3) typh  ang2(  9,  3) cala  can3( 11,  3)

THIS IS THE END OF THE DIVISIONS REQUESTED
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*****************************************************************************************************************
     DIVISION    1  (N= 140)    I.E. GROUP *

 EIGENVALUE 0.572  AT ITERATION   2

 ITEMS IN NEGATIVE GROUP   2  (N=  110)        I.E. GROUP *0
  acer  rub  acor  cal  alis  pla  alnu  rug  anem  can  ascl  inc  betu  pap  bide  cer  boeh  cyl  cala  ark  cala  can
  caly  sep  camp  apa  carx  aqu  carx  beb  carx  com  carx  dia  carx  hys  carx  lac  carx  ros  carx  sti  carx  str
  carx  vir  ceph  occ  cicu  bul  corn  amo  corn  foe  corn  sto  cype  str  deco  ver  eleo  ell  eleo  ery  epil  col
  epil  lep  equi  arv  equi  flu  eupa  mac  eupa  per  euth  gra  frax  pen  gali  pal  gali  tri  hype  kal  impa  cap
  iris  ver  iris  vir  junc  dud  junc  eff  junc  nod  lath  pal  leer  ory  lobe  kal  lycp  ame  lycp  uni  lysi  ter
  lysi  thy  lyth  sal  ment  arv  onoc  sen  pani  lin  pelt  vir  phal  aru  phra  aus  pile  pum  poly  amp  poly  lap
  poly  per  poly  pun  poly  sag  pont  cor  popu  bal  popu  tre  pote  ans  pote  nor  pote  pal  ranu  sce  rori  pal
  rume  mar  rume  orb  sagi  lat  salx  beb  salx  can  salx  dis  salx  exi  salx  luc  salx  ped  salx  pet  salx  ser
  scir  acu  scir  ame  scir  atr  scir  cyp  scir  flu  scir  val  scut  gal  scut  lat  sium  sua  sola  dul  spar  eur
  spir  alb  teuc  can  thel  pal  tria  vir  typh  ang  typh  lat  urti  dio  verb  has  vibu  len  viol  sp.  viti  rip

 ITEMS IN POSITIVE GROUP   3  (N=   30)        I.E. GROUP *1
  carx  int  carx  las  carx  lim  cham  cal  clad  mar  dros  rot  duli  aru  eleo  aci  eleo  sma  glyc  can  junc  bal
  junc  bre  junc  can  junc  pel  lari  lar  meny  tri  myrc  gal  pogo  oph  pote  fru  rhyn  alb  rosa  pal  sarr  pur
  scir  sub  soli  uli  spha  sp.  thuj  occ  tria  fra  trig  mar  vacc  mac  vacc  oxy

   END OF LEVEL   1

*****************************************************************************************************************
     DIVISION    2  (N= 110)    I.E. GROUP *0

 EIGENVALUE 0.314  AT ITERATION   1

 ITEMS IN NEGATIVE GROUP   4  (N=   96)        I.E. GROUP *00
  acer  rub  acor  cal  alis  pla  anem  can  ascl  inc  betu  pap  bide  cer  boeh  cyl  cala  ark  cala  can  caly  sep
  carx  beb  carx  com  carx  dia  carx  hys  carx  lac  carx  ros  carx  sti  carx  str  carx  vir  ceph  occ  cicu  bul
  corn  amo  corn  foe  corn  sto  cype  str  deco  ver  eleo  ell  eleo  ery  epil  col  epil  lep  equi  arv  eupa  mac
  eupa  per  euth  gra  frax  pen  gali  pal  gali  tri  hype  kal  impa  cap  iris  vir  junc  dud  junc  eff  junc  nod
  lath  pal  leer  ory  lobe  kal  lycp  ame  lysi  thy  lyth  sal  onoc  sen  pani  lin  pelt  vir  phal  aru  phra  aus
  pile  pum  poly  amp  poly  lap  poly  per  poly  pun  popu  bal  popu  tre  pote  ans  pote  nor  ranu  sce  rori  pal
  rume  mar  rume  orb  salx  beb  salx  can  salx  dis  salx  exi  salx  luc  salx  pet  salx  ser  scir  acu  scir  ame
  scir  atr  scir  cyp  scir  flu  scir  val  scut  gal  scut  lat  sium  sua  sola  dul  spar  eur  spir  alb  teuc  can
  thel  pal  tria  vir  typh  ang  urti  dio  verb  has  vibu  len  viol  sp.  viti  rip

 ITEMS IN POSITIVE GROUP   5  (N=   14)        I.E. GROUP *01
  alnu  rug  camp  apa  carx  aqu  equi  flu  iris  ver  lycp  uni  lysi  ter  ment  arv  poly  sag  pont  cor  pote  pal
  sagi  lat  salx  ped  typh  lat
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*****************************************************************************************
     DIVISION    3  (N=  30)    I.E. GROUP *1

 EIGENVALUE 0.496  AT ITERATION   2

 ITEMS IN NEGATIVE GROUP   6  (N=    4)        I.E. GROUP *10
  glyc  can  junc  bal  pote  fru  trig  mar

 ITEMS IN POSITIVE GROUP   7  (N=   26)        I.E. GROUP *11
  carx  int  carx  las  carx  lim  cham  cal  clad  mar  dros  rot  duli  aru  eleo  aci  eleo  sma  junc  bre  junc  can
  junc  pel  lari  lar  meny  tri  myrc  gal  pogo  oph  rhyn  alb  rosa  pal  sarr  pur  scir  sub  soli  uli  spha  sp.
  thuj  occ  tria  fra  vacc  mac  vacc  oxy

   END OF LEVEL   2

*****************************************************************************************
     DIVISION    4  (N=  96)    I.E. GROUP *00

 EIGENVALUE 0.168  AT ITERATION   2

 ITEMS IN NEGATIVE GROUP   8  (N=   73)        I.E. GROUP *000
  acer  rub  acor  cal  alis  pla  anem  can  ascl  inc  betu  pap  bide  cer  boeh  cyl  cala  ark  caly  sep  carx  beb
  carx  com  carx  dia  carx  hys  carx  sti  carx  vir  ceph  occ  corn  amo  corn  foe  cype  str  deco  ver  eleo  ell
  eleo  ery  epil  col  epil  lep  eupa  per  euth  gra  frax  pen  gali  pal  hype  kal  impa  cap  iris  vir  junc  dud
  junc  eff  junc  nod  lath  pal  leer  ory  lobe  kal  lyth  sal  pani  lin  pelt  vir  phal  aru  phra  aus  pile  pum
  poly  amp  poly  lap  poly  per  poly  pun  popu  tre  pote  ans  pote  nor  ranu  sce  rori  pal  rume  mar  rume  orb
  salx  beb  salx  dis  salx  exi  scir  ame  scir  atr  scir  flu  scut  gal  scut  lat  sola  dul  spar  eur  teuc  can
  tria  vir  typh  ang  urti  dio  verb  has  vibu  len  viol  sp.  viti  rip

 ITEMS IN POSITIVE GROUP   9  (N=   23)        I.E. GROUP *001
  cala  can  carx  lac  carx  ros  carx  str  cicu  bul  corn  sto  equi  arv  eupa  mac  gali  tri  lycp  ame  lysi  thy
  onoc  sen  popu  bal  salx  can  salx  luc  salx  pet  salx  ser  scir  acu  scir  cyp  scir  val  sium  sua  spir  alb
  thel  pal

*****************************************************************************************
     DIVISION    5  (N=  14)    I.E. GROUP *01

 EIGENVALUE 0.336  AT ITERATION   2

 ITEMS IN NEGATIVE GROUP  10  (N=   11)        I.E. GROUP *010
  alnu  rug  camp  apa  carx  aqu  equi  flu  iris  ver  lycp  uni  lysi  ter  poly  sag  pote  pal  salx  ped  typh  lat

 ITEMS IN POSITIVE GROUP  11  (N=    3)        I.E. GROUP *011
  ment  arv  pont  cor  sagi  lat
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*****************************************************************************************************************
     DIVISION    6  (N=   4)    I.E. GROUP *10

     DIVISION FAILS - THERE ARE TOO FEW ITEMS

*****************************************************************************************************************
     DIVISION    7  (N=  26)    I.E. GROUP *11

 EIGENVALUE 0.301  AT ITERATION   3

 ITEMS IN NEGATIVE GROUP  14  (N=   23)        I.E. GROUP *110
  carx  int  carx  las  carx  lim  cham  cal  clad  mar  dros  rot  duli  aru  junc  bre  junc  can  junc  pel  lari  lar
  meny  tri  myrc  gal  pogo  oph  rhyn  alb  sarr  pur  scir  sub  soli  uli  spha  sp.  thuj  occ  tria  fra  vacc  mac
  vacc  oxy

 ITEMS IN POSITIVE GROUP  15  (N=    3)        I.E. GROUP *111
  eleo  aci  eleo  sma  rosa  pal

END OF LEVEL   3

*****************************************************************************************************************
     DIVISION    8  (N=  73)    I.E. GROUP *000

 EIGENVALUE 0.136  AT ITERATION   1

 ITEMS IN NEGATIVE GROUP  16  (N=   21)        I.E. GROUP *0000
  acer  rub  betu  pap  cala  ark  carx  hys  carx  vir  corn  amo  eleo  ell  eupa  per  euth  gra  frax  pen  hype  kal
  junc  nod  lobe  kal  pani  lin  phal  aru  pote  ans  pote  nor  salx  dis  scir  ame  sola  dul  viol  sp.

 ITEMS IN POSITIVE GROUP  17  (N=   52)        I.E. GROUP *0001
  acor  cal  alis  pla  anem  can  ascl  inc  bide  cer  boeh  cyl  caly  sep  carx  beb  carx  com  carx  dia  carx  sti
  ceph  occ  corn  foe  cype  str  deco  ver  eleo  ery  epil  col  epil  lep  gali  pal  impa  cap  iris  vir  junc  dud
  junc  eff  lath  pal  leer  ory  lyth  sal  pelt  vir  phra  aus  pile  pum  poly  amp  poly  lap  poly  per  poly  pun
  popu  tre  ranu  sce  rori  pal  rume  mar  rume  orb  salx  beb  salx  exi  scir  atr  scir  flu  scut  gal  scut  lat
  spar  eur  teuc  can  tria  vir  typh  ang  urti  dio  verb  has  vibu  len  viti  rip
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********************************************************************************************************************
     DIVISION    9  (N=  23)    I.E. GROUP *001

 EIGENVALUE 0.239  AT ITERATION   2

 ITEMS IN NEGATIVE GROUP  18  (N=   17)         I.E. GROUP *0010
  cala  can  carx  lac  carx  ros  cicu  bul  corn  sto  equi  arv  eupa  mac  gali  tri  lycp  ame  lysi  thy  onoc  sen
  scir  acu  scir  cyp  scir  val  sium  sua  spir  alb  thel  pal

 ITEMS IN POSITIVE GROUP  19  (N=    6)         I.E. GROUP *0011
  carx  str  popu  bal  salx  can  salx  luc  salx  pet  salx  ser

********************************************************************************************************************
     DIVISION   10  (N=  11)    I.E. GROUP *010

 EIGENVALUE 0.259  AT ITERATION   2

 ITEMS IN NEGATIVE GROUP  20  (N=    6)         I.E. GROUP *0100
  camp  apa  carx  aqu  lycp  uni  poly  sag  salx  ped  typh  lat

 ITEMS IN POSITIVE GROUP  21  (N=    5)         I.E. GROUP *0101
  alnu  rug  equi  flu  iris  ver  lysi  ter  pote  pal

********************************************************************************************************************
     DIVISION   11  (N=   3)    I.E. GROUP *011

     DIVISION FAILS - THERE ARE TOO FEW ITEMS

********************************************************************************************************************
     DIVISION   14  (N=  23)    I.E. GROUP *110

 EIGENVALUE 0.291  AT ITERATION   2

 ITEMS IN NEGATIVE GROUP  28  (N=   17)         I.E. GROUP *1100
  carx  lim  cham  cal  clad  mar  dros  rot  junc  bre  junc  can  junc  pel  meny  tri  pogo  oph  rhyn  alb  sarr  pur
  scir  sub  soli  uli  spha  sp.  thuj  occ  vacc  mac  vacc  oxy

 ITEMS IN POSITIVE GROUP  29  (N=    6)         I.E. GROUP *1101
  carx  int  carx  las  duli  aru  lari  lar  myrc  gal  tria  fra

********************************************************************************************************************
     DIVISION   15  (N=   3)    I.E. GROUP *111
     DIVISION FAILS - THERE ARE TOO FEW ITEMS

  END OF LEVEL   4
 THIS IS THE END OF THE DIVISIONS REQUESTED
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*************************************************************************************************************************

