# Northern Fen Community Abstract

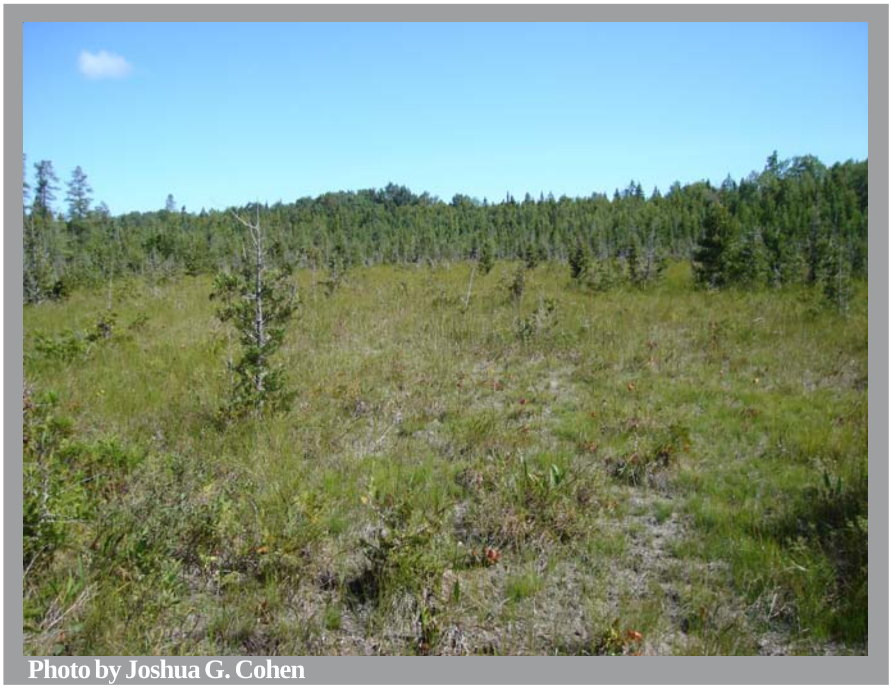
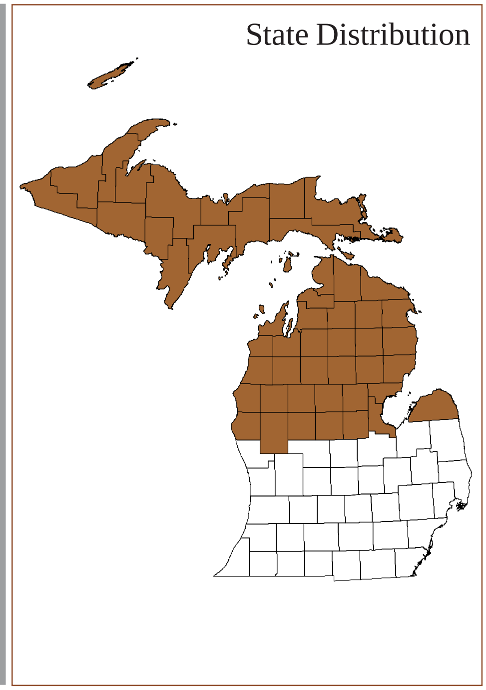


Photo by Joshua G. Cohen




**Overview**: Northern fen is a sedge- and rush-dominated wetland occurring on neutral to moderately alkaline saturated peat and/or marl influenced by groundwater rich in calcium and magnesium carbonates. The community occurs north of the climatic tension zone and is found primarily where calcareous bedrock underlies a thin mantle of glacial drift on flat areas or shallow depressions of glacial outwash and glacial lakeplains and also in kettle depressions on pitted outwash and moraines.

**Global and State Rank:** G3G5/S3

**Range:** Northern fen is a peatland type of glaciated landscapes of the northern Great Lakes region, ranging from Michigan west to Minnesota and northward into central Canada (Ontario, Manitoba, and Quebec) (Gignac et al. 2000, Faber-Langendoen 2001, Amon et al. 2002, NatureServe 2007). Northern fen may also occur in parts of the northeastern United States (i.e., New York and Maine). In Michigan, northern fens occur in the northern Lower Peninsula and the Upper Peninsula, most frequently in proximity to Great Lakes shorelines. Most documented occurrences from the Upper Peninsula are known from the eastern portion. Fens and other peatlands occur where excess moisture is abundant (where precipitation is greater than evapotranspiration) (Mitsch and Gosselink 2000). Conditions suitable for the development of fens have occurred in the northern Lake States for the past 8,000 years. Expansion of peatlands likely occurred following climatic cooling, approximately 5,000 years ago (Heinselman 1970, Boelter and Verry 1977, Riley 1989).

