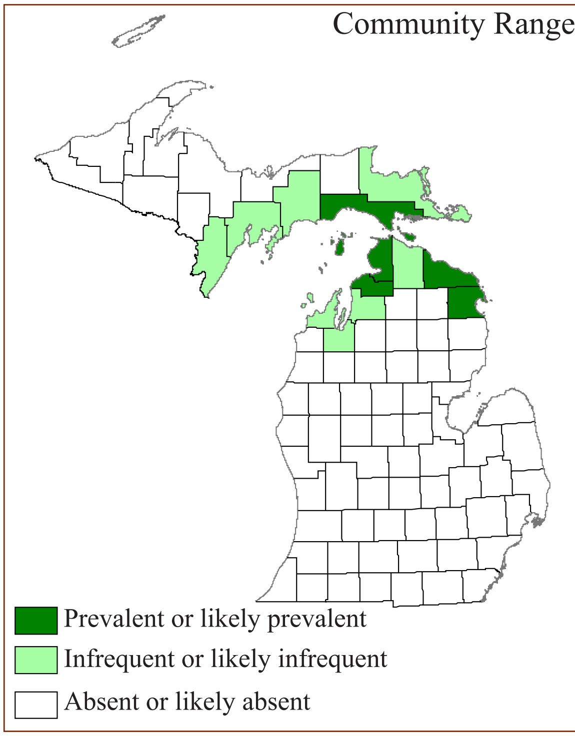
Coastal Fen — Community Abstract


Photo by Joshua G. Cohen



Overview: Coastal fen is a sedge- and rush-dominated lacustrine wetland that occurs on calcareous substrates along Lake Huron and Lake Michigan north of the climatic tension zone. The community occurs on marl and organic soils in historic coastal embayments and on moderately alkaline, carbonate-rich fine-textured sands and clays lakeward. Vegetation is comprised primarily of calciphilic species capable of growing on wet alkaline substrates. Fluctuating Great Lakes water levels at multiple spatial and temporal scales and groundwater seepage are the primary natural processes that influence community structure, species composition, and succession.

Global and State Rank: G1G2/S2

Range: Ecosystems classified as coastal fen have been documented sporadically throughout the world, especially in maritime areas. Coastal fen is locally distributed throughout its broad range, with the few sites mentioned in the scientific literature reported in southern Australia (Eardley 1943), the Shetland Islands (Bondevik et al. 2005), the Great Lakes region (Riley 1988, Moore et al. 1994, Minc and Albert 1998a), and northern California (Erman et al. 1977). In addition, "sea level fens" are found along the Atlantic shoreline of the eastern seaboard of the United States with occurrences documented in Massachusetts, Connecticut, New York, Delaware, Virginia, and Rhode Island (Ludwig and Rawinski 1993, Edinger et al. 2002, NatureServe 2009). Coastal fen within the Great Lakes region occurs on glacial lakeplains and where thin, discontinuous layers of glacial till overlay limestone along the flat, saturated shorelines of northern Lake Huron, Lake Michigan, southern Lake Superior (within Wisconsin), and Georgian Bay (Riley 1988, Moore et al. 1994, Minc 1996, Lee et al. 1998, Minc and Albert 1998a, 1998b, 2001, Epstein et al. 2002, Kost et al. 2007, Cohen 2009a, 2009b, Cohen et al. 2009, NatureServe 2009, MNFI 2010).

Fens and other related peatlands[1] typically occur in humid climates where excess moisture is abundant (where precipitation is greater than evapotranspiration) (Mitsch and Gosselink 2000). Fens can also develop in climates not suitable for the development of peatlands (e.g., in California) where consistent inflow of bicarbonate-rich groundwater occurs. Following

[1] Michigan Natural Features Inventory natural community classification groups coastal fen with other fen or peatland types (Kost et al. 2007). While coastal fen shares many properties of peatlands (i.e., groundwater influence, organic soils, and characteristic vegetation), it is not a true peatland in that significant areas of coastal fen that are influenced by Great Lakes water level fluctuation occur over very thin organic soils and/or mineral substrates.