ORDER OF SPECIES INCLUDING RARER ONES
  62 junc  nod!  93 pote  nor!   7 betu  pap!  10 cala  ark!  26 carx  vir!  39 eleo  ell!  48 euth  gra!  53 hype  kal
  67 lobe  kal!  77 pani  lin!  91 pote  ans! 112 scir  ame! 139 viol  sp.!   1 acer  rub!  18 carx  hys!  31 corn  amo
  47 eupa  per!  49 frax  pen! 104 salx  dis! 121 sola  dul!  79 phal  aru!  80 phra  aus!   3 alis  pla!   6 ascl  inc
   8 bide  cer!   9 boeh  cyl!  12 caly  sep!  16 carx  com!  24 carx  sti!  27 ceph  occ!  32 corn  foe!  34 cype  str
  35 deco  ver!  40 eleo  ery!  42 epil  col!  54 impa  cap!  60 junc  dud!  61 junc  eff!  66 leer  ory!  72 lyth  sal
  78 pelt  vir!  81 pile  pum!  84 poly  lap!  85 poly  per!  86 poly  pun!  95 ranu  sce!  97 rori  pal!  99 rume  mar
 102 salx  beb! 105 salx  exi! 113 scir  atr! 115 scir  flu! 119 scut  lat! 123 spar  eur! 126 teuc  can! 132 typh  ang
 134 urti  dio! 137 verb  has! 138 vibu  len! 140 viti  rip!   2 acor  cal!   5 anem  can!  15 carx  beb!  17 carx  dia
  43 epil  lep!  50 gali  pal!  56 iris  vir!  65 lath  pal!  83 poly  amp!  90 popu  tre! 100 rume  orb! 118 scut  gal
 130 tria  vir!  68 lycp  ame!  11 cala  can!  29 cicu  bul!  46 eupa  mac!  51 gali  tri! 111 scir  acu! 117 scir  val
  20 carx  lac!  23 carx  ros!  33 corn  sto!  71 lysi  thy!  76 onoc  sen! 125 spir  alb! 127 thel  pal!  44 equi  arv
 114 scir  cyp! 120 sium  sua!  25 carx  str! 106 salx  luc! 108 salx  pet!  89 popu  bal! 103 salx  can! 109 salx  ser
  14 carx  aqu! 107 salx  ped!  13 camp  apa!  69 lycp  uni!  87 poly  sag! 133 typh  lat!   4 alnu  rug!  94 pote  pal
  45 equi  flu!  55 iris  ver!  70 lysi  ter!  73 ment  arv!  88 pont  cor! 101 sagi  lat!  52 glyc  can!  57 junc  bal
  92 pote  fru! 131 trig  mar!  30 clad  mar!  58 junc  bre!  59 junc  can! 128 thuj  occ!  36 dros  rot!  63 junc  pel
 110 sarr  pur! 122 soli  uli!  22 carx  lim!  28 cham  cal!  74 meny  tri!  82 pogo  oph!  96 rhyn  alb! 116 scir  sub
 124 spha  sp.! 135 vacc  mac! 136 vacc  oxy!  19 carx  int!  37 duli  aru!  64 lari  lar!  75 myrc  gal! 129 tria  fra
  21 carx  las!  38 eleo  aci!  41 eleo  sma!  98 rosa  pal!


ORDER OF SAMPLE UNITS
  15 EPOUFETT !  31 KENYON   !  14 ELCAJON  !  38 PECK     !  58 VOIGHT   !   5 BIGSHOAL !   7 CHEBOYGB !   8 CHEBOYGC
  59 WAUGOSHA !  70 FONDULAC !  71 POKEGAMA !  72 POKEGAMB !  91 BADRIVM  !   2 BAIEDAWA !  10 CHURCHA  !  13 DUCKBAY
  21 GOGOMAID !  26 HURSLEYB !  30 KEMPS    !  46 ROACH    !  47 SANDIS   !  50 SHINGLEC !  54 SUGAR_A  !  55 SUGAR_B
  60 WHIPPLEA !  61 WHIPPLEB !  96 KAKAGON  ! 105 RASPBERB !   3 BAIEDEWC !   6 CARPPINE !   9 CHIPPEWA !  18 FISHDAM
  20 GOGOMAIA !  24 HOGISNDA !  25 HOGISNDB !  27 INDIAN   !  33 MACKINAC !  34 MISMER   !  35 MUNUSCON !  48 SCOTT
  49 SHINGLEB !  52 STMARTIN !  57 TOBICO   !  98 LONGISND !  99 MINKRIVA ! 100 MINKRIVB ! 101 MUDLAKE  ! 103 PESHTIGO
 108 W.TWIN_A !  73 BARNETT  !  74 CHIPPEWA !  77 CRANBERR !  78 CROOKEDA !  81 DELANEY  !  82 DEXTER   !  84 LAKEVIEW
  86 STERLING ! 109 W.TWIN_B !  80 DEERB    !  17 FALSE    !  45 PTMOULLE !  51 STCLAIR  !  75 CHIPPEWB !  89 PRESQUE
  94 DEADHORS ! 102 OCONTO   !   4 BETSIE   !  11 CLINTON  !  19 GALIEN   !  28 KALAMAZA !  29 KALAMAZD !  37 PAWPAW
  39 PENTWATR !  41 PINCONNA !  44 POTAWATT !  53 STONY_CR !  63 WHITEA   !  76 COLWELL  !  85 PTPENIN  !  87 HURON
  88 SHELDON  !  90 THOMPSON !  97 LITTLE   !  79 CROOKEDC !  83 FLYNNC   !  16 ERIEBAY  !  36 OTTER    !  42 PINE
  56 SWANCR   !  64 WHITEB   !  69 WILDISLE !  12 CORYEON  !  62 WHISKEY  !  65 WIGWAM   !  67 WILDISLA !  23 HARDWOOD
  66 WILDFBAY !  68 WILDISLB !  22 GRAND    ! 106 SISKEWIT !  92 BADRIVB  !   1 AUTRAIN  !  40 PEQUAMIN ! 104 RASPBERA
 107 STOCKTON !  32 LACLABEL !  43 PORTAGE  !  93 BARKBAYA !  95 HONJOHNA !
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                0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000001111111111
                0000000001111111111111111111111111111111111111111111111111111111111111111111111111111111111111111110000000111
                0011111110000000000000000000000000000000000000000000000000111111111111111111111111111111111111111100111111
                  0001111000011111111111111111111111111111111111111111111110000000000000000000000000001111111111111  000001
                             0000000000000000000000000000000000000111111111000000000000000000000001111100000000011  01111

                   *00                   *010                       *01011             *0110               *0111        *1
                EKEPVBCCWFPPBBCDGHKRSSSSWWKRBCCFGHHIMMMSSSTLMMMPWBCCCDDLSWDFPSCPDOBCGKKPPPPSWCPHSTLCFEOPSWWCWWWHWWGSBAPRSLPBH
                PELEOIHHAOOOAAHUOUEOAHUUHHAAAAHIOOONAIUCHTOOIIUE.AHRREEAT.EATTHRECELAAAAEIOTHOTUHHIRLRTIWHIOHIIAIIRIAUEATAOAO
                ONCCIGEEUNKKDIUCGRMANIGGIIKSIRISGGGDCSNOIMBNNNDSTRIAOLXKETELMCIEAOTILLLWNNTOILPREOTOYITNAILRIGLRLLASDTQSOCRRN
                UYAKGSBBGDEERERKOSPCDNAAPPAPEPPHOIIIKMUTNAIGKKLHWNPNOATERWRSOLPSDNSNIAAPTCANTWEOLMTONEEENTDYSWDDDDNKRRUPCLTKJ
                FOJ HHOOOUGGIDCBMLSHIGRRPPGBDPPDMSSAIESTGRCIRRATIEPBKNEVLIBEUAPQHTITEMMAWOWYEENNDPLKNBR CEIEKAIWFIDEIAABKAABO
                ENO TOYYSLAAVAHAAE  SL__LLOEEIEAANNNNRC LTOSIIKINTEEEERIIN  LIEUOOEONAAWANA_ALI OSEECA  RBSOEMSOBS WVIMETBGAH
                T N  AGGHAMMMWAYIY   EABEENRWNWMIDD A O EI NVVEG_TWRDY EN_  LRWER  N ZZ TNTC LN NO D Y    LNY LOAL IBNIROEEYN
                T    LBCACAB A  DB   C  AB BCEA AAB C N BN DAB OA ARA  WGB  E B S    AD RATR     N C      E   ADYB T  NANL AA

  93 pote  nor  --1-1-1-----------1-------1--------------1----1-1--------1--------1---------1--------------------------------  000000
  26 carx  vir  122122132----------------------------1----1-1----------------------------------------------------1-----------  000001
  39 eleo  ell  -----21-1---------------------------11---------------------1--1---1-----------------------------1------------  000001
  67 lobe  kal  1111111-2-----------------------------------1----------------------------------------------------------------  000001
  91 pote  ans  -2-111211---------------------1----1--1--------------------1-1--11---------------------1--1----11------------  000001
 112 scir  ame  1-1--122-----1---------------------2-------2------------------211-------------------------------1-1----------  000001
  18 carx  hys  ------1-1----------------------------1--------2----------1------111--------1---------------------1-----------  000010
  31 corn  amo  ------1------------------------------------1-----------1-2----1----1---------1-------------1-1---------------  000010
  47 eupa  per  11--111-1---------1----------1-----11----1---111------1----11-----1--1--1-11------1--11----111-111-----------  000010
  49 frax  pen  --1---1------------1-----------------1-11-11---------------11-1-------1----------1------1----11-1------------  000010
 121 sola  dul  ------1--3---------------------------------------1--------1--------1----1----1-------------------------------  000010
  79 phal  aru  ---1-11-1---------------------1-----1-1--1-1-1111---11-2-1-12-1-2-11---1-------41-2--14-1-----1--------------  000011
  80 phra  aus  -------------------1-1---------------111----11--1-1--------1-1--1----1----1-----32---21-2-11-----1----------4  00010
   3 alis  pla  -----------------------------------1-----------------1--------1-----------1--------1-11-1---11-1-------------  000110
   6 ascl  inc  ---------------------------------------1--1-1-----1-1----1--111---1---11----1---------1----------------------  000110
   8 bide  cer  -------------1--1-1---1--------------------------1------------------1--21-3---1------1-242-3533112-----------  000110
  12 caly  sep  -------------------------------------------1------11--------------1-1---1------2212-1-----1------------------  000110
  16 carx  com  ---------------------------------------------------112--1-----1--11-------11--------2------------1-----------  000110
  32 corn  foe  --------------------------------------------------111--------13--------------------22------------------------  000110
  35 deco  ver  ---------------------------------------------------11---1-1---------1--1--3---2------------------------------  000110
  42 epil  col  ----------------------------------------------------1--------1----1--1--1-1--------11-----------11-----------  000110
  54 impa  cap  ---------3-3-1-11-1-------1---11--11------1-121-21211211-1--1-1---112522132312311122311212--11---1-----------  000110
  61 junc  eff  ------------3------------------------------1------------------1--121----1------------------------------------  000110
  66 leer  ory  -------------------------------------------1--------------------111-1-211-1-1-1------21-31--1-----1----------  000110
  72 lyth  sal  -----------3--1---------------------------13---1--1-1-------31--13-1-11---1--1----1--11----1-----------------  000110
  78 pelt  vir  -------------------------------------------------------1--2---------3-22--3--11------------------------------  000110
  81 pile  pum  ---------------------------------------------------1-----1----------1--12-2-1-----1---1--1-------------------  000110
  84 poly  lap  ------------------1----------------------------------------------1-11111-2111--------32-42-1-----1-----------  000110
  85 poly  per  --------1----------------------------------------------------------------------------111-1111111-2-----------  000110
  86 poly  pun  -------------------------------------------------------------1-------11-1-1-1---1----1--11-------------------  000110
  95 ranu  sce  -------------1--1-1-----------------------------------------1-----------1-1-1--------1-111-1-111-------------  000110
  97 rori  pal  ------1-----------1-----------1-----------------------1--1-111----111-11121121-------2123322111112-----------  000110
 115 scir  flu  -----------------------------------------------1----1-1----------1--1111--------1-12-11----------------------  000110
 123 spar  eur  ----------------1-1-------13---1---1--------1-----1111---1-----12111-11121-12112---1--11-121--11----1--------  000110
 132 typh  ang  ------11-------11----1----------------1-----11---433132342312-3122-33--32----3111-333224111--11111-----------  000110
```