Several other natural peatland communities also occur in Michigan and can be distinguished from minerotrophic (nutrient-rich) northern fens, based on comparisons of nutrient levels, flora, canopy closure, distribution, landscape context, and groundwater influence (Kost et al. 2007). Northern fen is dominated by sedges, rushes, and grasses (Mitsch and Gosselink 2000). Additional open wetlands occurring on organic soils include coastal fen, poor fen, prairie fen, bog, intermittent wetland, and northern wet meadow. Bogs, peat-covered wetlands raised above the surrounding groundwater by an accumulation of peat, receive inputs of nutrients and water primarily from precipitation and are classified as ombrotrophic (rain-fed and subsequently nutrient-poor) (Gignac et al. 2000). The hydrology of fens is influenced by groundwater and as a result, fens have higher nutrient availability, increased alkalinity (less acidity), and greater species richness compared to bogs, with poor fens being most similar to bogs in terms of these factors and species composition. In addition to a greater importance by graminoids in fens versus bogs, nutrient-rich fens also are less dominated by sphagnum mosses (*Sphagnaceae*) with brown mosses (*Amblystegiaceae*) being more prevalent. Coastal fen is a sedge- and rush-dominated wetland that occurs on calcareous substrates adjacent

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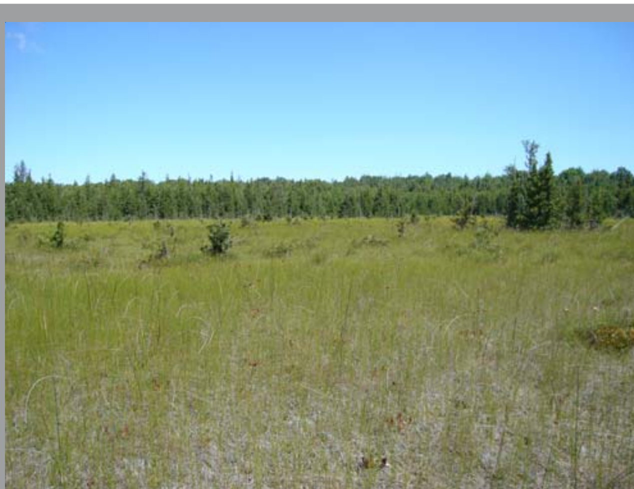
to Lake Huron and Lake Michigan where marl and organic soils accumulate in protected coves and abandoned coastal embayments. In contrast, northern fen is an inland system. Like northern fen, coastal fen, and poor fen, prairie fen is graminoid-dominated and groundwater-influenced, however prairie fen is restricted to south of the climatic tension zone. Intermittent wetland is an herb- or herb-shrub–dominated wetland that experiences fluctuating water levels seasonally and yearly. The soils of intermittent wetland are very strongly acid to strongly acid and range from loamy sand and peaty sand to peaty muck. Northern wet meadow, a groundwater-influenced wetland that occurs north of the climatic tension zone, is dominated by sedges and grasses, particularly *Carex stricta* (tussock sedge) and *Calamagrostis canadensis* (bluejoint grass), and occurs primarily on organic soils that can range from strongly acid to strongly alkaline.



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Northern fens can be differentiated from similar wetlands based on comparisons of nutrient levels, soil composition, flora, canopy closure, distribution, landscape context, and degree of groundwater influence.

**Rank Justification:** Northern fens are uncommon features of the northern Great Lakes region, occurring sporadically in Michigan's northern Lower Peninsula and the Upper Peninsula. The northern Lake States contain over six million hectares (15 million acres) of peatland (Boelter and Verry 1977). What percentage of that area is northern fen has yet to be determined. Likewise, 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 2007).