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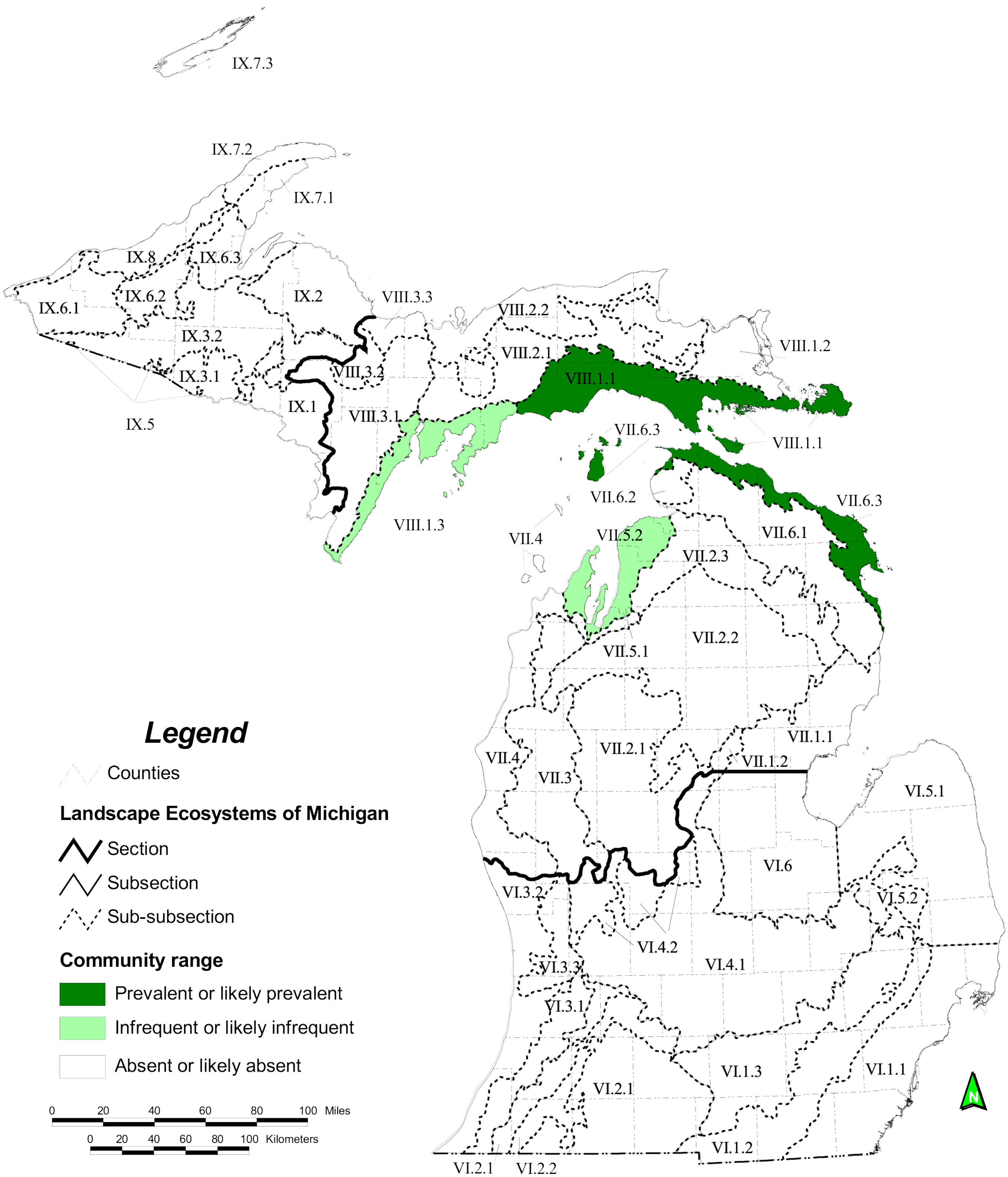

Ecoregional map of Michigan (Albert 1995) depicting distribution of coastal fen (Albert et al. 2008) glacial retreat and exposure of the northern Great Lakes shoreline 10,000 to 9,000 years ago (Sommers 1977), coastal fen likely began to develop along with other coastal wetlands. Stratigraphic evidence suggests that conditions suitable for the development of fens became widespread in the Lake States about 8,000 years ago, when sedge peats began to accumulate (Boelter and Verry 1977). Expansion of fens likely occurred following climatic cooling, approximately 5,000 years ago (Heinselman 1970, Boelter and Verry 1977, Riley 1989).

In Michigan, coastal fens occur in the northern Lower Peninsula and the southern Upper Peninsula along the northern shorelines of Lake Huron and Lake Michigan, both on the mainland and on Great Lakes islands. Coastal fens are concentrated in the Mackinac Straits area of both the Upper Peninsula and Lower Peninsula (Minc 1996, Minc and Albert 1998a, 1998b, 2001, Albert 2001, 2003, Albert et al. 2008). Within Michigan, coastal fens are relatively common in Sub-subsections VII.6.3 and VIII.1.1 and less frequent in Sub-subsections VII.5.2 and VIII.1.3 (Albert et al. 2008). Documented coastal fen element occurrences are restricted to the eastern Upper Peninsula in Sub-subsection VIII.1.1 (9 occurrences) and northern Lower Michigan in Sub-subsection VII.6.3 (10 occurrences) (MNFI 2010). Coastal fen is known from five counties in Michigan, with the majority of occurrences documented from Mackinac and Charlevoix Counties.

Rank Justification: Coastal fen is imperiled globally and in Michigan. Coastal fens are uncommon features of the northern Great Lakes region, occurring sporadically along the shoreline in Michigan's northern Lower Peninsula and eastern Upper Peninsula. As of winter 2010, a total of 19 high-quality coastal fens have been documented within Michigan, totaling 577 ha (1,426 ac). The average size of these occurrences is 30 ha (75 ac) and the range is from less than 1 to 212 ha (less than 1 to 525 ac) (MNFI 2010). The northern Lake States contain over 6 million ha (15 million ac) of peatland (Boelter and Verry 1977). Survey data indicate that coastal fen is a minor portion of that acreage. The current status of fens relative to their historical status is unknown (Bedford and Godwin 2003). Peatland scientists concur that fens have always been localized and not very abundant but have suffered from extensive loss, fragmentation, and degradation (Bedford and Godwin 2003, NatureServe 2009). Michigan's coastal fens have suffered much lower levels of degradation than most other fen types described in these studies, for several reasons, including lack of economically important marl or peat deposits and less favorable conditions for development, agriculture, and coastal recreational use.

Currently, coastal fens are threatened by non-native plant invasion, nutrient enrichment, flooding, off-road vehicle (ORV) activity, foot traffic, and development (Bedford and Godwin 2003, NatureServe 2009, MNFI 2010). These threats can cause direct impacts to the vegetation of coastal fens. Foot traffic in areas of fen has caused some trampling of vegetation and localized alteration of site hydrology (Cohen 2009a, MNFI 2010). The proximity of coastal fen to the Great Lakes shorelines makes them susceptible to Great Lakes water level fluctuations, including fluctuations driven by anthropogenic climate change. Fen vegetation is extremely sensitive to minor changes in water levels and chemistry, groundwater flow, and nutrient availability (Siegel 1988, Riley 1989). Conversion to more eutrophic wetlands can occur as the result of nutrient enrichment and raised water levels, which cause increased decomposition of peat. Eutrophication from pollution and altered hydrology has detrimentally impacted many fen types throughout the United States by generating conditions favorable for the establishment of invasive plant species (Riley 1989, Bedford and Godwin 2003) and dominance by aggressive, common natives such as broad-leaved cat-tail (*Typha latifolia*) (Richardson and Marshall 1986, Almendinger and Leete 1998b), but currently this does not appear to be the case for most coastal fens. Bedford et al. (1999) have noted a widespread decline in wetland species richness associated with the overall eutrophication of the landscape: nutrient enrichment has converted numerous species-rich wetlands such as fens into monospecific stands of nitrophilic species. Long-term studies are needed to determine if and how coastal fens are threatened by these trends.