```
134 urti  dio  --------1-----------------------------------------------------1---------1-----12111--1--1----1---------------------  000110
137 verb  has  ------------------------------------1-----1-----------------111-1-1----11-111-----1--11----1---1-1-----------  000110
  2 acor  cal  ---------3---------------1------------------1----11-21-----------------------------------------------------------  000111
 15 carx  beb  --------1-------1----------------1---1----1---2-11--------1-1111-11------1-1----------------------1-----------  000111
 50 gali  pal  ---------------------11--------------------------------222--------------------21-------------------2-----------  000111
 65 lath  pal  -----------------1--1----------1-1----1---11--1111-1-1-1------11---1---------------1----------------------------  000111
 83 poly  amp  -------------1111-11--1-21----111---1111121-11211211122211-2-11--112-52-1-1--11---1-1-1--221-11-121----------  000111
100 rume  orb  -----------------1---------11------------------11-1-1----1----1---1--1-1--111--------1----------------------------  000111
118 scut  gal  ---------------21-11---1------111---111--121-11---1-111111-111----11--121--1-11--1-111111-1------1-----------  000111
 68 lycp  ame  --1---111------11-11---------------11----1---------1-1-1-1--111----1-11--1-11-12--11-1--1-----1----11-1---1-----  001000
 11 cala  can  541111211---3311223312233-1-232243221232322-33335211222114-2431544311113251-443-333221-2-321--13211--1-1-1---  001001
 29 cicu  bul  1--------3---1----1--1--1-11-------11----1--11111-1-111111----111111-11-132-111---111----1-----11-11---------  001001
 46 eupa  mac  ---------------------1-------------11-1-11-112111--------1--------1-1-111-111-----1-------------1-21----------  001001
 51 gali  tri  ---------------111-111----------1----1-1--11---112-1112---1--1-1-111-1--1---11----112111-11------1111----------  001001
111 scir  acu  --11221-1------------------1---1------111211---11------1-----1----11--1-----1--------------------111----1-------  001001
117 scir  val  -----1-------3-------------------------1------1--1-----1-----1----11221-211-1-11---------11111-23131-11----------  001001
 20 carx  lac  ---------3344--441433423-233--2--------231--1-11312112114-1-----1-11---1111--13-1---1-----1-1--111-1-1---------1  001010
 23 carx  ros  ---------3--4--------211--12--------------1-------1------1----------11----------1--------------------1------1---------  001010
 33 corn  sto  -------------------------1---------1--11--1-11111--1-----11---1---1--------11--------------------111-1----------  001010
 71 lysi  thy  -------1---------1--1-------2-----1--121-----1-111-221112121211--1----1-----------21----11---------------11---------  001010
 76 onoc  sen  ---------5-----------1------------------------11--1-1-111-1--1----1-------------1------1-11------------------1----------  001010
125 spir  alb  ------1-------31-1-11-11-2-1-1-1111-1-2-21-1---11--1-2-3--1---11----------1-1-----------------1------1--1---1------  001010
127 thel  pal  -------------------------------1-----1------2-1111-21111213111-11-----1-----11--3----1-----------------1----------  001010
 44 equi  arv  -------------2-------1---------1----1--1-1-------------------------------------1------------------1-2------1-------  001011
114 scir  cyp  -------------1-----1-------------------------1---1--1---1---------1-1----------1------1----------------------------1  001011
120 sium  sua  ---------------1-1-1-------11-1------1---------------111-1----------------1-------1----11-------1--1----------1--  001011
 25 carx  str  3----11----514-12-13133-511-133332-13432242112322111--2--1-1-313-131--2-2-1-2-----121---1-2----1112----------  00110
108 salx  pet  ------1-------1-11111-1------1-12111111-1-11-1---1----11-----11-----1--------------------------1--------------------  00110
103 salx  can  -----11-----------------------11---1121-1-1--11--1-----------1---------------1-------------------------------------  00111
 14 carx  aqu  ---1----1-----3111111--2-11-322-2221--2--1--2121--1122---11-----11------2-2311-----------------12-1---------12  01000
107 salx  ped  --------------1-----1-11-111--11-----------1--1-------------1-------------------------------------------1----------  01000
 13 camp  apa  1--11-1-------1-11--1---1--2-111111-1211-11112221221111111-1-1---11--1--1-1211------------------------111---------  01001
 69 lycp  uni  ---11----------1-------------------1--1------2-1111121-11---1-----------------------1---2--1--------1---111--1-------  01001
 87 poly  sag  ----------------------1-------------------1----------11-11-----------------11-----------------1------------1-----------  01001
133 typh  lat  ------1-1----131121112112123-1--1-11--1111---11-1-111---------------11--112-111------2--1-1-1--------111-----1--  01001
  4 alnu  rug  -----11--3---2-2---1-1-1--1--111-1-1-11-11--111-11-11--1-2---------1--------111---------------------1----11-11---1--  01010
 94 pote  pal  1-----------311-1-11-111-1111-1-111121-11---1111-1111--1211---1-------------1---1-------------------1--1121-1--1--  01010
 45 equi  flu  ------1---3---3-1--1-11---------1---2----11--------11--1------1--------------------------------------------1-1-1---1-1  01011
 55 iris  ver  --------------------------11-----1--1-1-2-1--111--------------------1-------------------------------------------11----1--  01011
 70 lysi  ter  1---------------1-----1-----1-2-----1----11-------------------------------1------------------------------------1---------1  01011
 73 ment  arv  ---------3-----------------------------------1--11-------------1-------1-11----11----11---------------------1---------1--  011
 88 pont  cor  --------------11-11---11----------------------------------------1---------1-1-1-1------1-------1---1----1--------------1-1  011
101 sagi  lat  -----11-----3---1----1----2--------11----1--11111111111--1----11121-----1-11133----------11-----21--1-11-----1-3  011
 52 glyc  can  -----11-1------------------------1----------11-----1------------1---------------------------------------------1-----------  10
 57 junc  bal  -3211-1-1-----------------------11-----1-------12-----------------------------------------------1--------------11-1------------  10
 92 pote  fru  --1111111-------------------------1----2-1------------------------------------------------------------------------1-1--1--------  10
131 trig  mar  1-1--1111----------------------------11-------------------------------------------------------------------------1--1----------  10
 30 clad  mar  3-1211212-----------------------------1-------------------------------------------------------------------------1--1-32331-3-  11000
 58 junc  bre  -----2-11-----------------------------1----1-1----------------------------------------------------------------------2----------1  11000
 59 junc  can  -----2-11-----------------------------11-1--1-----------------11----------------------------------11-----1---1---------2-111  11000
128 thuj  occ  --1-1---1-----------------------------1---1----1-------------1---------------------------------------------------1--11------  11000
```

TWINSPAN for Herbaceous Zones

```
110 sarr  pur  --1-1-1-------------------1---------------------------------------------------------------------11121211---  110010
 22 carx  lim  ----1--------------------------------------------------------------------------------------------112121-1--  110011
 28 cham  cal  ------------------------------------------------------------------------------------------------1121111-111  110011
 74 meny  tri  ------------------------------------------------------------------------------------------------11312211---  110011
 82 pogo  oph  -----------------------------------------------------------------------------------------------3-1111-12---  110011
 96 rhyn  alb  ------------------------------------------------------------------------------------------------11-22221---  110011
124 spha  sp.  --------------------------1----------------------------------------------------------------------1313135---  110011
 19 carx  int  --11--------3-----------------------------1-1---------------------------------------------------11---------  110100
 37 duli  aru  ------------3--------1--------------------1-------11-----1--------------------------------------1--1--1-133  110101
 75 myrc  gal  ---1111------11------11---1-2211-2-1-1--1--1--3----------1--------------------------------------2131232-221  110101
129 tria  fra  --------------------------1--1-----1---------1-1-----1----1-------------------------------------111--1--1--  110101
 21 carx  las  -----23-1------1-11122---3-321-1--311-4--322-----------112--------------------------------------2231231-433  11011
 41 eleo  sma  -----1------3---------------------------1-------1-11-----------321-------1-1----------------2---11---1---11  111
 98 rosa  pal  --------------------------1--------------1---11------------------1-------111--------------------111-1------  111

               00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000001111111111
               00000000011111111111111111111111111111111111111111111111111111111111111111111111111111111111111110000000111
               00111111100000000000000000000000000000000000000000000001111111111111111111111111111111111001111111
                 0001111000011111111111111111111111111111111111111111111100000000000000000000000111111111111   000001
                            000000000000000000000000000000000111111111111111100000000000000000111111000000000111   01111
                            00000000000000111111111111111111111111000000000010000001111111111110000110000000111
```

TWINSPAN for Herbaceous Zones

APPENDIX VI

TWINSPAN Ordination of Shrub Zones

ALL SHRUB ZONES: Species occurring in 2 or more transects

```
 NUMBER OF SAMPLES     36

 NUMBER OF SPECIES    131

 LENGTH OF RAW DATA ARRAY  1554

 SPECIES NAMES
   1 abie  bal!   2 acer  rub!   3 alnu  rug!   4 andr  gla!   5 aron  mel!   6 ascl  inc!   7 betu  pap!   8 betu  pum
   9 bide  cer!  10 bide  con!  11 bide  fro!  12 cala  can!  13 call  pal!  14 camp  apa!  15 carx  aqu!  16 carx  bux
  17 carx  cho!  18 carx  com!  19 carx  ebu!  20 carx  exi!  21 carx  int!  22 carx  lac!  23 carx  las!  24 carx  lim
  25 carx  liv!  26 carx  pau!  27 carx  ros!  28 carx  str!  29 carx  tri!  30 carx  ves!  31 ceph  occ!  32 cham  cal
  33 cicu  bul!  34 clad  mar!  35 corn  amo!  36 corn  can!  37 corn  sto!  38 cusc  gro!  39 deco  ver!  40 dros  int
  41 dros  rot!  42 duli  aru!  43 eleo  sma!  44 equi  arv!  45 equi  flu!  46 equi  pal!  47 erio  spi!  48 erio  vir
  49 eupa  mac!  50 eupa  per!  51 frax  pen!  52 gali  pal!  53 gali  tri!  54 glyc  can!  55 ilex  ver!  56 impa  cap
  57 iris  ver!  58 junc  bal!  59 junc  pel!  60 kalm  pol!  61 lari  lar!  62 ledu  gro!  63 leer  ory!  64 lemn  min
  65 lycp  ame!  66 lycp  uni!  67 lysi  ter!  68 lysi  thy!  69 lyth  sal!  70 ment  arv!  71 meny  tri!  72 myrc  gal
  73 nemo  muc!  74 onoc  sen!  75 osmu  reg!  76 pelt  vir!  77 phal  aru!  78 phra  aus!  79 pice  gla!  80 pice  mar
  81 pile  fon!  82 pile  pum!  83 pinu  str!  84 plat  cla!  85 pogo  oph!  86 poly  amp!  87 pont  cor!  88 pote  ans
  89 pote  fru!  90 pote  nor!  91 pote  pal!  92 rhyn  alb!  93 rosa  pal!  94 rume  orb!  95 sagi  lat!  96 salx  beb
  97 salx  can!  98 salx  luc!  99 salx  ped! 100 salx  pet! 101 salx  pyr! 102 salx  ser! 103 sarr  pur! 104 sche  pal
 105 scir  acu! 106 scir  ces! 107 scir  cyp! 108 scut  gal! 109 sium  sua! 110 sola  dul! 111 soli  uli! 112 spar  eur
 113 spha  sp.! 114 spir  alb! 115 thel  pal! 116 thuj  occ! 117 tria  fra! 118 tria  vir! 119 trig  mar! 120 typh  ang
 121 typh  gla! 122 typh  lat! 123 urti  dio! 124 utri  cor! 125 utri  int! 126 utri  vul! 127 vacc  ang! 128 vacc  mac
 129 vacc  oxy! 130 vibu  rec! 131 viti  rip!

 SAMPLE-UNIT NAMES
   1 AUTRAIN  !   2 BADRIVER !   3 BARKBAY  !   4 BARLAKE  !   5 BLACK_A  !   6 BLACK_B  !   7 CARP_RIV !   8 CHEBOYGA
   9 CHEBOYGC !  10 DEER_CR  !  11 EASTBAY  !  12 EPOUFETT !  13 FONDULAC !  14 HOGISLD  !  15 HONJOHNA !  16 HONJOHNB
  17 HURSLEYA !  18 HURSLEYB !  19 INDEPEND !  20 INDIAN   !  21 KAKAGON  !  22 LACLABEL !  23 PEQUAMIN !  24 POTAWATT
  25 PTPENINS !  26 RASPBERR !  27 BIGSABLE !  28 SAGANING !  29 SANDISLD !  30 SISKEWIT !  31 STERLING !  32 STURGEON
  33 SUGARIS  !  34 THOMPSON !  35 WESTTWIN !  36 WHITERIV !

 CUT LEVELS:        0.00   10.00   20.00   40.00   60.00

   MAXIMUM NUMBER OF PSEUDOSPECIES POSSIBLE:    2537
   LENGTH OF DATA ARRAY AFTER DEFINING PSEUDOSPECIES:    1171
   TOTAL NUMBER OF PSEUDOSPECIES AND SPECIES:    265
   NUMBER OF SPECIES (EXCLUDING NO OCCURANCES):    131
```

```
*****************************************************************************************************************************
     DIVISION    1  (N=  36)    I.E. GROUP *

 EIGENVALUE 0.600  AT ITERATION   2
 INDICATORS, TOGETHER WITH THEIR SIGN
 myrc  gal2(-)   impa  cap1(+)   carx  las1(-)   utri  int1(-)
 MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

 ITEMS IN NEGATIVE GROUP   2  (N=   24)        I.E. GROUP *0
 AUTRAIN   BADRIVER  BARKBAY   BLACK_A   CARP_RIV  CHEBOYGA  CHEBOYGC  DEER_CR   EPOUFETT  HOGISLD   HONJOHNA  HONJOHNB
 HURSLEYA  HURSLEYB  INDEPEND  INDIAN    KAKAGON   LACLABEL  PEQUAMIN  RASPBERR  SANDISLD  SISKEWIT  STURGEON  SUGARIS

 BORDERLINE NEGATIVES    (N=    1)
 INDIAN

 ITEMS IN POSITIVE GROUP   3  (N=   12)        I.E. GROUP *1
 BARLAKE   BLACK_B   EASTBAY   FONDULAC  POTAWATT  PTPENINS  BIGSABLE  SAGANING  STERLING  THOMPSON  WESTTWIN  WHITERIV

