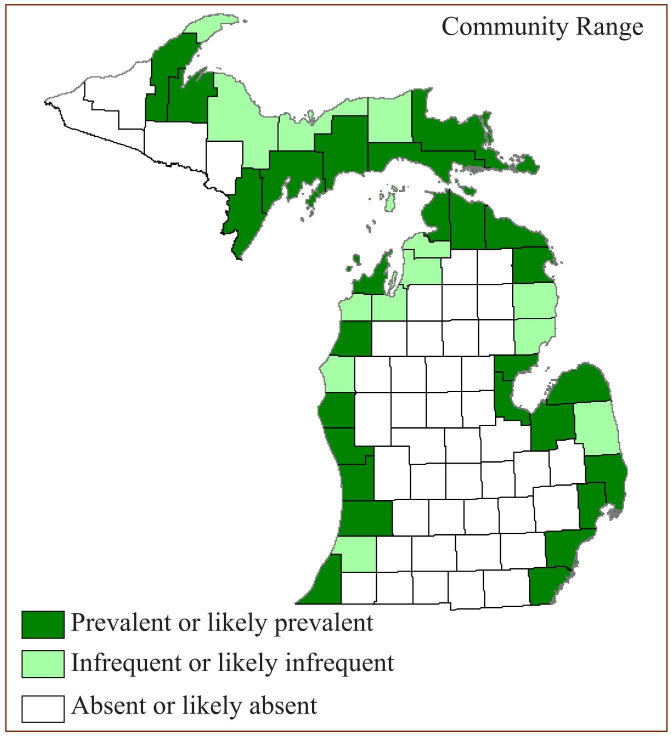

Photo by Ted Cline



Overview: Great Lakes marsh is an herbaceous wetland community restricted to the shoreline of the Great Lakes and their major connecting rivers.

Global and State Rank: G2/S3. A finer classification of Great Lakes marshes has been developed on the basis of a combination of physical and floristic descriptors (Minc 1997c, Minc and Albert 1998). In this classification, some subtypes have a G1/S1 status. The physical factors and floristic differences of several subtypes are described below (See Vegetation Descriptions below).

Range: Great Lakes marshes occur along all of the Great Lakes, including Lake Erie, Huron, Michigan, Ontario, St. Clair, and Superior, and along the connecting rivers, including Detroit, Niagara, St. Clair, St. Lawrence, and St. Marys (Kost et al. 2007). Only Michigan's Great Lakes marshes are shown on the map.

Rank Justification: Great Lakes wetlands are restricted to shorelines of the Great Lakes and connecting rivers. The ranking of marshes is based on comprehensive field surveys conducted along the entire U.S. shoreline of the Great Lakes (Albert et al. 1987, Albert et al. 1988, Albert et al. 1989, Minc 1997a, Minc 1997c, Minc and Albert 1998). Coastal wetlands have been degraded as the result of numerous forms of human management, including conversion to industrial, residential, or recreational uses, wetland fill, modification of near-shore currents, chemical pollution, sedimentation, and nutrient loading from agriculture or sewage plants.

Landscape and Abiotic Context: *Surficial Bedrock:* The physical and chemical characteristics of different surficial bedrock types affect both wetland location and species composition (Minc 1997c, Minc and Albert 1998). 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 bedrocks 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. In contrast, the softer, sedimentary bedrock types underlie Lakes Michigan, Huron, St. Clair, Erie, and Ontario, as well as the large rivers connecting the Great Lakes.

The physical structure of each bedrock type determines the distribution of coastal wetlands at a regional scale. Along the rugged Lake Superior shoreline of sandstone,