Physiographic Context: Michigan coastal fens are restricted to flat glacial lakeplains along the saturated shorelines of northern Lake Huron and Lake Michigan where thin, discontinuous layers of glacial till overlay limestone bedrock or limestone cobble (Albert et al. 1989, Minc 1996, 1997a, Minc and Albert 1998a, 1998b, 2001, Albert 2001, 2003, NatureServe 2009, MNFI 2010). The horizontally-deposited marine and

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nearshore sedimentary bedrocks of limestone and dolomite along the Lake Huron and Lake Michigan shores provide broad zones of shallow water and fine-textured substrates suitable for the development of coastal wetlands (Minc 1997a, Minc and Albert 2001). Glacial lakeplain embayments within this region are characterized by curving sections of shoreline, shallow water depth, and gently sloping bottom topography that combine to reduce wave height and energy and protect coastal wetlands, including coastal fen, from erosive wind and wave action (Minc 1997a). Coastal fens typically occur along the shorelines of protected embayments that are sheltered from frequent wind, wave, and ice action, which can prevent the development of peat or erode existing organic soils (Gates 1942, Minc 1997a, Minc and Albert 1998a, 1998b, 2001, NatureServe 2009). Protected embayments are deep shoreline indentations that occur where glacial scouring has carved into the resistant upland shoreline (Minc 1997a). Coastal fens are less frequently associated with open embayments and sand spit embayments (Minc 1997a).

Coastal fens typically develop where groundwater seepage percolates from either calcareous uplands or joints in the underlying limestone bedrock, or where calcareous clay till is exposed at the shoreline (Minc 1996, Kost et al. 2007). A few Michigan sites (e.g., Thompson's Harbor in Alpena County and Peck Bay and Voight Bay in Mackinac County) support visible seepages; other sites display limited observable groundwater flow (Albert et al. 1989, Kost et al. 2007, Cohen 2009a, MNFI 2010). Coastal fens are located where Devonian, Silurian, and Ordovician limestone and dolomite are at or near the surface, providing a source of carbonate-rich groundwater and soils (Albert 1995). Differences in bedrock and mineral soil characteristics determine the prevalence of seepages and springs. Calcium-rich lacustrine clays and tills also provide suitable substrates for development of coastal fens (Albert et al. 1989).

Coastal fens frequently occur within large shoreline complexes that may include Great Lakes marsh, limestone cobble shore, wooded dune and swale complex, rich conifer swamp, and northern fen. The surrounding uplands are typically dominated by mesic northern forest and boreal forest and can contain a significant component of northern white-cedar (*Thuja occidentalis*) (Albert et al. 1989, Albert 2001, 2003, Cohen 2009a, 2009b, Cohen et al. 2009, MNFI 2010). Coastal fens are often associated with springs and streams (Albert 2003). Since coastal fens occur over limestone bedrock, they can occur in association with karst features such as sinkholes (e.g., El Cajon Bay, Alpena County) (Albert 2003, Cohen et al. 2009, MNFI 2010).

Soils: The soils of coastal fen range from neutral to moderately alkaline, fine-textured sand to clay in areas immediately adjacent to the lake, to shallow marl and organic sediments in protected coastal embayments less influenced by storm waves. When lake levels rise, areas closer to the lakeshore become inundated and storm waves can wash away loose organic and marl sediments (Minc 1997a). The mineral soils of coastal fens are calcareous, nutrient-rich, and moisture-rich, deriving from marine deposits of eroded limestone and dolomite bedrock (Minc 1996, Minc and Albert 1998a, 1998b, 2001, Albert 2003). The organic soils of coastal fens are composed of shallow peat and/or marl with depth of the organic layer typically less than 7 cm (Albert et al. 1989, Minc 1996, Minc and Albert 1998, Cohen et al. 2009, MNFI 2010). Peat is a fibrous network of partially decomposed organic material that is formed under anaerobic conditions and can form shallow, patchy mats in protected areas of coastal fens (Heinselman 1963, Almendinger et al. 1986). The saturated surface peats of fens are formed from brown mosses and graminoids and, like the surface water, are neutral to alkaline and characterized by high availability of calcium and magnesium carbonates (Curtis 1959, Heinselman 1963, 1970, Schwintzer and Williams 1974, Boelter and Verry 1977, Almendinger et al. 1986, Swanson and Grigal 1989, NatureServe 2009).

In addition to peat, coastal fens often contain or develop on extensive areas of marl, a grayish, mineral substrate with a smooth, silty texture that is created when metabolism by algae results in precipitation of calcium carbonate (Treese and Wilkinson 1982, Almendinger and Leete 1998b, Amon et al. 2002, Bedford and Godwin 2003, NatureServe 2009). Shallow water supporting populations of marl-producing algae commonly occurs within coastal fens. Extensive marl flats develop in protected areas away from the shoreline, where marl accumulates in shallow, relatively warm water and eventually becomes sparsely vegetated by a unique suite of species able to survive in wet alkaline conditions (Albert et al. 1989, Minc 1996, Minc and Albert 1998a, 1998b, 2001, Albert 2003, Kost et al 2007, Cohen et al. 2009, NatureServe 2009, MNFI 2010). Low peat mounds or "islands" that support a continuous carpet of sphagnum mosses and ombrotrophic plant species are often dispersed throughout coastal fens, especially in extensive areas of marl flats. The organic soils of these peat islands are often acidic as a result of the reducing effect of sphagnum mosses and raised elevation above the underlying calcareous groundwater and substrate (MNFI 2010).