 NEGATIVE PREFERENTIALS
 andr  gla1( 11,  0) betu  pum1(  5,  0) carx  aqu1(  9,  0) carx  int1(  5,  0) carx  lac1( 11,  2) carx  las1( 15,  0)
 carx  lim1(  6,  0) carx  str1( 13,  3) cham  cal1( 13,  0) clad  mar1( 10,  0) dros  rot1(  8,  0) equi  flu1(  7,  0)
 iris  ver1(  6,  0) lari  lar1( 12,  0) lysi  ter1(  9,  1) meny  tri1( 10,  0) myrc  gal1( 22,  1) nemo  muc1(  5,  0)
 pogo  oph1(  7,  0) pote  pal1( 17,  3) rhyn  alb1(  7,  0) rosa  pal1( 10,  2) salx  ped1( 10,  0) salx  pet1(  8,  0)
 sarr  pur1( 11,  0) soli  uli1(  5,  0) spha  sp.1( 12,  0) spir  alb1( 11,  0) typh  lat1(  9,  2) utri  int1( 15,  0)
 utri  vul1(  6,  0) vacc  mac1(  8,  0) vacc  oxy1(  6,  0) andr  gla2(  8,  0) carx  las2( 12,  0) carx  str2(  9,  1)
 cham  cal2( 11,  0) meny  tri2(  6,  0) myrc  gal2( 21,  0) pote  pal2(  5,  0) spha  sp.2( 12,  0) carx  las3(  6,  0)
 carx  str3(  5,  0) cham  cal3(  6,  0) myrc  gal3( 13,  0) spha  sp.3(  9,  0)

 POSITIVE PREFERENTIALS
 bide  fro1(  0,  4) ceph  occ1(  0,  3) cicu  bul1(  4,  5) deco  ver1(  1,  4) eupa  per1(  3,  3) frax  pen1(  2,  3)
 gali  pal1(  0,  4) gali  tri1(  2,  3) impa  cap1(  2, 10) lemn  min1(  1,  4) lycp  ame1(  4,  7) onoc  sen1(  3,  5)
 pelt  vir1(  2,  4) poly  amp1(  1,  4) sagi  lat1(  3,  4) scut  gal1(  1,  6) sola  dul1(  0,  6) thel  pal1(  5,  5)
 tria  vir1(  2,  3) typh  gla1(  1,  3) urti  dio1(  0,  5) viti  rip1(  0,  3) alnu  rug2(  3,  7) deco  ver2(  0,  4)
 impa  cap2(  0,  6) pelt  vir2(  1,  3) sagi  lat2(  0,  3) thel  pal2(  0,  4) urti  dio2(  0,  3) alnu  rug3(  0,  6)
 deco  ver3(  0,  3) impa  cap3(  0,  5) sagi  lat3(  0,  3) thel  pal3(  0,  3)

 NON-PREFERENTIALS
 alnu  rug1( 21,  9) cala  can1( 15,  6) camp  apa1( 12,  4) corn  sto1(  5,  4) lycp  uni1(  5,  2) lysi  thy1(  7,  4)
 osmu  reg1(  4,  3) tria  fra1(  7,  2) cala  can2(  8,  4) cala  can3(  6,  4)

   END OF LEVEL   1
```

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*************************************************************************************************************************
      DIVISION    2  (N=  24)    I.E. GROUP *0

 EIGENVALUE 0.507  AT ITERATION   3
 INDICATORS, TOGETHER WITH THEIR SIGN
 andr  gla1(-)
 MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

 ITEMS IN NEGATIVE GROUP   4  (N=   11)          I.E. GROUP *00
 BADRIVER  BARKBAY   BLACK_A   DEER_CR   HONJOHNB  INDEPEND  LACLABEL  PEQUAMIN  RASPBERR  SISKEWIT  STURGEON

 ITEMS IN POSITIVE GROUP   5  (N=   13)          I.E. GROUP *01
 AUTRAIN   CARP_RIV  CHEBOYGA  CHEBOYGC  EPOUFETT  HOGISLD   HONJOHNA  HURSLEYA  HURSLEYB  INDIAN    KAKAGON   SANDISLD
 SUGARIS

 BORDERLINE POSITIVES    (N=    1)
 KAKAGON

 NEGATIVE PREFERENTIALS
 andr  gla1( 11,  0) aron  mel1(  4,  0) carx  int1(  5,  0) carx  las1( 10,  5) carx  lim1(  6,  0) cham  cal1( 11,  2)
 clad  mar1(  8,  2) corn  can1(  3,  0) dros  int1(  4,  0) dros  rot1(  8,  0) duli  aru1(  3,  0) eleo  sma1(  3,  0)
 equi  flu1(  6,  1) equi  pal1(  3,  0) erio  vir1(  3,  0) iris  ver1(  5,  1) kalm  pol1(  3,  0) lari  lar1(  8,  4)
 ledu  gro1(  4,  0) lycp  ame1(  3,  1) meny  tri1( 10,  0) nemo  muc1(  5,  0) pogo  oph1(  7,  0) rhyn  alb1(  7,  0)
 rosa  pal1(  7,  3) sarr  pur1( 10,  1) sche  pal1(  4,  0) spha  sp.1( 11,  1) thel  pal1(  4,  1) thuj  occ1(  3,  1)
 tria  fra1(  5,  2) vacc  mac1(  8,  0) vacc  oxy1(  6,  0) andr  gla2(  8,  0) carx  las2(  9,  3) cham  cal2(  9,  2)
 meny  tri2(  6,  0) rhyn  alb2(  3,  0) sarr  pur2(  3,  0) spha  sp.2( 11,  1) carx  las3(  5,  1) cham  cal3(  4,  2)
 spha  sp.3(  9,  0)

 POSITIVE PREFERENTIALS
 cala  can1(  3, 12) carx  str1(  2, 11) cicu  bul1(  1,  3) corn  sto1(  1,  4) eupa  per1(  0,  3) glyc  can1(  0,  3)
 junc  bal1(  0,  3) phal  aru1(  1,  3) pote  fru1(  0,  3) salx  can1(  0,  3) salx  pet1(  0,  8) scir  acu1(  0,  3)
 scir  cyp1(  0,  3) spir  alb1(  2,  9) cala  can2(  0,  8) carx  aqu2(  0,  4) carx  lac2(  0,  4) carx  str2(  1,  8)
 lysi  ter2(  0,  3) salx  pet2(  0,  3) cala  can3(  0,  6) carx  lac3(  0,  3) carx  str3(  0,  5) salx  pet3(  0,  3)

 NON-PREFERENTIALS
 alnu  rug1( 11, 10) betu  pum1(  3,  2) camp  apa1(  4,  8) carx  aqu1(  3,  6) carx  lac1(  4,  7) lycp  uni1(  2,  3)
 lysi  ter1(  4,  5) lysi  thy1(  4,  3) myrc  gal1( 11, 11) pote  pal1(  7, 10) salx  ped1(  5,  5) soli  uli1(  3,  2)
 typh  lat1(  4,  5) utri  int1(  9,  6) utri  vul1(  2,  4) myrc  gal2( 10, 11) pote  pal2(  2,  3) myrc  gal3(  6,  7)
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*****************************************************************************************************************************
     DIVISION    3  (N=  12)    I.E. GROUP *1

 EIGENVALUE 0.599  AT ITERATION   3
 INDICATORS, TOGETHER WITH THEIR SIGN
 cicu  bull(+)
 MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    0     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    1

 ITEMS IN NEGATIVE GROUP   6  (N=    7)         I.E. GROUP *10
 FONDULAC  POTAWATT  BIGSABLE  SAGANING  THOMPSON  WESTTWIN  WHITERIV

 ITEMS IN POSITIVE GROUP   7  (N=    5)         I.E. GROUP *11
 BARLAKE   BLACK_B   EASTBAY   PTPENINS  STERLING

 NEGATIVE PREFERENTIALS
 camp  apa1(  3,   1) carx  lac1(  2,   0) eupa  mac1(  2,   0) eupa  per1(  3,   0) frax  pen1(  3,   0) gali  tri1(  3,   0)
 leer  ory1(  2,   0) lycp  uni1(  2,   0) ment  arv1(  2,   0) pile  pum1(  2,   0) sagi  lat1(  3,   1) salx  beb1(  2,   0)
 cala  can2(  4,   0) camp  apa2(  2,   0) carx  lac2(  2,   0) corn  sto2(  2,   0) impa  cap2(  5,   1) lycp  uni2(  2,   0)
 onoc  sen2(  2,   0) sagi  lat2(  3,   0) salx  beb2(  2,   0) cala  can3(  4,   0) camp  apa3(  2,   0) corn  sto3(  2,   0)
 impa  cap3(  4,   1) onoc  sen3(  2,   0) sagi  lat3(  3,   0) salx  beb3(  2,   0) cala  can4(  2,   0) corn  sto4(  2,   0)

 POSITIVE PREFERENTIALS
 acer  rub1(  0,   1) bide  con1(  0,   2) bide  fro1(  0,   4) ceph  occ1(  0,   3) cicu  bull(  0,   5) cusc  gro1(  0,   2)
 deco  ver1(  0,   4) gali  pal1(  0,   4) ilex  ver1(  0,   2) lemn  min1(  0,   4) lysi  thy1(  1,   3) lyth  sal1(  0,   2)
 myrc  gal1(  0,   1) osmu  reg1(  1,   2) pelt  vir1(  0,   4) pile  fon1(  0,   2) poly  amp1(  1,   3) pote  pal1(  0,   3)
 rume  orb1(  0,   2) sium  sua1(  0,   1) sola  dul1(  2,   4) spar  eur1(  0,   1) thel  pal1(  2,   3) tria  vir1(  0,   3)
 typh  gla1(  0,   3) urti  dio1(  1,   4) vibu  rec1(  0,   2) bide  fro2(  0,   2) ceph  occ2(  0,   2) cicu  bul2(  0,   2)
 cusc  gro2(  0,   2) deco  ver2(  0,   4) gali  pal2(  0,   1) ilex  ver2(  0,   1) lemn  min2(  0,   1) lycp  ame2(  0,   1)
 osmu  reg2(  0,   1) pelt  vir2(  0,   3) thel  pal2(  1,   3) tria  vir2(  0,   1) typh  gla2(  0,   2) urti  dio2(  1,   2)
 ceph  occ3(  0,   1) cicu  bul3(  0,   1) deco  ver3(  0,   3) osmu  reg3(  0,   1) pelt  vir3(  0,   1) thel  pal3(  1,   2)
 typh  gla3(  0,   2) urti  dio3(  0,   2) deco  ver4(  0,   2) osmu  reg4(  0,   1) osmu  reg5(  0,   1)

 NON-PREFERENTIALS
 alnu  rug1(  5,   4) ascl  inc1(  1,   1) cala  can1(  4,   2) carx  com1(  1,   1) carx  str1(  2,   1) corn  sto1(  2,   2)
 impa  cap1(  6,   4) lycp  ame1(  3,   4) onoc  sen1(  3,   2) rosa  pal1(  1,   1) scut  gal1(  3,   3) tria  fra1(  1,   1)
 typh  ang1(  1,   1) typh  lat1(  1,   1) viti  rip1(  2,   1) alnu  rug2(  4,   3) scut  gal2(  1,   1) alnu  rug3(  4,   2)
 alnu  rug4(  1,   1)

   END OF LEVEL   2
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*************************************************************************************************************************
     DIVISION    4  (N=  11)    I.E. GROUP *00

EIGENVALUE 0.295  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
carx  exil(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP   8  (N=    2)         I.E. GROUP *000
LACLABEL  PEQUAMIN

ITEMS IN POSITIVE GROUP   9  (N=    9)         I.E. GROUP *001
BADRIVER  BARKBAY   BLACK_A   DEER_CR   HONJOHNB  INDEPEND  RASPBERR  SISKEWIT  STURGEON

NEGATIVE PREFERENTIALS
abie  ball(  1,   1) betu  papl(  1,   0) betu  puml(  1,   2) cala  canl(  1,   2) carx  exil(  2,   0) carx  paul(  1,   1)
carx  tril(  1,   1) corn  canl(  1,   2) duli  arul(  1,   2) equi  arvl(  1,   0) erio  spil(  1,   1) erio  virl(  1,   2)
ilex  verl(  1,   0) junc  pell(  1,   0) kalm  poll(  2,   1) ledu  grol(  2,   2) nemo  mucl(  2,   3) pice  marl(  2,   0)
pinu  strl(  2,   0) sche  pall(  2,   2) scir  cesl(  2,   0) soli  ulil(  2,   1) thuj  occl(  2,   1) utri  corl(  1,   1)
utri  vull(  1,   1) vacc  angl(  1,   1) clad  mar2(  1,   1) dros  int2(  1,   0) pogo  oph2(  1,   1) rhyn  alb2(  2,   1)

POSITIVE PREFERENTIALS
camp  apal(  0,   4) carx  aqul(  0,   3) carx  chol(  0,   2) carx  ebul(  0,   2) carx  intl(  0,   5) carx  lacl(  0,   4)
carx  lasl(  1,   9) carx  livl(  0,   2) carx  rosl(  0,   2) carx  strl(  0,   2) carx  vesl(  0,   2) eleo  smal(  0,   3)
equi  pall(  0,   3) iris  verl(  0,   5) lycp  amel(  0,   3) lycp  unil(  0,   2) lysi  terl(  0,   4) lysi  thyl(  0,   4)
osmu  regl(  0,   2) pelt  virl(  0,   2) plat  clal(  0,   2) pote  pall(  0,   7) salx  pedl(  0,   5) spir  albl(  0,   2)
thel  pall(  0,   4) tria  fral(  0,   5) typh  latl(  0,   4) cham  cal2(  0,   9) pote  pal2(  0,   2) sarr  pur2(  0,   3)
vacc  mac2(  0,   2) vacc  oxy2(  0,   2) andr  gla3(  0,   2) carx  las3(  0,   5) cham  cal3(  0,   4) myrc  gal3(  0,   6)
spha  sp.4(  0,   2)

NON-PREFERENTIALS
alnu  rugl(  2,   9) andr  glal(  2,   9) aron  mell(  1,   3) carx  liml(  1,   5) cham  call(  2,   9) clad  marl(  2,   6)
dros  intl(  1,   3) dros  rotl(  2,   6) equi  flul(  1,   5) lari  larl(  2,   6) meny  tril(  2,   8) myrc  gall(  2,   9)
pogo  ophl(  2,   5) rhyn  albl(  2,   5) rosa  pall(  1,   6) sarr  purl(  2,   8) spha  sp.1(  2,   9) utri  intl(  2,   7)
vacc  macl(  2,   6) vacc  oxyl(  1,   5) andr  gla2(  1,   7) carx  las2(  1,   8) meny  tri2(  1,   5) myrc  gal2(  2,   8)
spha  sp.2(  2,   9) spha  sp.3(  2,   7)
```