Historically, widespread fires following turn-of-the-century logging drastically altered many peatlands, either converting conifer swamp to open fen or bog systems or destroying the peat and converting peatlands to wetlands without organic soils (mineral soil wetlands) (Dean and Coburn 1927, Gates 1942, Curtis 1959). Logging of cedar and tamarack from peatland systems also favored the conversion of forested peatlands to open peatlands (Gates 1942, Dansereau and Segadas-Vianna 1952, Riley 1989). Beginning in the 1920s, effective fire control by the United States Forest Service and state agencies reduced the acreage of fires ignited by humans or lightning (Swain 1973). In landscapes where frequent fire was the prevalent disturbance factor, fire suppression has led to the conversion of open fens to closed-canopy peatlands or shrub thickets (Curtis 1959, Schwintzer 1981, Riley 1989).

Currently, fens are threatened by peat mining, logging, quarrying, agricultural runoff and nutrient enrichment, draining, flooding, off-road vehicle (ORV) activity, and development (Bedford and Godwin 2003, NatureServe 2007). Peat mining and cranberry farming have degraded numerous peatlands throughout the region (Gates 1942, Curtis 1959, Eggers and Reed 1997, Chapman et al. 2003). Michigan, along with Florida and Minnesota, are leaders in peat production (i.e., peat mining) in the United States (Miller 1981). In addition to direct impacts to vegetation, alteration of peatland hydrology from road building, quarrying, ORVs, creation of drainage ditches and dams, and sedimentation and runoff from logging has led to significant changes in peatland floristic composition and structure (Schwintzer and Williams 1974, Schwintzer 1978a, Riley 1989, Bedford and Godwin 2003, Chapman et al. 2003). Fen vegetation is extremely sensitive to minor changes in water levels and chemistry, groundwater flow, and nutrient availability (Siegel 1988, Riley 1989). A reduction in groundwater flow and subsequent decrease in nutrients in northern fens can result in the shift to less minerotrophic wetlands such as a poor fens or even bogs. Conversion to more eutrophic wetlands has occurred 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 fens 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

*Typha latifolia* (broad-leaved cat-tail) (Richardson and Marshall 1986, Almendinger and Leete 1998b). 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 northern fen into monospecific stands of nitrophilic species. Lowering of water tables from drainage has allowed for tree and shrub encroachment into open fens and the eventual succession to closed-canopy peatland (Almendinger and Leete 1998b). Increased shrub and tree canopy cover typically results in decreased species richness of fen systems (Bowles et al. 1996). In addition, lowering of the water table can reduce carbonate deposition at the fen surface and thereby alter the growing conditions, causing a loss in rare calciphilic vegetation and an increase in more common plants (Almendinger and Leete 1998b). The high alkalinity of fens makes them especially susceptible to acid rain and air pollution (Siegel 1988, Chapman et al. 2003). Atmospheric deposition can contribute nitrogen, sulphur, calcium, and heavy metals to fens (Damman 1990, Chapman et al. 2003). Fen systems that are surrounded by cultivated land and close to industrial and urban centers face a greater threat from dust-fall and atmospheric deposition from air pollution (Damman 1990).

**Physiographic Context:** Two landscape features are conducive to the development of peat; poorly drained, level terrain and small ice-block basins (e.g., kettle depressions) (Boelter and Verry 1977). Northern fen occurs on flat areas or shallow depressions of glacial outwash and glacial lakeplains, often in proximity to the Great Lakes shoreline, and also in kettle depressions on pitted outwash and moraines (Gates 1942, Verry 1975, Vitt and Slack 1975, Boelter and Verry 1977, Schwintzer 1978a, Siegel 1988, Kost et al. 2007, NatureServe 2007). Within outwash channels, fens are typically found where a constant flow of cold, calcareous groundwater seeps from the base of adjacent moraines. The overall topography of fens is flat to gently undulating with microtopography characterized by hummocks and hollows (Heinselman 1963, Vitt and Slack 1975, Wheeler et al. 1983, Siegel 1988, NatureServe 2007).

Fens found in kettle depressions are associated with active or extinct glacial lakes that are alkaline (Vitt and Slack 1975). Within kettle depressions, fens can occupy the entire basin or frequently occur as a floating mat on the margin of the remaining glacial lake (Vitt and Slack 1975, Schwintzer 1978a, Schwintzer 1978b). When fens occur along the edge of large bodies of water, they are found in sheltered bays or coves that are protected from wave and ice action, which can prevent the development of peat or erode existing peat mats (Gates 1942, NatureServe 2007).