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Climate: The range of coastal fen within the northern Lake States is characterized by a humid, continental climate with long, cold winters and short summers that are moist and cool to warm (Gates 1942, Boelter and Verry 1977, Damman 1990, Mitsch and Gosselink 2000). Michigan coastal fen falls within the following regions classified by Albert et al. (1986) and Albert (1995): Region II, Northern Lower Michigan, and Region III, Eastern Upper Michigan. Coastal fens occur in a cool snow-forest climate with short, warm summers, cold winters, and a large number of cloudy days. As lacustrine systems, their climate is modified by air masses crossing Lake Huron and Lake Michigan. The growing season length ranges from 120 to 150 days. The normal annual total precipitation ranges from 711 to 812 mm (28 to 32 in) and annual snowfall ranges from 1524 to 2032 mm (60 to 80 in). The daily maximum temperature in July ranges from 22 to 29 °C (72 to 85 °F), the daily minimum temperature in January ranges from “14 to “9 °C (6 to 15 °F), the yearly minimum temperature is typically “29 °C (“20 °F), and the mean annual temperature ranges between 5 to 6 °C (41 to 43 °F) (Albert et al. 1986, Barnes 1991, Albert 1995).

Natural Processes: Coastal fens are minerotrophic lacustrine wetlands, receiving inputs of water and nutrients from groundwater and from infrequent Great Lakes wave events. The high mineral content of the groundwater is derived from the limestone and dolomite and calcareous glacial tills and lacustrine clays exposed by wave action along the Great Lakes shoreline (Albert et al. 1989, Minc 1996, Minc and Albert 1998a, 1998b, 2001, Albert 2001, 2003). The hydrologic regime of coastal fens is directly linked to that of the Great Lakes. As such, the water table is not stable, being subject to seasonal fluctuations in Great Lakes water levels, short-term changes due to seiches and storm surges, and long-term, multi-year lake level fluctuations (Minc 1997a, 1997b, Minc and Albert 1998a, 1998b, 2001). Storm waves infrequently disturb coastal fens, reconfiguring the substrate and removing fine mineral sediments and organic soils (Minc 1997a, 1997b, Minc and Albert 1998a, 1998b, 2001). Seasonal and annual water level fluctuations restrict woody vegetation within coastal fens (Minc 1997a, 1997b, Minc and Albert 1998a, 1998b, MNFI 2010). Long-term cyclic fluctuations of Great Lakes water levels significantly influence vegetation patterns of coastal fen, with vegetation and organic soils becoming well established during low-water periods and reduced or eliminated during high-water periods (Minc 1997a, 1997b, Minc and Albert 1998a, 1998b, 2001). Organic and marl sediments can be washed away when lake levels rise and inundate nearshore areas of coastal fen, causing a successional shift from coastal fen to Great Lakes marsh or limestone cobble shore when the waters recede (Minc and Albert 1998a, 1998b). Windthrow caused by severe storms along the shoreline of Lake Michigan and Lake Huron can expand coastal fen farther inland, especially during Great Lakes high-water periods (Kost et al. 2007).

Coastal fens occur along level shoreline with broad zones of shallow water over horizontally-deposited marine and near-shore sedimentary bedrock. These areas of shallow and flat shoreline reduce the impact of erosive wave action and allow long-term lateral shifts of vegetative zones as lake levels fluctuate (Minc 1997a, Minc and Albert 2001). The ability for vegetation to shift laterally as water levels fluctuate results in a high degree of floristic continuity within these shifting zones (Minc 1997a).

Photo by Bradford S. Slaughter

Coastal fens are characterized by dynamic hydrology that is subject to seasonal fluctuations in Great Lakes water levels, short-term changes due to seiches and storm surges, and long-term multi-year lake level fluctuations.

As lacustrine systems, coastal fens are influenced directly by waters of the Great Lakes (Minc and Albert 2001). However, coastal fens are also influenced by groundwater seepage. The cool groundwater that enters fens is telluric (rich in mineral ions), having moved over or percolated through base-rich bedrock and calcareous glacial deposits and mineral soils (Schwintzer 1978b, Minc and Albert 1998a, 1998b, Bedford and Godwin 2003). As a result, the groundwater discharge into fens is mineral-rich, carrying high concentrations of calcium and magnesium carbonates (Curtis 1959, Heinselman 1970, Verry 1975, Boelter and Verry 1977, Schwintzer 1978b, 1981, Almendinger et al. 1986, Almendinger and Leete 1998b, Mitsch and Gosselink 2000, Amon et al. 2002, Bedford and Godwin 2003, NatureServe 2009). In addition to containing high levels of dissolved minerals, the groundwater of fens is circumneutral to alkaline and characterized by high specific conductivity, cool temperature, and a clear color resulting from low levels of dissolved organic matter (Verry 1975, Glaser et al.

1981, 1990, Wheeler et al. 1983, Riley 1989). Scientists studying minerotrophic fens in the Great Lakes have reported a wide range of pH values (5.0 – 8.0) (Heinselman 1970, Boelter and Verry 1977, Schwintzer 1978b, Glaser et al. 1981, 1990, Wheeler et al. 1983, Siegel and Glaser 1987, Riley 1989). Within coastal fens of Michigan, recorded pH values range between 6.3 and 8.2 (Minc 1996, Minc and Albert 1998a, 1998b, 2001, MNFI 2010). The degree of minerotrophy of a given fen and within a fen depends on a variety of factors including: the kind and amount of groundwater discharge; degree of dilution from precipitation and wave action; the characteristics of the bedrock and/or glacial deposits the groundwater has percolated through (i.e., older glacial sediments have less dissolved minerals due to prior leaching); the distance the water has traveled through the wetland; the thickness and character of the organic soils; the presence or absence of marl; vegetative composition; and the nature and strength of the organic acids produced by the fen vegetation (Heinselman 1963, 1970, Boelter and Verry 1977, Siegel and Glaser 1987, Amon et al. 2002, Siegel et al. 2006).