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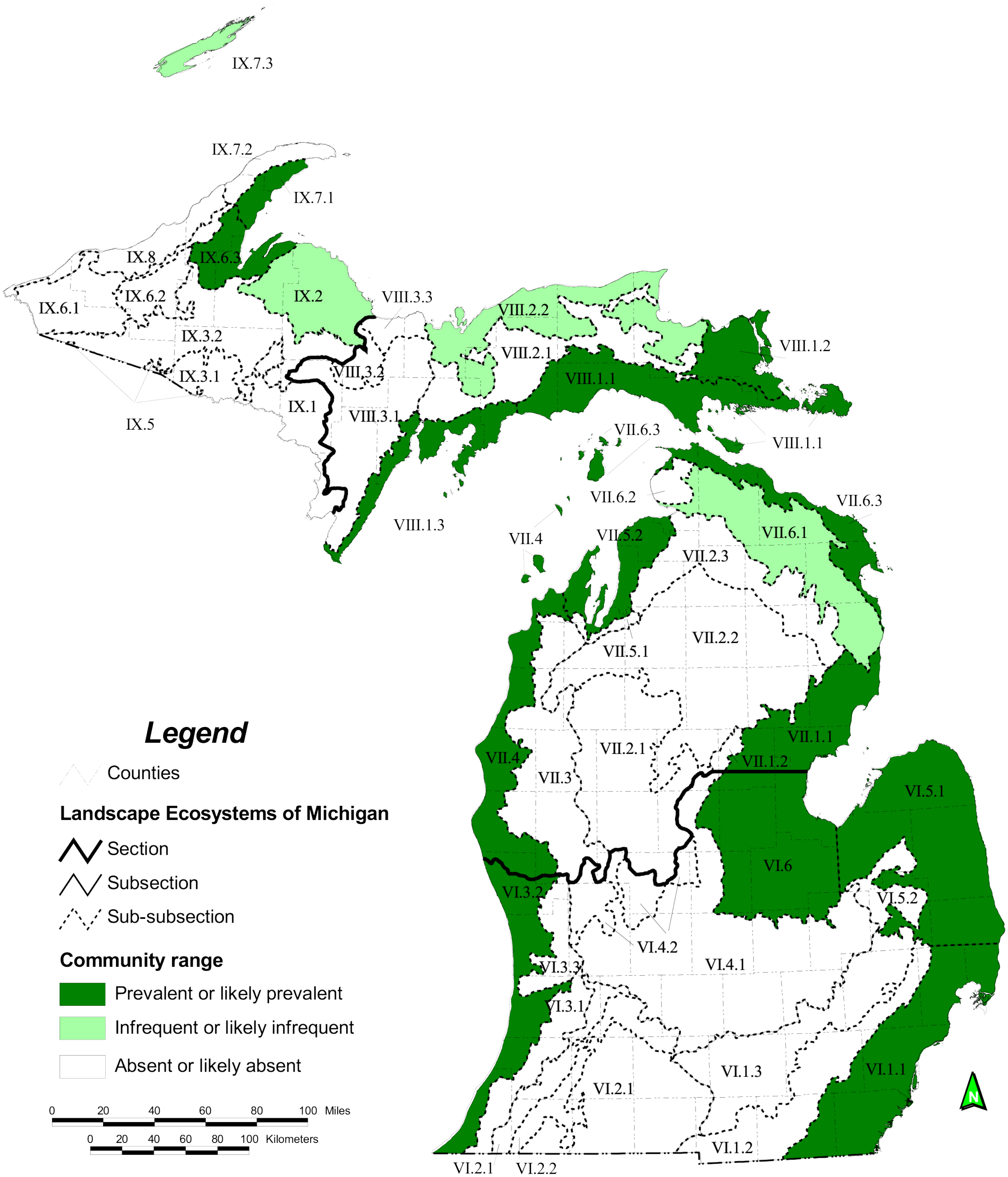

Ecoregional map of Michigan (Albert 1995) depicting distribution of Great Lakes marsh (Albert et al. 2008) igneous, and metamorphic rocks; coastal wetlands exist only behind protective barrier beaches or locally at stream mouths. In contrast, the horizontally-deposited marine and near-shore sedimentary rocks underlying Lakes Michigan, Huron, St. Clair, Erie, and Ontario, provide 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 and favor the development of poor fen or bog communities. In contrast, soils derived from marine deposits, including shale and marine limestone, dolomite, and evaporites, are typically more calcareous (less acid); where these bedrock types are at or near the surface, their alkalinity creates the preferred habitat for calciphilic aquatic plant species.

Aquatic System: Major aquatic systems, defined largely on water flow characteristics and residence time (Sly and Busch 1992), are applicable to the Great Lakes Basin; each has a different influence on associated coastal wetlands.

Lacustrine systems are controlled directly by waters of the Great Lakes, and involve wetlands of the Great Lakes shoreline strongly affected by littoral (longshore) currents and storm-driven wave action. Lacustrine habitats generally experience the greatest exposure to wind and wave action and to ice scour, the primary agents responsible for shore erosion and redeposition of sediments.

Connecting channels refer to the major rivers linking the Great Lakes, including the St. Marys, Detroit, St. Clair, Niagara, and St. Lawrence rivers. Connecting channels are characterized by a large flow, but seasonally stable hydrology; their shallowness and current result in earlier spring warming and better oxygenation than in other aquatic systems. All the connecting channels have been modified to accommodate shipping, resulting in changes in water level and increased shoreline erosion.