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*************************************************************************************************************************
     DIVISION    5  (N=  13)    I.E. GROUP *01

 EIGENVALUE 0.534  AT ITERATION   1
 INDICATORS, TOGETHER WITH THEIR SIGN
 lari  lar1(+)
 MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP    0     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    1

 ITEMS IN NEGATIVE GROUP  10  (N=    9)        I.E. GROUP *010
 AUTRAIN   HOGISLD   HONJOHNA  HURSLEYA  HURSLEYB  INDIAN    KAKAGON   SANDISLD  SUGARIS

 ITEMS IN POSITIVE GROUP  11  (N=    4)        I.E. GROUP *011
 CARP_RIV  CHEBOYGA  CHEBOYGC  EPOUFETT

 NEGATIVE PREFERENTIALS
 betu  pum1(  2,   0) carx  aqu1(  5,   1) carx  lac1(  7,   0) cham  cal1(  2,   0) cicu  bul1(  3,   0) impa  cap1(  2,   0)
 onoc  sen1(  2,   0) rosa  pal1(  3,   0) rume  orb1(  2,   0) sagi  lat1(  2,   0) salx  pet1(  7,   1) salx  pyr1(  2,   0)
 scir  cyp1(  3,   0) utri  int1(  5,   1) utri  vul1(  4,   0) alnu  rug2(  2,   0) carx  lac2(  4,   0) cham  cal2(  2,   0)
 salx  pet2(  3,   0) spir  alb2(  2,   0) typh  lat2(  2,   0) utri  int2(  2,   0) carx  lac3(  3,   0) cham  cal3(  2,   0)
 pote  pal3(  2,   0) salx  pet3(  3,   0) utri  int3(  2,   0) salx  pet4(  2,   0)

 POSITIVE PREFERENTIALS
 carx  bux1(  0,   2) clad  mar1(  0,   2) corn  amo1(  0,   1) equi  flu1(  0,   1) eupa  per1(  0,   3) frax  pen1(  1,   1)
 ilex  ver1(  0,   1) junc  bal1(  0,   3) junc  pel1(  0,   1) lari  lar1(  0,   4) lycp  ame1(  0,   1) lycp  uni1(  1,   2)
 lysi  ter1(  2,   3) ment  arv1(  0,   2) osmu  reg1(  0,   2) phal  aru1(  0,   3) pice  gla1(  0,   2) pote  ans1(  0,   2)
 pote  fru1(  0,   3) salx  can1(  0,   3) salx  luc1(  1,   1) salx  ped1(  2,   3) sarr  pur1(  0,   1) scir  acu1(  0,   3)
 scut  gal1(  0,   1) sium  sua1(  0,   1) soli  uli1(  0,   2) thuj  occ1(  0,   1) tria  fra1(  1,   1) tria  vir1(  0,   1)
 trig  mar1(  0,   2) typh  ang1(  0,   1) utri  cor1(  0,   1) camp  apa2(  1,   1) carx  las2(  1,   2) frax  pen2(  0,   1)
 junc  bal2(  0,   1) lari  lar2(  0,   1) lycp  uni2(  0,   1) lysi  ter2(  1,   2) osmu  reg2(  0,   1) phal  aru2(  0,   1)
 pice  gla2(  0,   1) pote  fru2(  0,   2) camp  apa3(  0,   1) carx  las3(  0,   1) junc  bal3(  0,   1) cala  can4(  0,   1)

 NON-PREFERENTIALS
 alnu  rug1(  7,   3) cala  can1(  9,   3) camp  apa1(  5,   3) carx  las1(  3,   2) carx  str1(  7,   4) corn  sto1(  3,   1)
 glyc  can1(  2,   1) lysi  thy1(  2,   1) myrc  gal1(  7,   4) pote  pal1(  8,   2) spir  alb1(  7,   2) typh  lat1(  4,   1)
 cala  can2(  6,   2) carx  aqu2(  3,   1) carx  str2(  5,   3) myrc  gal2(  7,   4) pote  pal2(  2,   1) cala  can3(  4,   2)
 carx  str3(  4,   1) myrc  gal3(  4,   3)
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*****************************************************************************************************
     DIVISION    6  (N=   7)    I.E. GROUP *10

EIGENVALUE 0.656  AT ITERATION   2
INDICATORS, TOGETHER WITH THEIR SIGN
cala  can1(-)
MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

ITEMS IN NEGATIVE GROUP  12  (N=    4)          I.E. GROUP *100
SAGANING  THOMPSON  WESTTWIN  WHITERIV

ITEMS IN POSITIVE GROUP  13  (N=    3)          I.E. GROUP *101
FONDULAC  POTAWATT  BIGSABLE

NEGATIVE PREFERENTIALS
ascl  incl(  1,  0) cala  can1(  4,  0) corn  amo1(  1,  0) equi  arv1(  1,  0) junc  bal1(  1,  0) lycp  ame1(  3,  0)
lycp  uni1(  2,  0) lysi  thy1(  1,  0) ment  arv1(  2,  0) phal  aru1(  1,  0) phra  aus1(  1,  0) poly  amp1(  1,  0)
pont  cor1(  1,  0) pote  nor1(  1,  0) typh  ang1(  1,  0) urti  dio1(  1,  0) viti  rip1(  2,  0) cala  can2(  4,  0)
carx  str2(  1,  0) corn  amo2(  1,  0) equi  arv2(  1,  0) frax  pen2(  1,  0) lycp  uni2(  2,  0) lysi  thy2(  1,  0)
phra  aus2(  1,  0) urti  dio2(  1,  0) cala  can3(  4,  0) corn  amo3(  1,  0) frax  pen3(  1,  0) alnu  rug4(  1,  0)
cala  can4(  2,  0) frax  pen4(  1,  0) cala  can5(  1,  0)

POSITIVE PREFERENTIALS
alnu  rug1(  2,  3) betu  pap1(  0,  1) camp  apa1(  1,  2) carx  com1(  0,  1) eupa  per1(  1,  2) lysi  ter1(  0,  1)
onoc  sen1(  1,  2) osmu  reg1(  0,  1) rosa  pal1(  0,  1) sagi  lat1(  0,  3) salx  can1(  0,  1) thuj  occ1(  0,  1)
tria  fra1(  0,  1) typh  lat1(  0,  1) alnu  rug2(  1,  3) betu  pap2(  0,  1) camp  apa2(  0,  2) carx  com2(  0,  1)
eupa  per2(  0,  1) impa  cap2(  2,  3) leer  ory2(  0,  1) lysi  ter2(  0,  1) onoc  sen2(  0,  2) pile  pum2(  0,  1)
sagi  lat2(  0,  3) scut  gal2(  0,  1) sola  dul2(  0,  1) thel  pal2(  0,  1) tria  fra2(  0,  1) typh  lat2(  0,  1)
alnu  rug3(  1,  3) betu  pap3(  0,  1) camp  apa3(  0,  2) carx  com3(  0,  1) carx  lac3(  0,  1) eupa  per3(  0,  1)
impa  cap3(  1,  3) leer  ory3(  0,  1) lysi  ter3(  0,  1) onoc  sen3(  0,  2) pile  pum3(  0,  1) sagi  lat3(  0,  3)
scut  gal3(  0,  1) sola  dul3(  0,  1) thel  pal3(  0,  1) tria  fra3(  0,  1) typh  lat3(  0,  1) betu  pap4(  0,  1)
impa  cap4(  0,  1) leer  ory4(  0,  1) salx  beb4(  0,  1) scut  gal4(  0,  1) thel  pal4(  0,  1)

NON-PREFERENTIALS
carx  lac1(  1,  1) carx  str1(  1,  1) corn  sto1(  1,  1) eupa  mac1(  1,  1) frax  pen1(  2,  1) gali  tri1(  2,  1)
impa  cap1(  3,  3) leer  ory1(  1,  1) pile  pum1(  1,  1) salx  beb1(  1,  1) scut  gal1(  2,  1) sola  dul1(  1,  1)
thel  pal1(  1,  1) carx  lac2(  1,  1) corn  sto2(  1,  1) salx  beb2(  1,  1) corn  sto3(  1,  1) salx  beb3(  1,  1)
corn  sto4(  1,  1)
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**********************************************************************************************************
     DIVISION    7  (N=   5)    I.E. GROUP *11

 EIGENVALUE 0.670  AT ITERATION   1
 INDICATORS, TOGETHER WITH THEIR SIGN
 bide  frol(-)
 MAXIMUM INDICATOR SCORE FOR NEGATIVE GROUP   -1     MINIMUM INDICATOR SCORE FOR POSITIVE GROUP    0

 ITEMS IN NEGATIVE GROUP  14  (N=    4)         I.E. GROUP *110
 BLACK_B   EASTBAY   PTPENINS  STERLING

 ITEMS IN POSITIVE GROUP  15  (N=    1)         I.E. GROUP *111
 BARLAKE

 NEGATIVE PREFERENTIALS
 acer  rub1(  1,   0) ascl  incl(  1,   0) bide  con1(  2,   0) bide  fro1(  4,   0) cala  can1(  2,   0) camp  apa1(  1,   0)
 carx  str1(  1,   0) ceph  occ1(  3,   0) corn  sto1(  2,   0) cusc  gro1(  2,   0) deco  ver1(  4,   0) gali  pal1(  4,   0)
 ilex  ver1(  2,   0) lycp  ame1(  4,   0) lysi  thy1(  3,   0) lyth  sal1(  2,   0) onoc  sen1(  2,   0) pelt  vir1(  4,   0)
 pile  fon1(  2,   0) poly  amp1(  3,   0) pote  pal1(  3,   0) rosa  pal1(  1,   0) sagi  lat1(  1,   0) scut  gal1(  3,   0)
 sium  sua1(  1,   0) sola  dul1(  4,   0) spar  eur1(  1,   0) thel  pal1(  3,   0) tria  fra1(  1,   0) tria  vir1(  3,   0)
 typh  ang1(  1,   0) typh  gla1(  3,   0) urti  dio1(  4,   0) vibu  rec1(  2,   0) viti  rip1(  1,   0) alnu  rug2(  3,   0)
 bide  fro2(  2,   0) ceph  occ2(  2,   0) cusc  gro2(  2,   0) deco  ver2(  4,   0) gali  pal2(  1,   0) ilex  ver2(  1,   0)
 impa  cap2(  1,   0) lemn  min2(  1,   0) lycp  ame2(  1,   0) pelt  vir2(  3,   0) scut  gal2(  1,   0) thel  pal2(  3,   0)
 tria  vir2(  1,   0) typh  gla2(  2,   0) urti  dio2(  2,   0) alnu  rug3(  2,   0) ceph  occ3(  1,   0) deco  ver3(  3,   0)
 impa  cap3(  1,   0) pelt  vir3(  1,   0) thel  pal3(  2,   0) typh  gla3(  2,   0) urti  dio3(  2,   0) alnu  rug4(  1,   0)
 deco  ver4(  2,   0)

 POSITIVE PREFERENTIALS
 carx  com1(  0,   1) myrc  gal1(  0,   1) osmu  reg1(  1,   1) rume  orb1(  1,   1) typh  lat1(  0,   1) cicu  bul2(  1,   1)
 osmu  reg2(  0,   1) cicu  bul3(  0,   1) osmu  reg3(  0,   1) osmu  reg4(  0,   1) osmu  reg5(  0,   1)

 NON-PREFERENTIALS
 alnu  rug1(  3,   1) cicu  bul1(  4,   1) impa  cap1(  3,   1) lemn  min1(  3,   1)

   END OF LEVEL   3

 THIS IS THE END OF THE DIVISIONS REQUESTED
**********************************************************************************************************
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**********************************************************************************************************
    DIVISION    1  (N= 131)    I.E. GROUP *

EIGENVALUE 0.862  AT ITERATION   2

ITEMS IN NEGATIVE GROUP   2  (N=   77)        I.E. GROUP *0
 abie bal  andr gla  aron mel  betu pum  bide cer  call pal  carx agu  carx bux  carx cho  carx ebu  carx exi
 carx int  carx lac  carx las  carx lim  carx liv  carx pau  carx ros  carx str  carx tri  carx ves  cham cal
 clad mar  corn can  dros int  dros rot  duli aru  eleo sma  equi flu  equi pal  erio spi  erio vir  glyc can
 iris ver  junc bal  junc pel  kalm pol  lari lar  ledu gro  lysi ter  meny tri  myrc gal  nemo muc  phal aru
 pice gla  pice mar  pinu str  plat cla  pogo oph  pote ans  pote fru  pote pal  rhyn alb  rosa pal  salx can
 salx luc  salx ped  salx pet  salx pyr  salx ser  sarr pur  sche pal  scir acu  scir ces  scir cyp  soli uli
 spha sp.  spir alb  thuj occ  trig mar  typh lat  utri cor  utri int  utri vul  vacc ang  vacc mac  vacc oxy