Areas of coastal fens protected from waves are characterized by the development of shallow peat and/or marl soils overlying the mineral substrate (MNFI 2010). Peat establishment requires an abundant supply of water; peatlands are concentrated in regions where precipitation is greater than evapotranspiration, producing substantial groundwater discharge (Dansereau and Segadas-Vianna 1952, Boelter and Verry 1977, Almendinger and Leete 1998b, Mitsch and Gosselink 2000), and where bedrock or impermeable clay sediments are near the surface, also promoting saturated conditions. Protected areas of coastal fen are characterized by saturated and inundated conditions that inhibit organic matter decomposition and allow for the accumulation of peat (Almendinger and Leete 1998b, Amon et al. 2002). Under cool and anaerobic conditions, the rate of organic matter accumulation exceeds organic decay (Schwintzer and Williams 1974, Damman 1990, Mitsch and Gosselink 2000). Low levels of oxygen due to saturated conditions protect plant matter from microorganisms and chemical actions that cause decay (Miller 1981). Despite favorable climatic conditions for the accumulation of peat, peat soils in coastal fens are typically shallow and concentrated along the upland margin due to periodic wave action and inundation that washes away organic sediments (Minc 1997a, Cohen et al. 2009, MNFI 2010). In addition to peat accumulation, marl can also develop in coastal fens. When carbonate-rich groundwater flows from underlying calcareous substrates, it provides a nutrient-rich environment for the rapid growth of stoneworts (*Chara* spp.) and other algae. The metabolism of these algae produces calcium carbonate, which precipitates as marl, a fine, grayish, mud-like substance (Minc and Albert 1998a, 1998b, 2001, Albert 2001, 2003, Kost et al. 2007, MNFI 2010).

Within the Mackinac Straits area, there are numerous northern fens that occur inland from the lakeshore, many of which are curvilinear in shape (MNFI 2010). These fens are old shorelines that were once coastal fens (Futyma 1992). With the rising of the earth's crust in northern Michigan (i.e., isostatic rebound) and subsequent recession of Great Lakes water levels (Dorr and Eschman 1970), the transition from coastal fen to inland northern fen likely occurred over thousands of years based on studies of numerous relict shorelines (Baedke and Thompson 2000, Baedke et al. 2004). However, coastal fen and northern fen share many similarities including the prevalence of a calciphilic, graminoid-dominated flora, marl, and groundwater influence. Coastal fen is differentiated from northern fen primarily based upon the connection of coastal fens to Great Lakes waters. In addition, coastal fens are characterized by shallower organic soils compared to northern fens, which often develop deep organic peats and/or marls.

Vegetation Description: Coastal fens support a unique and diverse heliophilous (sun-loving) flora with a rich herbaceous layer dominated by graminoids. In addition, the community is characterized by insectivorous plants, calciphilic forbs, and scattered low shrubs and stunted conifers (Gates 1942, Curtis 1959, Vitt and Slack 1975, Minc 1996, Minc and Albert 1998a, 1998b, 2001, Mitsch and Gosselink 2000, Amon et al. 2002, Bedford and Godwin 2003, NatureServe 2009). Floristically, fens are among the most diverse of all wetland types in the United States, exhibiting high species richness and diversity, and also supporting numerous rare and uncommon vascular plants, particularly calciphiles (Almendinger and Leete 1998a, 1998b, Bedford and Godwin 2003, NatureServe 2009). Species richness of fens is related to geographical location, climatic factors, nutrient availability, and habitat heterogeneity (Glaser et al. 1990, Glaser 1992). Species composition

Photo by Joshua G. Cohen

Diverse microhabitats, such as marl flats and low peat mounds, generate small-scale heterogeneity within coastal fens that contributes to the high floristic diversity.

of coastal fen varies depending on gradients in nutrient levels and water chemistry. Floristic diversity within coastal fens is correlated with high levels of available nutrients (i.e., calcium and magnesium carbonates) and microtopography (Riley 1989, Glaser et al. 1990). The high degree of small-scale environmental heterogeneity results in distinctive vegetational zonation (Amon et al. 2002, Bedford and Godwin 2003).

Vegetation zones that frequently occur within coastal fens include diverse fen meadows, sparsely-vegetated marl flats, shrub thickets, which often occur as narrow bands on the upland margin, low peat mounds dominated by sphagnum mosses, ericaceous shrubs, and scattered clumps of coniferous trees, and shallow pools of water (Minc 1997a, Cohen et al. 2009, MNFI 2010). As noted above, the metabolism of algae (i.e., stoneworts) in these pools of water produces calcium carbonate, which precipitates as marl. Floristic composition is determined by gradients in pH, light, soil moisture, and cation concentrations (nutrient availability) (Heinselman 1970, Vitt and Slack 1975, Schwintzer 1978a, Glaser et al. 1981, 1990, Siegel 1988, Anderson et al. 1996, Bedford et al. 1999). Very few introduced, weedy species are able to establish within fens, likely because of the unique growing conditions and competition from the adapted flora. Coastal fens are dominated by plants that thrive in minerotrophic conditions. Although calciphilic species dominate the majority of coastal fens, acidophilic species can establish on sphagnum-covered peat mounds, where they are isolated from the influence of mineral-rich groundwater and substrate (Wheeler et al. 1983, Amon et al. 2002). The vegetation assemblage growing on these low peat mounds is characterized by a continuous carpet of sphagnum mosses, low ericaceous, evergreen shrubs, and widely scattered or clumped, stunted conifer trees.