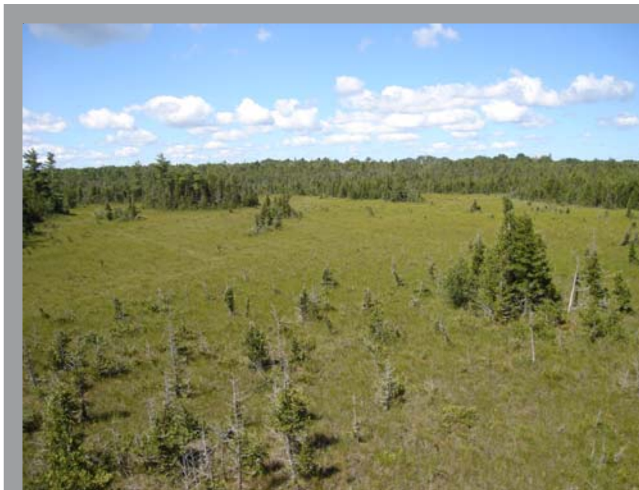

Photo by Joshua G. Cohen

Northern fens occurring on lakeplains (above) are typically more extensive than those found in kettle depressions (below).

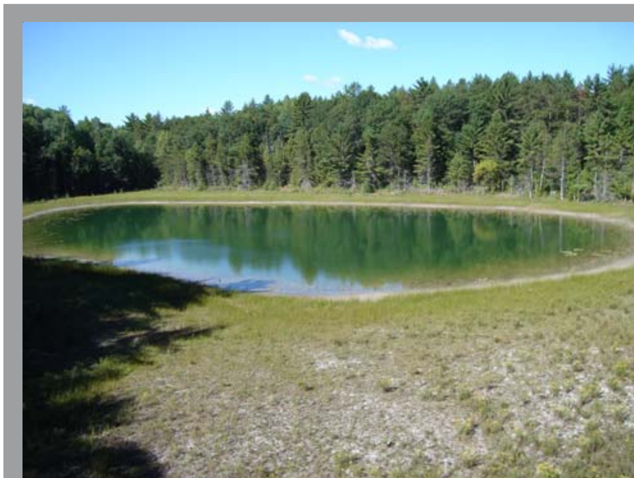

Photo by Joshua G. Cohen

Northern fens are strongly influenced by regional geomorphology. Fens occurring on former glacial lakebeds and drainageways tend to be more extensive than kettle fens, which are limited in area by the size of the glacial ice-block that formed the basin (Lindeman 1941). For example, the large peatlands of lakeplains and outwash plains are often over 100 acres while fens found in kettle depressions typically range from 10 to 50 acres (Michigan Natural Features Inventory 2007). Northern fens occurring on glacial outwash and glacial lakeplains occur on sapric to fibric peat or marly flats overlaying calcareous bedrock, typically dolomite or limestone of Devonian age (Heinselman 1970, Schwintzer 1978b, Schwintzer 1981, Amon et al. 2002, NatureServe 2007). The majority of documented northern fens within Michigan occur on old glacial lakebeds nearby the Great Lakes shoreline.

Northern fens often occur within large wetland complexes, typically adjacent to and grading into other wetland communities such as poor fen, northern wet meadow, northern shrub thicket, and rich conifer swamp. Northern fens within kettle depressions that contain active glacial lakes and ponds often border aquatic communities such as submergent marsh and emergent marsh. Northern fen can also occur as one of many zones within matrix communities such as wooded dune and swale complex. Upland community types found adjacent to northern fen include boreal forest, dry-mesic northern forest, dry northern forest, and pine barrens.