Riverine aquatic systems refer to smaller rivers tributary to the Great Lakes whose water quality, flow rate, and sediment load are controlled in large part by their individual drainages. But these rivers are also strongly influenced by the Great Lakes near their mouth. The portion of the tributary controlled by fluctuations in lake level have been called **freshwater estuaries** or **buried river mouths**. Here, there is a zone of transition from stream to lake within which water level, sedimentation, erosion, and biological processes are controlled by fluctuations in lake level.

Glacial Landform: 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 processes, and in their floristic composition.

The major morphometric types are presented below. Several morphometric types can co-occur, while others are gradational. Many of these geomorphic features are unique to the Great Lakes coasts and are typically overlooked in national wetland classification schemes (Herdendorf et al. 1981). Since the floristic diversity of a wetland is dependent on the diversity of wetland habitats, the variety of morphometric types represented is significant for understanding the vegetational characteristics of a site.

Morphometric Types of Great Lakes Coastal Wetlands

Ia. Lacustrine - Open embayment. Embayment open to the lake, but shallow water depth reduces wave height and energy. Wetlands are limited to a narrow fringe of emergent vegetation.

Ib. Lacustrine – Protected embayment. Deep indentation or embayment in upland shoreline provides protection from wind and wave energy, allowing extensive emergent wetland development.

Ic. Lacustrine – 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. Extensive shallow water emergent vegetation; composition reflects degree of connectivity with Great Lakes.

Id. Lacustrine – 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 also enclose small swales.

Sheltered embayments allow for sediment accumulation and wetland development.

Ie. Lacustrine – Dune and swale complex. Low sand dunes or beach ridges alternate with swales, often forming large wetland complexes. Swales adjacent to lake may contain herbaceous wetlands and/or open water. Further inland the wetlands are typically treed.

If. Lacustrine – Tombolo. An island connected to the mainland by a beach ridge or series of beach ridges. Enclosed lagoons can contain dense growth of aquatic vegetation, and there is occasionally a fringe of emergent vegetation outside of the tombolo.

IIa. Connecting Channel – Channel-side wetland. Stream-side wetland along main channel of river is exposed to current and wave action. Vegetation is frequently limited to a thin fringe paralleling the shore.

IIb. Connecting Channel – Channel embayment. Embayment along the connecting river channel provides protection from erosion. Extensive wetland development can occur.

IIIa. Riverine – Delta. Stream sediments are deposited at the mouth of a river, creating multiple channels, low islands, and abandoned meanders. Deltas associated with both large connecting channels and smaller tributaries. Extensive, diverse wetlands typically develop.

IIIb. Riverine – Lacustrine estuary (Drowned river mouth). Drowned river mouths occur at the mouth of tributary streams where water levels are under the influence of the Great Lakes. Drowned river mouths can be completely open to the lake or separated from the lake by a sand bar (Barred estuary), but most are currently maintained open by navigation channels. The portion of the stream affected by the Great Lakes water level can extend several miles upstream, thus producing extensive, fertile wetland habitat.

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. These differences 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 or northern affinities also occur. Lake Erie wetlands, for example, are rich in southern marsh species at the northern edge of their range; a southern wet-prairie floristic element is present as well (Keddy and Reznicek 1985, 1986; Stuckey 1989). 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. Other species common to many Great Lakes coastal wetlands reveal regional concentrations corresponding to a north-south gradient (Minc 1997c).

Natural Processes: Fluctuations in water levels are one of the most important influences on Great Lakes wetlands. These fluctuations occur over three temporal scales: (1) **short-term fluctuations (seiche)** in water level caused by persistent winds and/or differences in barometric pressure; (2) **seasonal fluctuations** reflecting the annual hydrologic cycle in the Great Lakes basin; and (3) **interannual fluctuations** in lake level as a result of variable precipitation and evaporation within their drainage basins (Minc 1997b, Minc and Albert 1998).

All of these scales contribute to the dynamic character of coastal wetlands, although interannual fluctuations result in the greatest wetland variability. These extreme lake-level fluctuations can range from 3.5 to 6.5 feet (1.3-2.5 m), and occur with no regular periodicity. In general, as water levels rise and fall, vegetation communities shift landward during high-water years and lakeward during low-water years. However, 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. Since individual species display different tolerance limits along one or more of these dimensions, species composition can also change dramatically within a zone.

Coastal wetland systems are adapted to and require periodic inundation. Water-level regulation has significantly reduced the occurrence of extreme high and low water levels on Lake Ontario and to a lesser degree on Lake Superior. This disruption of the natural cycle favors species intolerant of water-depth change, excludes species requiring periodic exposure of fertile substrates, and potentially leads 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).