ITEMS IN POSITIVE GROUP   3  (N=   54)        I.E. GROUP *1
 acer rub  alnu rug  ascl inc  betu pap  bide con  bide fro  cala can  camp apa  carx com  ceph occ  cicu bul
 corn amo  corn sto  cusc gro  deco ver  equi arv  eupa mac  eupa per  frax pen  gali pal  gali tri  ilex ver
 impa cap  leer ory  lemn min  lycp ame  lycp uni  lysi thy  lyth sal  ment arv  onoc sen  osmu reg  pelt vir
 phra aus  pile fon  pile pum  poly amp  pont cor  pote nor  rume orb  sagi lat  salx beb  scut gal  sium sua
 sola dul  spar eur  thel pal  tria fra  tria vir  typh ang  typh gla  urti dio  vibu rec  viti rip

 END OF LEVEL   1


**********************************************************************************************************
    DIVISION    2  (N=  77)    I.E. GROUP *0

EIGENVALUE 0.336  AT ITERATION   1

ITEMS IN NEGATIVE GROUP   4  (N=   54)        I.E. GROUP *00
 abie bal  andr gla  aron mel  betu pum  bide cer  call pal  carx cho  carx ebu  carx exi  carx int  carx las
 carx lim  carx liv  carx pau  carx ros  carx tri  carx ves  cham cal  clad mar  corn can  dros int  dros rot
 duli aru  eleo sma  equi flu  equi pal  erio spi  erio vir  iris ver  junc pel  kalm pol  lari lar  ledu gro
 meny tri  nemo muc  pice mar  pinu str  plat cla  pogo oph  rhyn alb  salx ped  salx ser  sarr pur  sche pal
 scir ces  soli uli  spha sp.  thuj occ  trig mar  utri cor  utri int  vacc ang  vacc mac  vacc oxy

ITEMS IN POSITIVE GROUP   5  (N=   23)        I.E. GROUP *01
 carx aqu  carx bux  carx lac  carx str  glyc can  junc bal  lysi ter  myrc gal  phal aru  pice gla  pote ans
 pote fru  pote pal  rosa pal  salx can  salx luc  salx pet  salx pyr  scir acu  scir cyp  spir alb  typh lat
 utri vul
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*************************************************************************************************************
     DIVISION    3  (N=  54)    I.E. GROUP *1

EIGENVALUE 0.432  AT ITERATION   1

ITEMS IN NEGATIVE GROUP   6  (N=   45)         I.E. GROUP *10
 acer  rub  alnu  rug  ascl  inc  betu  pap  bide  con  bide  fro  carx  com  ceph  occ  cicu  bul  corn  amo  corn  sto
 cusc  gro  deco  ver  equi  arv  eupa  mac  eupa  per  gali  pal  gali  tri  ilex  ver  impa  cap  leer  ory  lemn  min
 lycp  ame  lysi  thy  lyth  sal  onoc  sen  osmu  reg  pelt  vir  pile  fon  pile  pum  poly  amp  sagi  lat  salx  beb
 scut  gal  sium  sua  sola  dul  spar  eur  thel  pal  tria  fra  tria  vir  typh  ang  typh  gla  urti  dio  vibu  rec
 viti  rip

ITEMS IN POSITIVE GROUP   7  (N=    9)         I.E. GROUP *11
 cala  can  camp  apa  frax  pen  lycp  uni  ment  arv  phra  aus  pont  cor  pote  nor  rume  orb

  END OF LEVEL   2

*************************************************************************************************************
     DIVISION    4  (N=  54)    I.E. GROUP *00

EIGENVALUE 0.132  AT ITERATION   1

ITEMS IN NEGATIVE GROUP   8  (N=   45)         I.E. GROUP *000
 abie  bal  andr  gla  aron  mel  carx  cho  carx  ebu  carx  exi  carx  int  carx  las  carx  lim  carx  liv  carx  pau
 carx  tri  carx  ves  cham  cal  clad  mar  corn  can  dros  int  dros  rot  duli  aru  eleo  sma  equi  flu  equi  pal
 erio  spi  erio  vir  iris  ver  kalm  pol  lari  lar  ledu  gro  meny  tri  nemo  muc  pice  mar  pinu  str  plat  cla
 pogo  oph  rhyn  alb  sarr  pur  sche  pal  scir  ces  soli  uli  spha  sp.  thuj  occ  utri  cor  vacc  ang  vacc  mac
 vacc  oxy

ITEMS IN POSITIVE GROUP   9  (N=    9)         I.E. GROUP *001
 betu  pum  bide  cer  call  pal  carx  ros  junc  pel  salx  ped  salx  ser  trig  mar  utri  int

*************************************************************************************************************
     DIVISION    5  (N=  23)    I.E. GROUP *01

EIGENVALUE 0.210  AT ITERATION   2

ITEMS IN NEGATIVE GROUP  10  (N=   19)         I.E. GROUP *010
 carx  aqu  carx  bux  carx  str  glyc  can  junc  bal  myrc  gal  phal  aru  pice  gla  pote  ans  pote  fru  pote  pal
 rosa  pal  salx  luc  salx  pet  salx  pyr  scir  acu  scir  cyp  spir  alb  utri  vul

ITEMS IN POSITIVE GROUP  11  (N=    4)         I.E. GROUP *011
 carx  lac  lysi  ter  salx  can  typh  lat
```

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*******************************************************************************************************
     DIVISION    6  (N=  45)    I.E. GROUP *10

EIGENVALUE 0.251  AT ITERATION   2

ITEMS IN NEGATIVE GROUP  12  (N=   25)        I.E. GROUP *100
 acer  rub  ascl  inc  bide  con  bide  fro  ceph  occ  cicu  bul  cusc  gro  deco  ver  gali  pal  ilex  ver  lemn  min
 lycp  ame  lysi  thy  lyth  sal  osmu  reg  pelt  vir  pile  fon  poly  amp  sium  sua  spar  eur  tria  fra  tria  vir
 typh  gla  urti  dio  vibu  rec

ITEMS IN POSITIVE GROUP  13  (N=   20)        I.E. GROUP *101
 alnu  rug  betu  pap  carx  com  corn  amo  corn  sto  equi  arv  eupa  mac  eupa  per  gali  tri  impa  cap  leer  ory
 onoc  sen  pile  pum  sagi  lat  salx  beb  scut  gal  sola  dul  thel  pal  typh  ang  viti  rip

*******************************************************************************************************
     DIVISION    7  (N=   9)    I.E. GROUP *11

EIGENVALUE 0.300  AT ITERATION   2

ITEMS IN NEGATIVE GROUP  14  (N=    6)        I.E. GROUP *110
 frax  pen  lycp  uni  ment  arv  phra  aus  pont  cor  pote  nor

ITEMS IN POSITIVE GROUP  15  (N=    3)        I.E. GROUP *111
 cala  can  camp  apa  rume  orb

  END OF LEVEL   3

THIS IS THE END OF THE DIVISIONS REQUESTED
*******************************************************************************************************
```

```
ORDER OF SPECIES INCLUDING RARER ONES
  17 carx  cho!  19 carx  ebu!  21 carx  int!  25 carx  liv!  30 carx  ves!  43 eleo  sma!  46 equi  pal!  57 iris  ver
  84 plat  cla! 129 vacc  oxy!   4 andr  gla!   5 aron  mel!  24 carx  lim!  41 dros  rot!  45 equi  flu!  71 meny  tri
 103 sarr  pur! 113 spha  sp.! 128 vacc  mac!   1 abie  bal!  20 carx  exi!  26 carx  pau!  29 carx  tri!  34 clad  mar
  36 corn  can!  40 dros  int!  42 duli  aru!  47 erio  spi!  48 erio  vir!  60 kalm  pol!  62 ledu  gro!  73 nemo  muc
  80 pice  mar!  83 pinu  str!  85 pogo  oph!  92 rhyn  alb! 104 sche  pal! 106 scir  ces! 127 vacc  ang!  32 cham  cal
  23 carx  las!  61 lari  lar! 111 soli  uli! 124 utri  cor! 116 thuj  occ!   8 betu  pum!  27 carx  ros!   9 bide  cer
  13 call  pal!  99 salx  ped! 102 salx  ser!  59 junc  pel! 119 trig  mar! 125 utri  int!  16 carx  bux!  79 pice  gla
  88 pote  ans!  89 pote  fru! 105 scir  acu!  15 carx  aqu!  54 glyc  can!  98 salx  luc! 100 salx  pet! 107 scir  cyp
 114 spir  alb! 126 utri  vul!  72 myrc  gal! 101 salx  pyr!  28 carx  str!  58 junc  bal!  77 phal  aru!  91 pote  pal
  93 rosa  pal!  22 carx  lac!  67 lysi  ter!  97 salx  can! 122 typh  lat! 117 tria  fra!  68 lysi  thy! 109 sium  sua
   2 acer  rub!  55 ilex  ver!  69 lyth  sal!  75 osmu  reg! 112 spar  eur! 118 tria  vir!   6 ascl  inc!  10 bide  con
  11 bide  fro!  31 ceph  occ!  33 cicu  bul!  38 cusc  gro!  39 deco  ver!  52 gali  pal!  64 lemn  min!  65 lycp  ame
  76 pelt  vir!  81 pile  fon!  86 poly  amp! 121 typh  gla! 123 urti  dio! 130 vibu  rec! 110 sola  dul! 115 thel  pal
  18 carx  com!  56 impa  cap! 108 scut  gal! 131 viti  rip!  35 corn  amo!  49 eupa  mac!  63 leer  ory!  74 onoc  sen
  82 pile  pum!  95 sagi  lat!  96 salx  beb!  50 eupa  per! 120 typh  ang!   7 betu  pap!  37 corn  sto!  44 equi  arv
  53 gali  tri!   3 alnu  rug!  70 ment  arv!  78 phra  aus!  87 pont  cor!  90 pote  nor!  51 frax  pen!  66 lycp  uni
  12 cala  can!  14 camp  apa!  94 rume  orb!


ORDER OF SAMPLE UNITS
  22 LACLABEL !  23 PEQUAMIN !   5 BLACK_A  !  26 RASPBERR !  32 STURGEON !   2 BADRIVER !   3 BARKBAY  !  16 HONJOHNB
  10 DEER_CR  !  19 INDEPEND !  30 SISKEWIT !  15 HONJOHNA !  21 KAKAGON  !   1 AUTRAIN  !  14 HOGISLD  !  20 INDIAN
  33 SUGARIS  !  17 HURSLEYA !  18 HURSLEYB !  29 SANDISLD !   7 CARP_RIV !   8 CHEBOYGA !   9 CHEBOYGC !  12 EPOUFETT
  28 SAGANING !  34 THOMPSON !  35 WESTTWIN !  36 WHITERIV !  13 FONDULAC !  24 POTAWATT !  27 BIGSABLE !   6 BLACK_B
  11 EASTBAY  !  25 PTPENINS !  31 STERLING !   4 BARLAKE  !
```

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                   000000000000000000000000011111111111
                   000000000000111111111111100000011111
                   001111111111000000000111100011100001

                    Group *00    *010    *011  *10   *11

                   LPBRSBBHDISHKAHISHHSCCCESTWWFPBBEPSB
                   AELATAAOENIOAUONUUUAAHHPAHEHOOILATTA
                   CQASUDRNEDSNKTGDGRRNREEOGOSINTGASPER
                   LUCPRRKJREKJARIIASSDPBBUAMTTDASCTERL
                   AAKBGIBO_PEOGASARLLI_OOFNPTEUWAKBNLA
                   BM_EEVAHCEWHOILNIEESRYYEISWRLAB_AIIK
                   EIAROEYNRNINNND SYYLIGGTNOIIATLBYNNE
                   LN RNR B DTA      ABDVACTGNNVCTE  SG