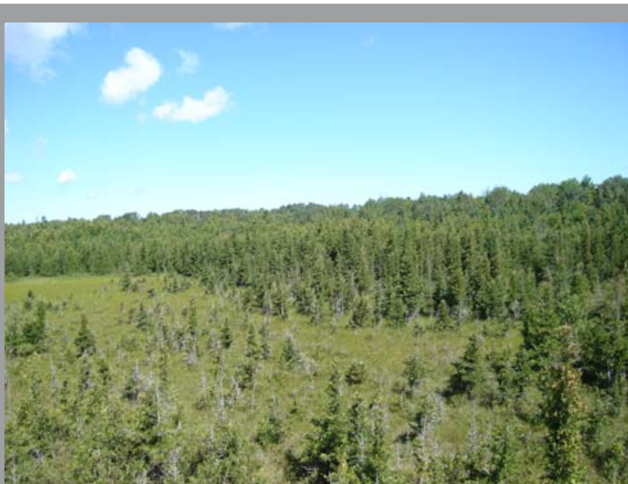
Photo by Joshua G. Cohen

Northern fen often grades to rich conifer swamp.

**Hydrology:** Northern fens are minerotrophic peatlands, receiving inputs of water and nutrients primarily from nutrient-rich groundwater (Heinselman 1970, Vitt and Slack 1975, Boelter and Verry 1977, Schwintzer 1981, Schwintzer and Tomberlin 1982, Riley 1989, Bedford and Godwin 2003). Groundwater discharge produces continuously saturated conditions in the rooting zone. Because groundwater is the primary source of water input, the water table of fens is stable, typically at the soil surface with the peat soils saturated but seldom flooded (Heinselman 1970, Schwintzer 1978b, Schwintzer 1981, Riley 1989, Amon et al. 2002, Bedford and Godwin 2003). The cool groundwater that enters fens is telluric (rich in mineral ions), having moved over or percolated through base-rich bedrock, calcareous glacial deposits, or mineral soil (Schwintzer 1978b, 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, Schwintzer 1981, Almendinger et al. 1986, Almendinger and Leete 1998b, Mitsch and Gosselink 2000, Amon et al. 2002, Bedford and Godwin 2003, NatureServe 2007). While levels of available calcium, magnesium, and nitrogen are typically high within northern fens, phosphorous can be limiting (Richardson and Marshall 1986, Riley 1989, Bedford et al. 1999, Mitsch and Gosselink 2000, Amon et al. 2002). Low concentrations of phosphorous can result from co-precipitation with carbonate, microbial immobilization, reduced aeration of the rooting zone, and iron toxicity (Richardson and Marshall 1986, Almendinger and Leete 1998, Amon et al. 2002, Bedford et al. 1999).

In addition to 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, Wheeler et al. 1983, Riley 1989, Glaser et al. 1990). 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, Wheeler et al. 1983, Siegel and Glaser 1987, Riley 1989, Glaser et al. 1990). Within northern fens of Michigan, recorded pH values range between 5.6 and 8.0. 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; 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 peatland; the thickness and character of the peat (Heinselman 1963, Heinselman 1970, Boelter and Verry 1977, Siegel and Glaser 1987, Amon et al. 2002); and the presence or absence of marl.

**Soils:** The organic soils of northern fens are composed of peat and/or marl, which are typically one to three meters deep (Glaser et al. 1981). Peat is a fibrous network of partially decomposed organic material that is formed under anaerobic conditions and can form a shallow, continuous mat in northern fens (Almendinger et al. 1986, Heinselman 1963). The surface peats of fens are saturated, range from sapric to fibric peat, and like the surface water, are neutral to alkaline and characterized by high nutrient availability (Curtis 1959, Heinselman 1963, Heinselman 1970, Schwintzer and Williams 1974, Boelter and Verry 1977, Almendinger et al. 1986, Swanson and Grigal 1989, NatureServe 2007). Sapric peat, which is held together by roots and rhizomes, is highly decomposed with occasional fragments of sedge, reed, and shrub. Fibric peat, which is loosely compacted, contains partially decomposed mosses with fragments of wood and occasionally sedge. Fibric peat has high water-retaining capacity and large intercellular pores that permit rapid water movement (The rate of water movement through saturated fibric peat is 1,000 times faster than water movement through sapric peats) (Boelter and Verry 1977). Hemic peats are intermediate between sapric and fibric peats in terms of decomposition and water-retaining capacity (Boelter and Verry 1977, Miller 1981, Swanson and Grigal 1989). Peats of fens tend to have lower water-retaining capacity compared to the peats of bogs (Miller 1981). Peat composition changes with depth and depending on the successional history of a given fen. Generally, fiber content and hydraulic conductivity decrease with depth; deeper peats are more decomposed, retain more water, and drain slower than surface peats (Verry 1975, Boelter and Verry 1977).