Vegetation Description: This classification is based on field surveys conducted along the entire U.S. shoreline of the Great Lakes (Albert et al. 1987, Albert et al. 1988, Albert et al. 1989, Minc 1997a, Minc 1997c, Minc and Albert 1998). The preceding abiotic variables (including aquatic system, water level fluctuations, surficial bedrock, glacial landform, and climate) combine to determine the distribution, as well as the morphology, species composition, and floristic quality of Great Lakes coastal wetlands. The final, synthetic classification of Great Lakes coastal wetlands (based on both abiotic and vegetation analyses) identified nine groups, each with distinctive floristic characteristics and a restricted geographic distribution (Minc 1997c, Minc and Albert 1998). Vegetation zonation and key species are discussed below.

(1) Lake Superior Poor Fen. This group contains most of the wetlands sampled along the Lake Superior shoreline (Albert et al. 1987, Minc 1997a, Minc 1997c). Since marshes cannot develop along unprotected stretches of Lake Superior's harsh shoreline, these wetlands occupy sheltered sites, including barrier-beach lagoons, estuaries, and tributary river deltas. These sites are characterized by fairly acidic, sandy soils and an extreme northern climate. As a result, organic decomposition is retarded and deep organic soils develop. Most of the marshes found along the Canadian shoreline of Lake Superior and on the granitic bedrock of the North Channel and Georgian Bay also fall into this class.

Characteristic vegetation includes northern poor fen in the herbaceous zone grading into poor shrub fen at the inland wetland periphery. The poor fen is typically the most extensive zone within Lake Superior wetlands. Species showing strong preferences for this habitat include *Sphagnum* spp., the forbs *Sarracenia purpurea* (pitcher-plant), *Menyanthes trifoliata* (buckbean), *Rhynchospora alba* (beak-rush), *Triadenum fraseri* (marsh St. John's-wort), *Pogonia ophioglossoides* (rose pogonia), and the shrubs *Chamaedaphne calyculata* (leatherleaf), *Andromeda glaucophylla* (bog rosemary), *Myrica gale* (sweet gale), *Vaccinium macrocarpon* (large cranberry) and *V. oxycoccus* (small cranberry). Continuity in species composition for northern poor fen is strong across a considerable range of lake levels (Minc 1997b).

The emergent zone, typically only a narrow fringe, contains species associated with clear, well-aerated waters, including a low-density mix of *Eleocharis smallii* (spike-rush), *Sparganium fluctuans* (bur-reed), *Schoenoplectus subterminalis* (bulrush), *Nuphar variegata* (yellow pond-lily), *Brasenia schreberi* (water shield), *Megalodonta beckii* (water-marigold), and *Potamageton gramineus* (pondweed).

(2) Northern Rich Fen. This group is concentrated near the Straits of Mackinac and located on marly substrates. In Ontario, many of the wetlands found on Cockburn and Manitoulin Islands, as well as the Bruce Peninsula can also be classed as rich fens. Most of these sites occupy sandy embayments where limestone bedrock or cobble is at or near the surface. 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.

The calciphiles *Chara* sp. (muskgrass) and *Eleocharis rostellata* (spike-rush) frequently dominate the emergent zones, along with *Schoenoplectus acutus* (hardstem bulrush). Overall species diversity is low. The herbaceous zone — the most distinctive and diagnostic zone — is consistently a northern rich fen. *Calamagrostis canadensis* (blue-joint grass) can dominate, but the calciphiles *Carex viridula* (sedge) and *Lobelia kalmii* (Kalm's lobelia) are key species for this group. Other fen species include *Cladium mariscoides* (twig-rush), *Potentilla anserina* (silverweed), *Panicum lindheimeri* (panic grass), *Triglochin maritimum* (common bog arrow-grass), and *Hypericum kalmianum* (Kalm's St. John's-wort). Common woody species include *Myrica gale*, *Potentilla fruticosa* (shrubby cinquefoil), and *Larix laricina* (larch). This characteristic suite of calciphiles make the Northern Rich Fen type readily recognizable across a range of lake-level fluctuations (Minc 1997b).

(3) Northern Great Lakes Marsh. This group includes all marshes along the St. Marys River, as well as circumneutral sites of Lake Superior and northern Lake Michigan and Lake Huron; it is the largest group of Great Lakes wetlands sampled (Albert et al. 1987, Albert et al. 1989, Minc 1997a). Marshes of this type occur on a diversity of glacial landforms and substrates, including clay lakeplain, sand lakeplain, and sandy ground moraine. Sites vary: Lake Superior northern marshes typically inhabit open water and stream margins, often within a larger poor fen complex, while those of northern Lakes Michigan and Lake Huron are typically found in relatively protected coastal embayments. The largest group of sites, however, is the channel-side wetlands and embayments along the St. Marys River. For Ontario, this type is expected to be common on the Canadian portion of the St. Marys River, including the eastern side of St. Joseph Island.