  21 carx  int   ----11--111-------------------------  000
  43 eleo  sma   -------11-1-------------------------  000
  46 equi  pal   ---1--1---1-------------------------  000
  57 iris  ver   ----111-11-----1--------------------  000
 129 vacc  oxy   -1--1221--1-------------------------  000
   4 andr  gla   12132322221-------------------------  000
   5 aron  mel   -11------12-------------------------  000
  24 carx  lim   -111-1--1-1-------------------------  000
  41 dros  rot   1111-112--1-------------------------  000
  45 equi  flu   -1--2111-1------------1-------------  000
  71 meny  tri   1222-321121-------------------------  000
 103 sarr  pur   113211121-1------------1------------  000
 113 spha  sp.   33434333322-2-----------------------  000
 128 vacc  mac   11311--121--------------------------  000
  34 clad  mar   1211--311-1-----------11------------  000
  36 corn  can   1-----1--1--------------------------  000
  40 dros  int   -21---11----------------------------  000
  42 duli  aru   1-----1-1---------------------------  000
  48 erio  vir   1-1-1-------------------------------  000
  60 kalm  pol   11----1-----------------------------  000
  62 ledu  gro   11----11----------------------------  000
  73 nemo  muc   11----11-1--------------------------  000
  85 pogo  oph   212--111--1-------------------------  000
  92 rhyn  alb   221---121-1-------------------------  000
 104 sche  pal   11----1---1-------------------------  000
  32 cham  cal   1143322223233-----------------------  000
  23 carx  las   -2123333322-1---2--123--------------  000
  61 lari  lar   111111-1--1---------1112------------  000
 111 soli  uli   11-1------------------11------------  000
 124 utri  cor   -1-----1---------------1------------  000
 116 thuj  occ   11-------1--------------1------1----  000
   8 betu  pum   1----1-1---11-----------------------  001
  27 carx  ros   ----1-----1-----1-------------------  001
  99 salx  ped   ----111-1-1-1---1---11-1------------  001
 119 trig  mar   ----------1----------11-------------  001
 125 utri  int   111-11111-2----11331--1-------------  001
  79 pice  gla   ----------------------12------------  010
  89 pote  fru   ---------------------122------------  010
 105 scir  acu   --------------------111-------------  010
  15 carx  aqu   --1----11---1221-3--2---------------  010
  54 glyc  can   ---------------1---1--1-------------  010
 100 salx  pet   -------------1111443-1--------------  010
 107 scir  cyp   -----------1-----1-1----------------  010
 114 spir  alb   ------1---131-1211-1-1-1------------  010
 126 utri  vul   -1--------1-----1311----------------  010
  72 myrc  gal   221333233324232233--2333-----------1  010
 101 salx  pyr   ---------1------1--1----------------  010
```

28	carx	str	---21------13233-133212--2--1---1--	010
58	junc	bal	-------------------113--1----------	010
77	phal	aru	----1---------------211--1---------	010
91	pote	pal	--2-2111111111-1331-1-2-------111--	010
93	rosa	pal	-1-1-1-2111311--------------1--1---	010
22	carx	lac	----1---111321-1-331-----2-3-------	011
67	lysi	ter	-------1111-12-----2-12------3-----	011
97	salx	can	-------------------111------1------	011
122	typh	lat	-----11--11-12--1-3-1--------3----1	011
117	tria	fra	----11-1-11--1-----1---------3--1--	100
68	lysi	thy	-----111--1-1--1----1----2----11-1-	100
109	sium	sua	----1--------------1----------1----	100
55	ilex	ver	-1-------------------1---------2-1-	100
69	lyth	sal	----1-------------------------11---	100
75	osmu	reg	-------11-----------12------1----15	100
118	tria	vir	--------2------------1--------11-2-	100
11	bide	fro	------------------------------1122-	100
31	ceph	occ	------------------------------123--	100
33	cicu	bul	----------1-1--11-------------11123	100
38	cusc	gro	-------------------------------2-2-	100
39	deco	ver	--1---------------------------3244-	100
52	gali	pal	------------------------------1112-	100
64	lemn	min	--------------1---------------121-1	100
65	lycp	ame	----1--1--1----------1-111----2111-	100
76	pelt	vir	--1-----2---------------------1232-	100
86	poly	amp	---------------1-------1------11-1-	100
121	typh	gla	--2---------------------------33-1-	100
123	urti	dio	--------------------------2---3311-	100
110	sola	dul	-------------------------1--3-1111-	101
115	thel	pal	---1---11-1-1------------1---433-2-	101
18	carx	com	----------------------------3-----1	101
56	impa	cap	------------1--1--------1323431-131	101
108	scut	gal	---------------------1--11--4-11-2-	101
35	corn	amo	--------------------1-----3--------	101
63	leer	ory	------1-------------------1-4------	101
74	onoc	sen	----------11-1----------1--33-11---	101
82	pile	pum	-------------------------1--3------	101
95	sagi	lat	-----1-----1----1----------333--1--	101
96	salx	beb	--------------1---------3--4-------	101
50	eupa	per	-------------------111-1----13-----	101
120	typh	ang	---------------------1-1---------1-	101
7	betu	pap	1----------------1-----------4-----	101
37	corn	sto	----------111--1-----1--4---4-11---	101
44	equi	arv	-1------------------------2--------	101
53	gali	tri	----------1--------1----11--1------	101
3	alnu	rug	11111112111122111--11-1--4133323-41	101
70	ment	arv	--------------------1-1-11---------	110
78	phra	aus	----------------1--------2---------	110
51	frax	pen	---------------1------2-1-4-1------	110
66	lycp	uni	----1----1----1------12-22---------	110
12	cala	can	1-----1---11123333123-145334----11-	111
14	camp	apa	----111--1-1112-1--11-3--1--33-1---	111
94	rume	orb	-------1-----1-1----------------1-1	111
			00000000000000000000000111111111111	
			00000000001111111111111000000111111	
			00111111110000000001111000001110001	

Appendix VII-A
Mean Percent Cover Value for Species Occurring in Emergent Zones[1]

Species	1	2	2.b	3	4	5	6	7	8	9
ACOR_CAL	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.7
ALIS_PLA	0.0	0.0	0.3	0.0	0.0	0.0	1.3	1.8	0.0	0.0
BIDE_CER	0.0	0.1	3.0	0.0	0.0	4.2	4.7	3.5	0.0	0.0
BRAS_SCH	2.7	0.0	0.0	0.1	0.0	0.1	0.0	3.8	5.7	0.0
CALA_CAN	0.0	0.0	0.0	0.0	0.6	0.6	1.8	0.0	0.0	0.2
CARX_AQU	0.3	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
CARX_COM	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.8
CARX_HYS	0.0	0.2	0.0	0.1	0.0	0.4	0.0	0.0	0.0	0.0
CARX_LAC	0.0	0.0	0.0	0.8	0.0	0.0	0.8	0.0	0.0	0.0
CARX_LAS	3.5	0.0	0.0	0.1	0.0	5.6	0.0	0.0	0.0	0.0
CARX_STR	0.7	0.0	0.0	0.0	0.0	0.7	0.8	0.0	0.0	0.0
CARX_VIR	0.0	1.6	1.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
CERA_DEM	1.2	0.0	0.0	1.7	27.5	7.6	0.1	10.5	37.6	25.0
CHARA_SP	0.2	10.5	16.0	1.7	0.0	2.2	3.5	0.0	0.0	3.0
CICU_BUL	0.0	0.2	0.3	0.1	0.2	0.3	0.1	0.3	0.0	0.2
DECO_VER	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
DULI_ARU	1.7	0.0	0.0	0.1	0.0	0.8	0.0	0.0	0.0	0.0
ELEO_ACI	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
ELEO_SMA	4.1	1.9	2.3	7.4	1.0	2.1	1.2	0.0	0.0	1.0
ELOD_CAN	2.2	0.2	1.3	2.5	11.5	4.9	0.0	4.3	13.9	7.0
EQUI_FLU	0.3	0.0	0.3	3.4	0.0	0.0	0.0	0.0	0.0	0.0
EUPA_PER	0.0	0.1	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0
HETE_DUB	1.4	0.0	0.0	1.4	1.0	0.8	3.8	2.4	0.1	2.8
IMPA_CAP	0.0	0.0	1.7	0.1	0.0	0.1	0.1	0.3	0.0	0.0
JUNC_BRE	0.0	0.8	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
JUNC_CAN	0.0	0.6	3.3	0.0	0.0	0.0	0.1	0.6	0.0	0.0
JUNC_PEL	0.2	0.6	4.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
LEER_ORY	0.0	0.0	2.0	0.2	0.0	2.4	0.2	3.2	0.0	0.0
LEMN_MIN	0.0	0.0	0.0	0.0	8.0	9.5	0.7	5.4	0.0	0.6
LEMN_TRI	0.0	0.0	0.0	0.0	0.0	5.0	0.0	1.3	19.6	14.7
LYCP_AME	0.0	0.1	0.3	0.1	0.0	0.7	0.1	0.0	0.0	0.1
LYTH_SAL	1.4	0.0	0.0	0.2	0.6	0.0	0.0	1.2	0.0	0.0
MEGA_BEC	2.3	0.0	0.0	1.0	0.0	0.2	0.0	0.0	0.0	0.0
MYRC_GAL	0.3	0.0	0.0	0.4	0.0	2.1	0.0	0.0	0.0	0.0
MYRI_EXA	3.3	0.5	0.0	0.8	1.0	1.6	1.2	0.0	3.1	10.0
MYRI_HET	1.0	0.5	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
MYRI_SPI	0.0	0.0	0.0	0.1	4.6	0.3	2.9	3.2	4.3	2.6
MYRI_VER	3.3	0.0	4.0	0.5	0.0	1.5	1.2	0.0	0.0	0.0
NAJA_FLE	1.8	0.6	10.7	3.7	4.0	0.0	3.7	4.9	0.6	6.9
NITE_FLE	0.0	0.0	0.0	0.1	0.0	0.0	1.9	3.1	0.0	0.8
NUPH_ADV	0.0	0.0	0.0	0.0	0.3	9.7	0.0	10.6	14.0	0.0
NUPH_VAR	8.1	2.5	1.7	2.1	4.9	0.5	0.0	0.0	0.0	3.2
NYMP_ODO	1.1	0.0	0.3	1.4	7.3	9.2	1.0	3.8	18.9	13.3
PELT_VIR	0.0	0.0	0.0	0.0	0.0	18.7	0.0	0.0	0.0	0.0
PHRA_AUS	0.0	0.0	0.0	0.3	0.0	0.1	0.0	1.9	0.0	0.1
POLY_AMP	0.0	0.6	0.8	0.5	0.0	1.4	0.4	0.3	0.0	0.2

Species	1	2	2.a	3	4	5	6	7	8	9
POLY_LAP	0.0	0.0	0.3	0.0	0.0	0.6	1.8	1.2	0.0	0.0
PONT_COR	1.8	0.0	2.0	2.0	0.0	3.2	0.2	2.5	4.4	0.0
POTA_AMP	1.2	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	0.0
POTA_BER	0.2	0.2	0.0	0.3	0.0	1.9	0.0	0.0	0.0	3.0
POTA_CRI	0.0	0.0	0.0	0.0	0.0	0.3	0.0	2.5	0.6	3.6
POTA_FRI	1.3	0.0	0.3	0.1	0.0	0.0	0.2	0.0	0.6	9.7
POTA_GRA	2.5	2.2	0.0	3.7	0.3	0.0	0.4	1.6	0.1	0.0
POTA_ILL	0.0	0.7	0.0	0.5	0.0	0.0	0.5	0.0	0.0	0.0
POTA_NAT	0.8	0.2	0.3	3.7	0.0	0.0	0.0	0.3	3.5	0.4
POTA_OBT	0.0	0.2	0.0	0.5	1.6	0.2	0.3	0.0	0.0	0.0
POTA_PEC	0.0	0.2	0.0	0.6	3.2	1.3	0.9	4.9	0.1	3.0
POTA_RIC	0.2	0.7	0.0	1.2	0.3	0.0	1.1	0.0	0.0	0.9
POTA_ROB	1.6	0.0	0.0	0.4	0.0	0.2	0.0	0.0	0.0	0.0
POTA_ZOS	1.3	0.0	0.0	1.6	0.0	0.2	0.0	0.1	12.2	14.2
POTE_PAL	0.5	0.0	0.0	0.7	0.0	0.7	0.0	0.0	0.0	0.4
RANU_LON	0.0	0.0	0.0	0.1	0.0	1.2	0.0	0.0	0.0	0.6
RORI_PAL	0.0	0.0	1.5	0.0	0.0	0.5	2.1	1.2	0.0	0.0