In addition to peat, northern fens often contain or develop on extensive areas of marl, a grayish, mineral substrate with a smooth, silty texture that develops 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 2007). Areas containing marl deposits such as old glacial lakebeds are level and referred to as marl flats. Shallow water supporting populations of marl-producing algae commonly overlays marl flats. Often dispersed throughout northern fens, especially in extensive areas of marl flats, are low peat mounds or islands that support a continuous carpet of sphagnum mosses and a full complement of ombrotropic species. The pH of these peat islands is often extremely acidic as a result of the reducing effect of sphagnum mosses and raised elevation above the underlying calcareous groundwater (Michigan Natural Features Inventory 2007).

Photo by Joshua G. Cohen

Marl develops when algal metabolism leads to the precipitation of calcium carbonate.

**Climate:** Peatlands develop in humid climates where precipitation exceeds evapotranspiration (Boelter and Verry 1977, Gignac et al. 2000, Bedford and Godwin 2003). The northern Lake States are 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). The Michigan range of northern fen falls within the area classified by Braun (1950) as the Northern Hardwood-Conifer Region (Hemlock/White Pine/Northern Hardwoods Region) and within the following regions classified by Albert et al. (1986) and Albert (1995): Region II, Northern Lower Michigan; Region III, Eastern Upper Michigan; and Region IV, Western Upper Michigan. The Northern Hardwood-Conifer Region has a cool snow-forest climate with short, warm summers, cold winters, and a large number of cloudy days. The mean number of freeze-free days is between 90 and 160, and the average number of days per year with snow cover of 2.5 cm or more is between 80 and 140. The normal annual total precipitation ranges from 740 to 900 mm with a mean of 823 mm. The daily maximum temperature in July ranges from 24 to 29 °C (75 to 85 °F), the daily minimum temperature in January ranges from –21 to –9 °C (–5 to 15 °F) and the mean annual temperature is 7 °C (45 °F) (Albert et al. 1986, Barnes 1991). Temperatures vary less in peatlands compared to the surrounding landscape because of groundwater influence, the insulating effect of fens' saturated peat carpet during the growing season, and snow cover in winter (Burns 1906, Curtis 1959, Heinselman 1963, Glaser 1992). Fens are characterized by microclimates that are cooler in the summer and warmer in the winter compared to the regional climate (Heinselman 1963, Bedford and Godwin 2003).

**Natural Processes:** Peat establishment requires an abundant supply of water; peatlands occur 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). Saturated and inundated conditions 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 protect plant matter from microorganisms and chemical actions that cause decay (Miller 1981). Fens have greater levels of microbial activity compared to bogs because of the lesser acidity and higher base status of minerotrophic waters. As a result, organic matter decay is greater while peat accumulation is lesser in fens versus bogs (Heinselman 1970).

In addition to peat accumulation, deep layers of marl can also develop in fens. When carbonate-rich groundwater flows from underlying calcareous substrates, it provides a nutrient-rich environment for the rapid growth of stonewort (*Chara* spp.) and other algae. The metabolism of these algae produces calcium carbonate, which precipitates as marl, a fine, grayish, mud-like substance. It is not uncommon for marl deposits to reach several meters or more in depth (Treese and Wilkinson 1982).

Development and expansion of fens occurs via two different processes in glacial lakeplain and outwash versus kettle depressions. Fens develop in glacial lakeplain and outwash where groundwater influence maintains saturated conditions that inhibit organic matter decomposition and allow for peat accumulation (Almendinger and Leete 1998b). Peat develops vertically and spreads horizontally (Boelter and Verry 1977). Estimates of vertical accumulation of peat range between 100 to 200 cm per 1,000 years (Mitsch and Gosselink 2000).