Photo by Dennis A. Albert

Northern Great Lakes Marsh type

The open emergent zone features *Schoenoplectus acutus* (hardstem bulrush), *Eleocharis smallii* (spike-rush), *Schoenoplectus subterminalis*, *Equisetum fluviatile* (water horsetail), *Najas flexilis* (slender naiad), and *Sparganium eurycarpum* (common bur-reed), along with the submergent pondweeds *Potamageton gramineus* and *P. natans*. The herbaceous zone is consistently a northern wet meadow dominated by *Calamagrostis canadensis* (blue-joint grass), and the sedges *Carex stricta* and *C. lacustris*; key forbs include *Campanula aparinoides* (marsh bell-flower) and *Potentilla palustris* (marsh cinquefoil). A narrow band of shrubs includes *Spiraea alba* (meadowsweet), *Salix petiolaris* (meadow willow), *Alnus rugosa* (speckled alder), and *Myrica gale*.

(4) Green Bay Disturbed Marsh. This Lake Michigan group contains a small number of relatively well-protected sites, including deltaic channels, estuarine channels, and sheltered sand-spit embayments, primarily within Green Bay, WI. These sites are located near the **tension zone** and display both northern and southern vegetation characteristics. These sites share a highly disturbed habitat. The adjacent flat, poorly drained clay lakeplain has been intensively farmed with row crops, and waters of Green Bay are generally characterized as quite turbid, owing both to erosion from agricultural activities and to industrial and urban pollution.

Emergent zone dominants are species associated with quiet, nutrient-rich waters, and typically more abundant in the southern Great Lakes. Key species include *Ceratophyllum demersum* (coontail), *Elodea canadensis* (common waterweed), *Lemna minor* (small duckweed), *Spirodela polyrhiza* (great duckweed), *Nymphaea odorata* (sweet-scented waterlily), and *Sagittaria latifolia* (common arrowhead). The herbaceous zone is a wet meadow of *Calamagrostis canadensis*, *Carex stricta*, and *C. lacustris*. Wet meadow species more characteristic of the south include *Impatiens capensis* (spotted touch-me-not) and *Typha angustifolia* (narrow-leaved cat-tail), as well as the exotics *Lythrum salicaria* (purple loosestrife), *Phragmites australis* (giant bulrush), and *Phalaris arundinacea* (reed canary grass). A distinct shrub zone was seldom encountered in sampling transects (Minc 1997a) due to heavy disturbance in the uplands.

Owing to the relatively flat topography, fluctuations in Lake Michigan's water level considerably alter the size of these coastal wetlands as well as their species composition (Harris et al. 1977). Receding high waters expose substantial portions of sandy beach and open mud flats, which are quickly colonized by dense stands of *Schoenoplectus tabernaemontani* (softstem bulrush), *Bidens cernuus* (nodding bur-marigold), and one or more species of *Polygonum* (smartweed). Over a period of several years, these colonizing species decline and are replaced by a sedge meadow consisting primarily of *Carex* spp. and *Calamagrostis canadensis* (Harris et al. 1981).

(5) Lake Michigan Lacustrine Estuaries (Buried River Mouth). This group consists of barred lacustrine estuaries of western Lower Michigan, generally south of the **tension zone**. All of the major rivers along this stretch have lacustrine estuaries at their mouths (Albert et al. 1988, Albert et al. 1989, Minc 1997c, Minc and Albert 1998). 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, where the rivers occupy linear floodplains cut into surrounding 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 (mucks and peats) throughout the emergent and herbaceous vegetation zones. Open stream channels are generally shallow and nutrient rich, owing to the input of fine sediments and the presence of deep underlying organic substrates. While the site type (barred lacustrine estuary) occurs on Ontario portions of Lakes Ontario and Erie, the characteristic assemblage of plants may not occur.

In the emergent zone, *Nuphar advena* (yellow pond-lily) 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. *Nymphaea odorata* can form particularly dense beds in these sites.

The herbaceous zone conforms to the southern wet meadow type. *Calamagrostis canadensis* is a frequent dominant, but key southern species include *Impatiens capensis*, *Rorippa palustris* (yellow cress), *Polygonum lapathifolium* (nodding smartweed), and *Leersia oryzoides* (cut grass). The shrub zone includes *Alnus rugosa*, *Cornus stolonifera* (red-osier dogwood), along with *Fraxinus pennsylvanica* (red ash) and *Osmunda regalis* (royal fern).