Sedges and rushes dominate the herbaceous layer of fens. Most of the graminoids of coastal fens are rhizomatous, an adaptation well suited to the dynamic environment of the Great Lakes shoreline (Kost et al. 2007). The most abundant sedges, rushes, and grasses include twig-rush (*Cladium mariscoides*), Baltic rush (*Juncus balticus*), bluejoint grass (*Calamagrostis canadensis*), tufted bulrush (*Trichophorum cespitosum*), beaked spike-rush (*Eleocharis rostellata*), golden-seeded spike-rush (*E. elliptica*), hair grass (*Deschampsia cespitosa*), hardstem bulrush (*Schoenoplectus acutus*), three-square (*S. pungens*), white beak-rush (*Rhynchospora alba*), little bluestem (*Andropogon scoparius*), wiregrass sedge (*Carex lasiocarpa*), Buxbaum's sedge (*C. buxbaumii*), yellow sedge (*C. flava*), little green sedge (*C. viridula*), ebony sedge (*C. eburnea*), and hair-like sedge (*C. capillaris*). Additional graminoids include marsh wild-timothy (*Muhlenbergia glomerata*), beak-rush (*Rhynchospora capillacea*), Crawe's sedge (*Carex crawei*), elk sedge (*C. garberi*), and panic grass (*Panicum lindheimeri*). The sparsely-vegetated marl flats typically support twig-rush, beak-rushes, spike-rushes (i.e., beaked spike-rush), rushes, bulrushes, and sedges. Few-flower spike-rush (*Eleocharis quinqueflora*) is often prevalent on wet mineral soil flats along the lakeward margin of coastal fens.

The common forbs of coastal fen include many species occurring in other calcium-rich habitats along northern Lake Michigan and Lake Huron including low calamint (*Calamintha arkansana*), Kalm's lobelia (*Lobelia kalmii*), false asphodel (*Tofieldia glutinosa*), grass-of-Parnassus (*Parnassia glauca*), dwarf Canadian primrose (*Primula mistassinica*), Indian paintbrush (*Castilleja coccinea*), Ohio goldenrod (*Solidago ohioensis*), bog goldenrod (*S. uliginosa*), common bog arrow-grass (*Triglochin maritimum*), balsam ragwort (*Senecio pauperculus*), common boneset (*Eupatorium perfoliatum*), small-fringed gentian (*Gentianopsis procera*), mermaid-weed (*Proserpinaca palustris*), bastard toadflax (*Comandra umbellata*), yellow lady's-slipper (*Cypripedium calceolus* var. *pubescens*), grass-leaved goldenrod (*Euthamia graminifolia*), common water horehound (*Lycopus americanus*), silverweed (*Potentilla anserina*), Seneca snakeroot (*Polygala senega*), northern bog violet (*Viola nephrophylla*), asters (*Aster* spp.), and white camas (*Zigadenus glaucus*). Several carnivorous plants grow in the coastal fens, including sundew (*Drosera rotundifolia*), linear-leaved sundew (*D. linearis*), pitcher-plant (*Sarracenia purpurea*), butterwort (*Pinguicula vulgaris*, state special concern), and bladderworts (*Utricularia cornuta* and *U. intermedia*). These carnivorous species can survive in habitats where nitrogen supplies are limited and are well adapted to the calcareous environment of coastal fens, where iron and aluminum may render phosphorous insoluble (Crum 1988). Forbs that are characteristic of the marl flats include false asphodel, common bog arrow-grass, grass-of-Parnassus, Kalm's lobelia, white camas, and Ohio goldenrod. Forbs prevalent along the upper margins of coastal fen include purple gerardia (*Agalinis purpurea*), nodding ladies' tresses (*Spiranthes cernua*), and gay wings (*Polygala paucifolia*).

Brown mosses are common in shallow pools and along edges of the fen. These include scorpidium moss (*Scorpidium scorpioides*), star campylium moss (*Campylium polygamum*), cinclidium moss (*Cinclidium stygium*), and calliergon moss (*Calliergon trifarium*) (Crum 1988). Spikemoss (*Selaginella selaginoides*) is equally common on moist substrates (Crum 1988).

Shrub cover within coastal fens is low (typically less than 25%) (NatureServe 2009). Shrubs found in coastal fen include shrubby cinquefoil (*Potentilla fruticosa*), sweet gale (*Myrica gale*), Kalm's St. John's-wort (*Hypericum kalmianum*), Labrador tea (*Ledum groenlandicum*), large cranberry (*Vaccinium macrocarpon*), creeping juniper (*Juniperus horizontalis*), alder-leaved buckthorn (*Rhamnus alnifolia*), soapberry (*Shepherdia canadensis*), and bog willow (*Salix pedicellaris*). Ericaceous shrubs occur within the low shrub layer of coastal fens but with far lesser frequency and at lower density than in bogs and poor fens. Among these heath shrubs, bog rosemary (*Andromeda glaucophylla*), Labrador tea, and small cranberry (*Vaccinium oxycoccos*) are particularly common on low peat mounds within coastal fen.

Trees within coastal fens are widely scattered, often occurring in clumps on low peat mounds, and are typically of low stature. Stunted northern white-cedar (*Thuja occidentalis*) and tamarack (*Larix laricina*) are most prevalent; additional trees include balsam poplar

(*Populus balsamifera*), black spruce (*Picea mariana*), and paper birch (*Betula papyrifera*). Trees are often scattered throughout the fen but are concentrated along the upland margin, and are often killed when Great Lakes water levels rise, especially in low areas and near the lake. (Above species lists were compiled from Voss 1972, 1985, 1996, Albert et al. 1989, Minc 1996, 1997a, 1997b, Minc and Albert 1998a, 1998b, 2001, Albert 2001, 2003, Penskar et al. 2002, Johnston et al. 2007, Cohen 2009a, Cohen et al. 2009, NatureServe 2009, MNFI 2010)


Photo by Joshua G. Cohen

Conifer and shrub cover become denser with increasing distance from the shoreline and increasing depth of organic soils.