SAGI_GRA	2.3	0.5	0.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0
SAGI_LAT	3.5	1.4	5.3	2.5	9.4	2.9	0.5	3.8	0.0	1.2
SAGI_RIG	0.1	0.0	0.0	0.8	2.0	0.0	0.0	0.9	0.0	3.3
SCIR_ACU	0.8	7.0	14.0	10.0	0.0	0.4	1.5	0.2	2.5	0.7
SCIR_AME	0.4	2.1	0.0	2.2	0.0	0.0	5.5	0.5	0.0	0.0
SCIR_CYP	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.3	0.0	0.0
SCIR_FLU	0.0	0.0	0.0	0.0	0.5	0.6	0.4	0.4	0.0	0.0
SCIR_SUB	4.7	0.0	0.0	4.4	0.0	0.0	0.0	0.0	1.8	0.0
SCIR_VAL	0.4	0.1	3.3	0.4	3.6	2.4	3.0	5.4	1.8	0.0
SIUM_SUA	0.0	0.0	0.3	0.0	0.0	0.2	0.0	0.0	0.0	0.3
SPAR_CHL	0.3	0.0	0.0	0.3	0.0	0.7	0.0	0.0	0.0	2.3
SPAR_EUR	1.0	0.0	0.0	3.3	3.8	7.6	0.5	2.5	0.0	0.8
SPAR_FLU	5.3	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
SPRD_POL	0.0	0.0	0.0	0.4	3.6	23.1	0.0	0.3	11.9	6.9
TYPH_ANG	0.6	0.1	0.0	1.9	6.3	0.0	4.0	2.1	0.0	1.0
TYPH_GLA	0.0	0.0	0.0	0.0	0.0	1.8	1.9	3.0	0.1	0.7
TYPH_LAT	0.9	0.0	0.3	1.6	0.0	2.9	0.0	0.4	0.0	0.0
UTRI_INT	2.5	0.0	0.0	0.2	0.3	0.2	0.0	0.0	0.0	1.6
UTRI_VUL	4.7	0.0	3.0	3.1	1.3	1.0	0.0	0.9	16.1	13.8
VALL_AME	2.3	0.0	0.0	2.5	5.3	0.0	4.1	1.7	3.8	10.1
WOLF_COL	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	6.1	0.0
ZIZA_AQU	0.2	0.0	5.0	1.6	1.0	0.9	0.0	0.0	0.0	7.3

[a]For group definition, see text and Table 15. Group 2b includes 3 sites associated with Group 2.

Appendix VII-B
Mean Percent Cover Value for
Species Occurring in Herbaceous Zones[a]

Species	1	2	3	4	5	6	7	8	9
alis pla	0.0	0.0	0.0	0.0	0.7	0.9	0.4	0.0	0.5
alnu rug	0.9	1.3	1.9	3.2	0.9	0.1	0.0	0.1	1.4
ascl inc	0.0	0.0	0.2	0.3	0.4	0.0	0.2	0.0	0.2
bide cer	0.0	0.0	0.2	0.0	5.1	17.8	5.3	1.4	1.0
cala can	1.7	16.4	14.9	43.0	18.9	14.1	21.2	17.4	11.0
caly sep	0.0	0.0	0.2	2.0	1.1	0.1	3.2	0.0	0.5
camp apa	0.8	2.8	3.3	4.0	3.4	0.0	0.0	3.3	2.9
carx aqu	1.5	2.6	5.6	3.0	5.8	1.8	0.0	0.9	4.3
carx beb	0.0	0.1	0.5	2.6	0.2	0.3	0.3	0.0	0.1
carx com	0.0	0.0	0.0	0.6	1.0	0.1	0.0	0.0	3.8
carx lac	1.3	0.2	13.9	7.3	4.1	1.4	0.2	9.8	5.2
carx las	21.6	4.1	6.1	0.4	0.0	0.0	0.0	3.1	0.0
carx ros	0.3	0.0	2.7	1.1	0.1	0.4	0.0	1.0	0.0
carx str	1.0	6.0	17.9	6.8	7.2	3.8	3.6	2.8	3.3
carx vir	0.0	8.0	0.2	0.0	0.0	0.5	0.0	0.0	0.0
cham cal	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cicu bul	0.2	0.6	1.4	1.3	2.8	2.2	0.3	3.9	2.2
clad mar	13.4	6.4	0.0	0.0	0.0	0.5	0.0	0.0	0.0
corn sto	0.2	0.1	0.6	0.8	0.5	1.1	0.0	0.1	0.1
deco ver	0.0	0.0	0.0	0.0	2.9	0.0	0.0	4.4	0.3
duli aru	5.7	0.0	0.6	0.0	0.0	0.0	0.0	0.8	0.3
eleo sma	2.0	0.1	0.7	5.8	0.9	1.1	0.0	0.0	1.2
equi flu	2.5	0.0	1.9	0.0	0.0	0.0	0.0	0.1	0.3
eupa mac	0.1	0.0	0.8	0.5	2.6	1.3	0.0	0.0	0.0
eupa per	0.0	3.1	0.5	0.6	1.9	2.0	0.5	0.3	0.0
frax pen	0.0	0.4	0.3	0.0	0.2	0.2	0.6	0.0	0.3
gali tri	0.6	0.2	1.4	5.4	1.2	0.5	1.5	0.0	7.7
impa cap	0.0	0.2	2.0	6.5	18.1	4.3	2.5	7.7	11.5
iris ver	0.8	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.0
junc bal	0.1	4.3	0.6	0.0	0.0	0.4	0.3	0.0	0.0
junc can	2.0	1.3	0.3	0.0	0.0	0.6	0.9	0.0	0.0
lath pal	0.0	0.2	0.7	0.8	0.1	0.0	0.0	0.1	0.9
leer ory	0.1	0.0	0.1	0.9	3.8	0.5	4.4	0.2	0.0
lemn min	0.0	0.0	0.2	2.2	0.2	2.0	0.0	0.4	0.1
lobe kal	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
lycp ame	0.3	1.4	0.5	0.1	2.3	1.0	0.4	4.5	0.4
lycp uni	0.4	1.1	0.8	2.0	0.0	0.8	1.7	0.2	2.8
lysi ter	0.7	1.3	0.5	0.0	0.1	0.0	0.0	0.0	0.0
lysi thy	1.0	1.0	1.8	3.9	0.2	0.0	0.0	7.0	5.8
lyth sal	0.0	0.0	1.5	6.1	0.8	0.8	4.5	0.6	0.1
ment arv	0.6	0.4	1.0	0.0	1.8	0.0	0.7	0.0	0.0
meny tri	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
myrc gal	12.0	4.6	1.9	0.0	0.0	0.0	0.0	1.1	0.0
onoc sen	0.1	0.3	1.7	0.3	0.1	0.0	0.3	0.1	1.0
phal aru	0.0	1.0	0.5	4.9	0.9	0.7	13.8	1.7	0.7
phra aus	3.6	0.1	0.6	1.9	0.8	1.2	9.7	0.0	0.0

Species	1	2	3	4	5	6	7	8	9
poly amp	0.1	2.2	3.3	4.2	11.9	4.7	2.6	6.3	5.4
poly lap	0.0	0.0	0.0	0.1	3.9	2.0	10.6	0.0	0.0
poly per	0.0	0.0	0.0	0.0	0.1	4.8	0.5	0.0	0.0
pont cor	1.0	0.0	0.3	0.0	2.4	0.2	0.3	0.6	0.0
pote ans	0.0	4.2	0.2	0.9	0.0	1.1	0.0	0.0	0.0
pote fru	0.8	2.9	0.5	0.0	0.0	0.3	0.0	0.0	0.0
pote nor	0.0	0.4	0.1	1.1	0.3	0.0	0.0	0.0	0.0
pote pal	2.2	0.8	3.2	1.0	0.4	0.3	0.0	5.6	2.2
ranu sce	0.0	0.0	0.2	0.0	1.0	2.4	1.0	0.0	0.0
rhyn alb	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
rori pal	0.0	0.1	0.0	0.1	5.2	8.6	4.9	0.4	0.0
rosa pal	1.5	0.2	0.2	0.1	0.9	0.0	0.0	0.0	0.0
rume orb	0.0	0.0	0.2	0.9	1.2	0.0	0.1	0.0	0.6
sagi lat	2.7	0.8	1.4	4.0	2.0	2.0	0.5	8.5	3.0
salx can	0.0	0.8	0.9	0.8	0.3	0.0	0.0	0.0	0.0
salx ped	0.1	0.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0
salx pet	0.0	0.2	1.9	0.6	0.1	0.0	0.0	0.1	0.9
sarr pur	4.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
scir acu	0.3	3.7	1.2	1.7	0.6	0.4	0.0	0.0	0.8
scir ame	0.0	3.2	0.8	0.9	0.0	0.8	1.1	0.0	0.0
scir cyp	0.6	0.0	0.3	0.6	0.0	0.0	0.3	0.6	0.2
scir flu	0.0	0.0	0.0	0.6	0.8	0.0	1.6	0.6	1.7
scir val	0.1	0.1	0.6	3.7	4.0	8.3	1.7	0.0	0.3
scut gal	0.0	0.6	1.6	0.2	2.5	0.7	1.9	5.4	1.8
sium sua	0.1	0.1	0.4	0.0	0.2	0.6	0.0	0.5	0.4
spar eur	0.3	0.0	1.3	2.1	5.7	0.8	2.2	3.5	1.3
spir alb	0.2	0.6	3.0	0.3	0.2	0.0	0.0	5.1	2.1
thel pal	0.1	0.7	0.8	1.4	0.8	0.0	0.0	11.5	5.9
thuj occ	0.2	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0
tria fra	1.4	0.6	0.3	0.9	0.0	0.0	0.0	0.0	1.1
trig mar	0.0	1.5	0.2	0.0	0.0	0.3	0.0	0.0	0.0
typh ang	0.0	0.5	0.7	10.2	7.3	7.7	11.5	24.3	27.7
typh lat	0.7	0.9	4.0	1.0	3.5	0.6	0.6	0.0	2.2
urti dio	0.0	0.0	0.0	1.4	2.4	1.7	0.6	0.4	0.0
utri int	9.4	0.0	3.4	0.4	0.0	0.0	0.0	2.2	0.5
utri vul	1.7	0.0	2.7	1.0	0.0	0.0	0.0	0.0	0.1
verb has	0.0	0.0	0.1	0.3	1.1	0.2	1.0	0.0	0.1

[a]For group definition, see text and Table 15.

Appendix VII-C
Mean Percent Cover Value for Species Occurring in Shrub Zones[a]

Species	1	2	3	4	5	6	7	9	9.b
alnu rug	7.1	2.0	3.8	66.7	11.9	0.0	0.0	25.2	7.2
andr gla	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8
betu pum	1.4	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
bide fro	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	0.0
cala can	1.7	18.9	15.7	26.7	13.1	100.0	27.5	1.1	0.0
camp apa	0.8	6.8	3.1	8.3	10.0	0.0	0.0	0.6	0.0
carx aqu	1.2	3.3	5.0	0.0	0.0	0.0	0.0	0.0	4.3
carx int	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3
carx lac	5.2	0.0	8.9	10.0	0.0	0.0	0.0	0.0	1.5
carx las	13.8	11.8	2.0	0.0	0.0	0.0	0.0	0.0	12.7
carx lim	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
carx str	3.1	12.6	14.9	16.7	1.3	0.0	0.0	0.2	0.0
ceph occ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.8	0.0
cham cal	12.9	0.0	3.6	0.0	0.0	0.0	0.0	0.0	31.9
cicu bul	0.1	0.0	0.4	0.0	5.0	0.0	0.0	5.0	0.0
clad mar	5.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	2.8
corn sto	0.5	0.4	0.5	0.0	10.0	40.0	0.0	1.0	0.0
deco ver	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.8	1.1
dros rot	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
equi flu	2.4	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
eupa per	0.0	2.2	0.0	0.0	6.3	5.0	0.0	0.0	0.0
frax pen	0.0	3.1	0.3	0.0	13.8	0.0	0.6	0.0	0.0
gali pal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0
gali tri	0.4	0.0	0.9	1.7	1.3	0.0	2.5	0.0	0.0
impa cap	1.7	0.0	0.4	20.0	18.8	0.0	2.5	8.7	0.0
iris ver	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.8
lari lar	1.2	3.6	0.0	0.0	0.0	0.0	0.0	0.0	3.1
lemn min	0.0	0.0	0.1	0.0	1.3	0.0	0.0	4.0	0.0
lycp ame	0.3	0.3	0.0	1.7	0.0	5.0	2.5	6.9	0.0
lycp uni	0.3	3.4	0.1	13.3	0.0	0.0	15.6	0.0	0.0
lysi ter	1.1	6.6	0.2	0.0	5.0	0.0	0.0	0.0	1.0
lysi thy	1.0	0.1	1.0	10.0	0.0	0.0	0.0	4.2	0.0
meny tri	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9
myrc gal	21.9	25.0	12.3	0.0	1.3	0.0	0.0	0.0	18.7
nemo muc	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
onoc sen	3.0	0.0	0.0	0.0	5.0	0.0	3.1	2.2	0.0
osmu reg	0.0	2.9	0.0	0.0	21.3	0.0	0.0	0.4	0.2
pelt vir	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5	11.5
phal aru	0.2	5.3	0.0	6.7	0.0	0.0	0.0	0.0	0.0
pogo oph	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6
poly amp	0.0	0.0	0.6	0.0	0.0	5.0	0.0	5.2	0.0
pote ans	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pote fru	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pote pal	4.0	3.1	7.7	0.0	0.0	0.0	0.0	3.1	0.8
rhyn alb	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5
rosa pal	4.9	0.0	1.1	0.0	1.3	0.0	0.0	0.1	2.7

Species	1	2	3	4	5	6	7	9	9.2
sagi lat	2.3	0.0	0.6	0.0	10.0	0.0	0.0	0.7	0.0
salx beb	3.3	0.0	0.1	0.0	0.0	0.0	20.0	0.0	0.0
salx ped	0.6	3.8	0.5	0.0	0.0	0.0	0.0	0.0	0.8
salx pet	0.3	1.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
sarr pur	5.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	15.1
scut gal	0.0	0.3	0.0	3.3	10.0	0.0	0.6	6.1	0.0
sola dul	0.0	0.0	0.0	8.3	5.0	0.0	0.0	1.3	0.0
soli uli	0.9	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
spha sp.	21.6	0.0	2.5	0.0	0.0	0.0	0.0	0.0	41.3
spir alb	1.8	1.9	6.2	0.0	0.0	0.0	0.0	0.0	0.0
thel pal	0.8	0.0	0.4	1.7	10.0	0.0	0.0	21.5	0.2
thuj occ	0.3	1.3	0.0	0.0	1.3	0.0	0.0	0.0	0.0
tria fra	1.0	0.4	0.0	0.0	5.0	0.0	0.0	0.2	0.0
tria vir	0.0	1.6	0.0	0.0	0.0	0.0	0.0	4.5	6.3
typh lat	2.5	2.1	3.5	0.0	6.3	0.0	0.0	0.0	0.0
urti dio	0.0	0.0	0.0	0.0	2.5	0.0	0.0	12.6	0.0
utri int	3.8	0.3	7.8	0.0	0.0	0.0	0.0	0.0	6.2
utri vul	0.1	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0
vacc mac	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.0
vacc oxy	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a]For group definition, see text and Table 15. Group 9b includes 2 poor fen sites.

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