(6) Saginaw Bay Lakeplain Marsh. This group contains most sites from Saginaw Bay. 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. Wetland morphological types range from protected sand-spit embayments to open coastal embayments.

Wetlands in this group contain a mix of northern and southern species; this dual affinity may reflect the location of the climatic **tension zone** across Saginaw Bay. In addition, most sites contain ample floristic evidence of surrounding intensive agricultural land-use. This vegetation assemblage may not be found on Ontario's Great Lakes shoreline, as the equivalent, large, protected embayment does not occur along the Canadian G. L. shoreline this far south.

Along more open stretches of the bay, *Schoenoplectus pungens* (three-square bulrush) typically forms a dense fringe of emergent marsh, apparently due to its greater tolerance of extreme wave action. In more protected sites, the emergent zone contains *Schoenoplectus acutus* and *Eleocharis smallii*, although not in great densities. Excessive sedimentation and turbidity appear to exclude many submergent species typically found within northern emergent marshs, including most pondweeds. *Schoenoplectus pungens*, *Schoenoplectus tabernaemontani*, *Typha angustifolia*, and *Najas flexilis* are frequently present.

The southern wet meadow has a high percentage of early successional and disturbance species, including *Bidens cernuus*, *Impatiens capensis*, *Rorippa palustris*, *Schoenoplectus tabernaemontani*, and *Polygonum lapathifolium*. Common exotics include *Lythrum salicaria*, *Phragmites australis*, *Phalaris arundinacea*, and *Polygonum persicaria* (lady's thumb). The absence of a distinct shrub swamp zone for this group may reflect the intensity of land-use in this area, in which fertile lacustrine soils are farmed as close to G. L. coastal wetlands as possible.

(7) Lake Erie-St. Clair Lakeplain Marsh. This group includes all sites from the glacial lakeplain of western Lake Erie and Lake St. Clair. 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 postglacial rise in lake level.

The St. Clair River delta 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. The St. Clair River delta has higher submergent plant diversity than most sites on either Saginaw Bay or Lake Erie. All 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. The Long Point, Ontario and Presque Isle, Pennsylvania sandspits share many habitats and species.

All of the wetlands occupy fairly protected sites (estuaries, barrier-beach lagoons, or sand-spit embayments); in addition, the Lake Erie sites enjoy the most moderate climate of the Great Lakes region. As a result, the emergent marshes and wet meadows of both Lake Erie and Lake St. Clair feature a relatively southern flora with a high proportion of disturbance species.

Common species of the emergent zone include the floating duckweeds (*Lemna minor* and *Spirodela polyrhiza*), *Ceratophyllum demersum*, *Elodea canadensis*, and *Nuphar advena* (Albert et al. 1988, Minc 1997a, Minc 1997c, Minc and Albert 1998). *Sagittaria latifolia*, *Schoenoplectus tabernaemontani*, *Typha angustifolia*, and *T.* x *glauca* (hybrid cat-tail) are common edge species. *Nelumbo lutea* (American lotus) attains very high densities at selected Lake Erie sites.

The southern wet meadow zone is dominated by *Calamagrostis canadensis*, *Phalaris arundinacea*, *Typha angustifolia*, and *Polygonum lapathifolium*. 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. As in the case for Saginaw Bay, fertile lacustrine soils are farmed as close to coastal wetlands as possible, resulting in the absence of a distinct shrub swamp.

(8) Lake Ontario Lagoon Marshes. U.S. wetlands along eastern and southeastern Lake Ontario are primarily barrier-beach lagoons (Minc 1997a, Minc 1997c, Minc and Albert 1998). In Ontario, exposed Prince Edward Island and Wolfe Island sites share similar vegetation. These sites share protected conditions and dampening of natural lake-level fluctuations.

Three distinct shoreline areas contain barrier-beach lagoons. Along the north shore on Prince Edward and Wolfe islands in Ontario, NE-SW oriented drumlins are protected by low barrier beaches, as are the N-S oriented drumlins along the southern shore of Lake Ontario. The shallow lagoons on the south shore include East Bay, Black Creek, and Sterling Creek. Along eastern Lake Ontario, sand accumulation has created a low shoreline of bays with barrier beaches and sand dunes rising up to 30 m above the lake. The barrier beaches create a string of shallow lagoons and wetlands, including Deer Creek, Cranberry Pond, South Colwell Pond, and Lakeview Pond.

The emergent zones support submergent species such as *Ceratophyllum demersum*, *Elodea canadensis*, *Spirodela polyrhiza*, *Lemna trisulca*, *Nuphar advena*, *Nymphaea odorata*, and *Potamogeton zosteriformis* (flat-stemmed pondweed). All of these reflect the well-protected and nutrient-rich waters of the lagoons.