Plant species composition responds rapidly to changes in water levels. Among the species that appear in large numbers in coastal fens when the water level drops are butterwort, Kalm's St. John's-wort, low calamint, Kalm's lobelia, grass-of-Parnassus, Indian paintbrush, dwarf Canadian primrose, silverweed, and Houghton's goldenrod (*Solidago houghtonii*, federal/state threatened) (Minc 1997b, Kost et al. 2007). As noted, coastal fens occur in areas of shallow and flat shoreline that allow for the lateral shifting of vegetative zones. Since the vegetation shifts laterally as water levels fluctuate, coastal fens are characterized by a high degree of overall species continuity or consistency in species composition during lake level fluctuations (Minc 1997a).

Michigan Indicator Species: northern white-cedar, shrubby cinquefoil, twig-rush, low calamint, Baltic rush, Kalm's lobelia, sweet gale, tamarack, pitcher-plant, false asphodel, tufted bulrush, grass-of-Parnassus, dwarf Canadian primrose, Indian paintbrush, Kalm's St. John's-wort, yellow sedge, wiregrass sedge, Ohio goldenrod, beaked spike-rush, butterwort, small-fringed gentian, balsam ragwort, stoneworts, and common bog-arrow grass.

Other Noteworthy Species: Great Lakes coastal wetlands provide critical habitat for invertebrates, birds, fish, and mammals (Albert 2001). A wide array of insect species utilizes the diversity of microhabitats within coastal fen, including aquatic pools with oxygen rich water, streams, and waved-washed shoreline (Cuthrell 2010, personal communication). Numerous butterflies and moths are restricted to fens because their food plants occur within these wetland systems (Riley 1989), but inventories have not been conducted in coastal fen to determine which lepidopterans utilize this habitat. In addition, many land snails are associated with coastal fens, including the rare species listed below. Crayfish and minnow populations are abundant within coastal fens during high water years (Albert 2003). Hine's emerald dragonfly (*Somatochlora hineana*, federal/state endangered) utilizes coastal fens, where their larvae hide within crayfish burrows (Cuthrell 1999, Lee et al. 2006).

Rare herptiles that utilize coastal fens include Blanding's turtle (*Emydoidea blandingii*, state special concern), eastern box turtle (*Terrapene c. carolina*, state special concern), and eastern massasauga (*Sistrurus c. catenatus*, federal candidate species and state special concern). The northern Lower Peninsula and Bois Blanc Island represent the northern range limit of eastern massasauga in Michigan (Lee and Legge 2000). If suitable nesting trees or snags are available, merlin (*Falco columbarius*, state threatened), bald eagle (*Haliaeetus leucocephalus*, state special concern), and osprey (*Pandion haliaetus*, state special concern) can be found nesting on the margins of coastal fens. Migrating birds utilize nearshore habitat such as coastal fen for feeding and resting. During spring migration, when few alternative sources of nutrients are available, terrestrial migratory songbirds feed on midges from coastal wetlands (Ewert and Hamas 1995). Mammals utilizing coastal wetlands include beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), river otter (*Lutra canadensis*), and mink (*Mustela vison*) (Albert 2001).

Coastal fens support numerous rare plants, including many calciphilic species (Almendinger and Leete

1998b, Bedford and Godwin 2003). Rare plants associated with coastal fens include prairie Indian-plantain (*Cacalia plantaginea*, state special concern), bulrush sedge (*Carex scirpoidea*, state threatened), English sundew (*Drosera anglica*, state special concern), butterwort (*Pinguicula vulgaris*, state special concern), and Houghton's goldenrod (*Solidago houghtonii*, federal/state threatened). Butterwort and Houghton's goldenrod are found along moist edges of coastal fens and typically colonize lakeward during low water years. The upland margin of coastal fen can support populations of dwarf lake iris (*Iris lacustris*, federal/state threatened) and Richardson's sedge (*Carex richardsonii*) (Albert 2003).

Rare Plants Associated with Coastal Fen (E, Endangered; T, Threatened; SC, species of special concern: LT, Federally Threatened).
Cacalia plantaginea (prairie Indian-plantain, SC)
Carex richardsonii (Richardson's sedge, SC)
Carex scirpoidea (bulrush sedge, T)
Drosera anglica (English sundew, SC)
Iris lacustris (dwarf lake iris, LT, T)
Pinguicula vulgaris (butterwort, SC)
Solidago houghtonii (Houghton's goldenrod, LT, T)

Rare Animals Associated with Coastal Fen (E, Endangered; T, Threatened; SC, species of special concern; LE, Federally Endangered; LT, Federally Threatened).
Ardea herodias rookery (great blue heron rookery[2])
Botaurus lentiginosus (American bittern, SC)
Catinella exile (Pleistocene catinella, T)
Circus cyaneus (northern harrier, SC)
Emydoidea blandingii (Blanding's turtle, SC)
Euconulus alderi (land snail, T)
Haliaeetus leucocephalus (bald eagle, SC)
Merolonche dolli (Doll's merolonche moth, SC)
Pandion haliaetus (osprey, SC)
Phyciodes batesii (tawny crescent, SC)
Planogyra asteriscus (eastern flat-whorl, SC)
Sistrurus c. catenatus (eastern massasauga, SC[3])
Somatochlora hineana (Hine's emerald, LE, E)
Somatochlora incurvata (incurvate emerald, SC)
Terrapene c. carolina (eastern box turtle, SC)
Vertigo elatior (tapered vertigo, SC)
Vertigo morsei (six-whorl vertigo, E)
Vertigo pygmaea (crested vertigo, SC)
Williamsonia fletcheri (ebony boghaunter, SC)

[2]Protected by the Migratory Bird Treaty Act of 1918
[3]Federal candidate species


Photo by Michael A. Kost
Butterwort and dwarf lake iris occur along the margins of coastal fens and adjacent rich conifer swamp.

Conservation and Biodiversity Management: Coastal fen is an uncommon community type in the Great Lakes region that contributes significantly to the overall biodiversity of northern Michigan by providing habitat for a unique suite of plants and wide variety of animal species. Numerous rare species are associated with fens, including many calciphiles that depend on the carbonate-rich substrate. Given the rarity of coastal fen, its contribution to regional biodiversity, and the threats to this community type, coastal fens are high priorities for stewardship and monitoring activity.