The herbaceous zone is a broad wet meadow of *Typha angustifolia*, along with *Calamagrostis canadensis* and *Thelypteris palustris* (marsh fern). Cat-tail's 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 shrub zones divide into two distinct types. The more common type was buttonbush thicket with *Cephalanthus occidentalis* (buttonbush), *Decodon verticillata* (swamp loosestrife), and *Alnus rugosa*. These wetlands typically contained *Thelypteris palustris* and *Peltandra virginica* in mucky openings. The other type, poor shrub fen was encountered in areas of low water flow behind barriers, typically distant from the active stream channel. Here, poor fen shrubs (*Chamaedaphne calyculata*, *Myrica gale*, *Vaccinium macrocarpon*, and *Andromeda glaucophylla*) dominate, while *Sphagnum* spp. and *Sarracenia purpurea* attain high cover values in the groundcover.

(9) St. Lawrence River Estuaries (Buried River Mouth). These sites occur only along the upper reaches of the St. Lawrence River where the river is strongly influenced by Lake Ontario. This stretch features both granitic islands and bedrock knobs on the adjacent mainland.

Small streams or rivers occupy preglacial valleys cut through the 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. Crooked Creek is one of the best examples of this wetland community along this stretch of the St. Lawrence River (Herdendorf et al. 1981), while those of nearby Chippewa and Cranberry creeks are also of considerable importance to fish and wildlife (Geis and Kee 1977). It is expected that the wetlands on the nearby Canadian islands and mainland are similar.

The emergent zone is characterized by high densities of floating species, including *Utricularia vulgaris* (great bladderwort), *Lemna trisulca*, *Spirodela polyrhiza*, *Ceratophyllum demersum*, *Elodea canadensis*, *Potamogeton zosteriformis*, *P. friesii* (Fries's pondweed), and *Zizania aquatica* (wild rice) (Minc 1997a, Minc 1997c, Minc and Albert 1998). The exotic *Hydrocharis morsus-ranae* (frog's bit) is abundant. The herbaceous zone is a broad wet meadow zone with deep organic soils (often > 4 m), featuring a broad band of *Typha angustifolia*, with a narrow band of *Calamagrostis canadensis*, *Thelypteris palustris*, and *Impatiens capensis* near shore. Dominance of cat-tail reflects the reduction of natural lake-level fluctuations.

Michigan Indicator Species: *Schoenoplectis acutus*, *Schoenoplectis pungens*, *Eleocharis palustris* (*E. smallii*). A large number of other species could be treated as indicators for the several geographically or geomorphically distinct marsh types found along the Great Lakes (see vegetation description).

Other Noteworthy Species: Rare plants include *Sagittaria montevidensis* (arrowhead, state threatened), *Nelumbo lutea* (American lotus, state threatened), *Hibiscus laevis* (smooth rose-mallow, presumed extirpated from Michigan), and *Zizania aquatica* var. *aquatica* (wild rice, state threatened). Rare animals include *Chlidonias niger* (black tern, state special concern), *Rallus elegans* (king rail, state endangered), *Sterna forsteri* (Forster's tern, state threatened), *Cistothorus palustris* (marsh wren, state special concern), *Nycticorax nycticorax* (black-crowned night-heron, state special concern), *Ixobrychus exilis* (least bittern, state threatened), *Botaurus lentiginosus* (American bittern, state special concern), *Circus cyaneus* (northern harrier, state special concern), *Xanthocephalus xanthocephalus* (yellow-headed blackbird, state special concern), *Falco columbarius* (merlin, state threatened), *Pantherophis spiloides* (gray ratsnake, state special concern), *Emydoidea blandingii* (Blanding's turtle, state special concern), and *Somatochlora hineana* (Hine's emerald dragonfly, state endangered).

Conservation/Management: Great Lakes coastal wetlands provide important habitat for insects, fish, waterfowl, water birds, and mammals. Over 50 species of fish were documented to utilize the coastal wetlands of northern Lake Huron (Gathman and Keas 1999), including several game fish. Fish utilize coastal wetlands in all parts of their life cycle, including egg, larval, immature, and adult stages. A broad range of invertebrates occupy this habitat, providing food for fish and birds (Gathman and Keas 1999). Coastal wetlands have long been recognized as critical habitat for the migration, feeding, and nesting of waterfowl. The Great Lakes and connecting rivers are parts of several major flightways. Many other shore birds also feed, nest, and migrate in and through these wetlands. During spring migration, when few alternative sources of nutrients are available, terrestrial migratory songbirds feed on midges from the G.L. marshes (Ewert and Hamas 1995). Mammals utilizing coastal wetlands include *Castor canadensis* (beaver), *Ondatra zibethicus* (muskrat), *Lutra canadensis* (river otter), and *Mustela vison* (mink).

Both urban and agricultural development have resulted in severe degradation and loss of coastal marshes through pollution, land management, and ecosystem alteration:

Urban development has impacted coastal wetlands in the following ways:

- 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 has had the following impacts on coastal wetlands:

- Drainage has eliminated large areas of marshes and coastal wetlands.
- 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.
- Introduction of exotic plants has altered macrophyte species composition.

Several exotic plants and animals pose a threat to the integrity of coastal wetlands. Exotics often outcompete native organisms, as well as altering their habitat (Hart et al. 2000). Significant exotic plants include *Lythrum salicaria*, *Phragmites australis*, *Phalaris arundinacea*, *Myriophyllum spicatum* (Eurasian milfoil), *Potamogeton crispus* (curly-leaf pondweed), and many less aggressive species. *Hydrocharis moris-ranae*, an aggressive floating-leaved plant, is expanding westward from the St. Lawrence River and Lake Ontario into Lake Erie and the Detroit River, and has recently been documented in Michigan.

Exotic animals include *Dreissena polymorpha* (zebra mussel), *Cyprinus carpio* (common carp), *Neogobius* spp. (gobies), and *Bythotrephes cederstroemi* (spiny water flea), to name but a few. Many exotics arrive in shipping ballast and many others were purposefully introduced.

Research Needs: An important research need is the comparison of the biota of inland wetlands to Great Lakes coastal wetlands. There is ongoing research to document the faunal diversity of coastal wetlands, with research concentrated on invertebrates and fish (Minns et al. 1994, Brazner and Beals 1997, Burton et al. 1999, Gathman et al. 1999). Both faunal groups are being investigated as potential indicators of wetland quality. The effect of exotics on community dynamics and ecological processes also needs investigation, as does the effect of global warming. Further research on hydrological restoration is needed for degraded systems.

Similar Communities: Submergent marsh, emergent marsh, northern wet meadow, southern wet meadow, interdunal wetland, lakeplain wet prairie, lakeplain wet-mesic prairie, northern fen, coastal fen, poor fen, northern shrub thicket, southern shrub-carr, wooded dune and swale complex.

Other Classifications:

Michigan Natural Features Inventory (MNFI) Presettlement Vegetation:
6222 (Great Lakes Marsh)

Michigan Department of Natural Resources (MDNR):
N (marsh), Z (water)

Michigan Resource Information Systems (MIRIS):
621 (Aquatic bed wetland), 622 (Emergent wetland), 624 (Deep marsh)

The Nature Conservancy (Code, Alliance, Common Name):

V.C.2.N.a; Potamogeton gramineus – Potamogeton natans Northern Great Lakes Shore Herbaceous Vegetation; Grassy Pondweed- Floating Pondweed Northern Great Lakes Shore Herbaceous Vegetation.

V.C.2.N.a; Potamogeton zosteriformis – Ceratophyllum demersum – Elodea canadensis Southern Great Lakes Shore Herbaceous Vegetation; Flat-stem Pondweed – Coontail – Canadian Waterweed Southern Great Lakes Shore Herbaceous Vegetation.

V.C.2.N.a; Schoenoplectus acutus – Schoenoplectus subterminalis – Eleocharis palustris – (Schoenoplectus americanus) Northern Great Lakes Shore Herbaceous Vegetation; Hardstem Bulrush – Water Bulrush – Marsh Spikerush – (Chairmaker’s Bulrush) Northern Great Lakes shore Herbaceous Vegetation.

V.C.2.N.a; Typha spp. – Schoenoplectus tabernaemontani – Mixed Herbs Southern Great Lakes Shore Herbaceous Vegetation; Cattail Species – Softstem Bulrush – Mixed Herbs Southern Great Lakes Shore Herbaceous Vegetation.

Related Abstracts: Coastal fen, interdunal wetland, lakeplain wet prairie, lakeplain wet-mesic prairie, northern shrub thicket, northern wet meadow, poor fen, southern wet meadow, wooded dune and swale complex, wild rice, gray ratsnake, Blanding's turtle, Hines emerald, Forster's tern, black tern, northern harrier, and king rail.

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Photo by Joshua G. Cohen

Great Lakes marsh in Grand Traverse County

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Great Lakes marsh on Drummond Island. Photo by Bradford S. Slaughter.

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