Protecting the hydrology of coastal fens is critical to their long-term viability. Wetland systems are sensitive to slight changes in water chemistry; modifications in fen hydrology can result in significant shifts in vegetation. Resource managers operating in uplands adjacent to fens should take care to minimize the impacts of management to hydrologic regimes, especially increased surface flow and reduction in groundwater recharge. Increased surface flow and reduction in groundwater recharge can be prevented by establishing no-cut buffers around coastal fens and avoiding road construction and complete canopy removal in forest stands immediately adjacent to fens. In addition, road and trail construction through fens should be avoided to prevent hydrologic alterations. Roads and trails can impede surface flow, which results in sustained flooding on the upslope margin of the road and drying on the downslope margin of the road, causing significant changes in species composition and structure. Perhaps the greatest threat to coastal fens comes from off-road vehicle (ORV) traffic, which can destroy populations of sensitive species and drastically alter fen hydrology through rutting (Cohen 2009a, Cohen et al. 2009, MNFI 2010). The creation of deep ruts in the loose soils of coastal fen alters surface flows and species composition, and generates opportunities for invasive plants to establish. Reduction of access to shoreline systems will help decrease detrimental impacts caused by ORVs.

Particularly aggressive invasive species that have the potential to threaten diversity and structure of coastal fens include glossy buckthorn (*Rhamnus frangula*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha* x*glauca*), reed canary grass (*Phalaris arundinacea*), and reed (*Phragmites australis*). These non-native plants have colonized similar habitats such as prairie fen and Great Lakes marsh in southern Lower Michigan, and thus have the potential to detrimentally impact coastal fen as well, especially following anthropogenic disturbance. Coastal fens are vulnerable to invasion by non-native weedy annuals, such as dog mustard (*Erucastrum gallicum*) and wall rocket (*Diplotaxis muralis*), following recession of lake levels (Cohen et al. 2009). Monitoring and control efforts to detect and remove invasive plants before they become widespread will help maintain the ecological integrity of coastal fens and surrounding natural communities.

Research Needs: Coastal fen has been little researched and exhibits numerous regional, physiographic, hydrologic, and edaphic variants. The diversity of variation throughout its range demands the continual refinement of regional classifications of coastal fens that focus on the inter-relationships among vegetation, physiography, and hydrology. Coastal fens and related community types (i.e., northern fen, Great Lakes marsh, and limestone cobble shore) can be difficult to differentiate. Research on abiotic and biotic indicators that help distinguish similar natural communities would be useful for field classification. Systematic surveys for coastal fens and related ecosystems are needed to help prioritize conservation and management efforts. More research is needed to elucidate the relationship of chemical factors and nutrients to the floristic community structure of fens (Amon et al. 2002). The examination of non-native plant establishment in coastal fens and means of controlling invasive species is especially critical. Given the sensitivity of fens to slight changes in hydrology and nutrient availability, it is important for scientists to predict how fens will be affected by climate change and atmospheric deposition of nutrients and acidifying agents (Heinselman 1970, Riley 1989, Bedford et al. 1999, Gignac et al. 2000, Mitsch and Gosselink 2000).

Photo by Joshua G. Cohen

More research is needed to better understand how coastal fen is influenced by Great Lakes water level fluctuations.

Similar Natural Communities: Great Lakes marsh, interdunal wetland, intermittent wetland, lakeplain wet-mesic prairie, limestone cobble shore, northern fen, poor fen, prairie fen, rich conifer swamp, sand and gravel beach, and wooded dune and swale complex.

Other Classifications:

Michigan Natural Features Inventory Circa 1800 Vegetation (MNFI): Emergent Marsh (6221), Great Lakes marsh (6222), and Wet Meadow (6224).

Michigan Department of Natural Resources (MDNR): N (marsh).

Michigan Resource Information Systems (MIRIS): 62 (non-forested wetland) and 622 (emergent wetland).

NatureServe Ecological Systems Classification:

CES201.722: Northern Great Lakes Coastal Marsh

The Nature Conservancy National Classification: CODE; ALLIANCE; ASSOCIATION; COMMON NAME

III.B.2.N.g; *Dasiphora fruticosa ssp. floribunda – Myrica gale* – (*Carex lasiocarpa*) Saturated Shrubland Alliance; *Dasiphora fruticosa ssp. floribunda – Myrica gale* Rich Shore Fen Shrubland; Shrubby-cinquefoil – Sweetgale Rich Shore Fen Shrubland; Shrubby-cinquefoil – Sweetgale Rich Shore Fen

V.A.5.N.m; *Calamagrostis canadensis – Carex viridula – Cladium mariscoides – Lobelia kalmii* Saturated Herbaceous Alliance; *Calamagrostis canadensis – Carex viridula – Cladium mariscoides – Lobelia kalmii* Herbaceous Vegetation; Bluejoin – Little Green Sedge – Smooth Sawgrass – Ontario Lobelia Herbaceous Vegetation; Great Lakes Sedge Rich Shore Fen

Related Abstracts: Great Lakes marsh, interdunal wetland, intermittent wetland, lakeplain wet-mesic prairie, limestone cobble shore, northern fen, poor fen, prairie fen, rich conifer swamp, sand and gravel beach, wooded dune and swale complex, American bittern, bald eagle, Blanding's turtle, crested vertigo, eastern box turtle, eastern flat-whorl, eastern massasauga, *Euconulus alderi* (land snail), great blue heron rookery, incurvate emerald, Hine's emerald dragonfly, merlin, northern harrier, osprey, Pleistocene catinella, six-whorled vertigo, tapered vertigo, butterwort, dwarf lake iris, English sundew, Houghton's goldenrod, prairie Indian-plantain, and Richardson's sedge.

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