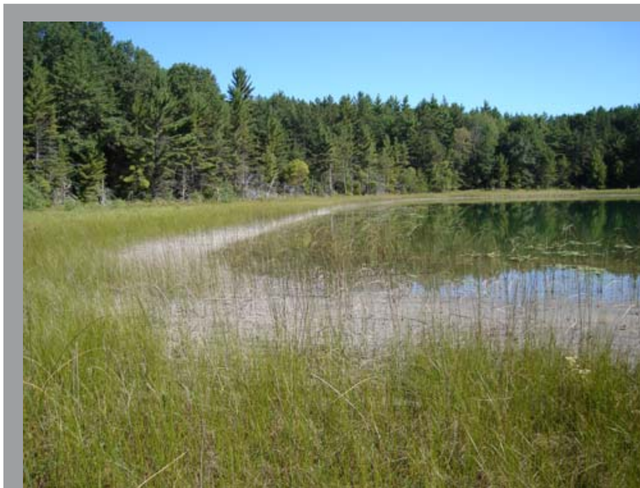
Photo by Joshua G. Cohen

Northern fens develop through lake-filling in kettle depressions.

Lake-filling or terrestrialization occurs in small kettle lakes with minimal wave action where gradual peat accumulation results in the development of a sedge mat that can fill the basin or occur as a floating mat within the lake or as a grounded mat along the water's edge (Gates 1942, Bay 1967, Curtis 1959, Heinselman 1963, Mitsch and Gosselink 2000). Floating mats of fen sedges, such as *Carex lasiocarpa* (wiregrass sedge), pioneer open water or emergent marsh. Wiregrass sedge possesses rhizomes that can grow out into open water. The interlacing of rhizomes and roots forms a floating mat that is buoyed by water and accumulates organic matter in the form of sapric peat (Gates 1942). Over time fen mats are often invaded by ericaceous shrubs and acidifying sphagnum mosses (Osvald 1935, Gates 1942, Schwintzer and Williams 1974, Swineheart and Parker 2000).

Extensive marl flats form through accumulation of marl on the bottom of hardwater lakes or former shallow embayments of the Great Lakes. Marl can build up and fill entire lake basins and shallow embayments, eventually becoming sparsely vegetated by a unique suite of species able to survive in alkaline conditions.

The invasion of sphagnum moss into fen systems often results in the conversion of fens to more acidic communities such as poor fen or bog. Succession in lake-filled basins typically proceeds from lake to marsh to fen to poor fen or bog (Heinselman 1963, Boelter and Verry 1977, Schwintzer 1981, Swineheart and Parker 2000). Once sphagnum mosses become established on fen peat or on marl flats, they maintain and enhance saturated and acidic conditions, which in turn promote continued sphagnum peat development (Heinselman 1963). The ability of sphagnum to absorb and hold cations increases the acidity and low nutrient availability of peatlands (Osvald 1935, Curtis 1959, Verry 1975, Vitt and Slack 1975, Boelter and Verry 1977). In addition, accumulating sphagnum peat can dilute groundwater influence by absorbing large amounts of precipitated water, impeding drainage, and increasing the distance of the rooting zone from telluric water (Dansereau and Segadas-Vianna 1952, Vitt and Slack 1975, Schwintzer 1981). Sphagnum moss, which has numerous pores, partitions, and capillary space, has an enormous water-holding capacity (Osvald 1935, Dansereau and Segadas-Vianna 1952, Curtis 1959); sphagnum peat can hold 15 to 30 times its own weight in water (Miller 1981, Mitsch and Gosselink 2000). In addition to sphagnum peat accumulation, beaver dams can also cause blocked drainage in fens and the subsequent succession of fens to bogs (Heinselman 1963, Heinselman 1970).

Photo by Joshua G. Cohen

Northern fen can succeed to rich conifer swamp in the absence of disturbance factors that maintain open conditions.

Fens frequently succeed to northern shrub thicket or rich conifer swamp. Lowering of the water table of fens results in the increase in decomposition rates of organic matter and the subsequent accumulation of compact peat that is more conducive to shrub and tree growth (Schwintzer and Williams 1974, Schwintzer 1981, Riley 1989, Almendinger and Leete 1998b, Gignac et al. 2000). Conversions of bog to fen can also occur, however with far less frequency (Glaser et al. 1990). A discharge of alkaline groundwater at the peat surface of a bog, caused by a change in hydraulic head, can result in the conversion of bog vegetation to fen vegetation (Siegel and Glaser 1987, Glaser et al. 1990). Mixing of as little as 10% groundwater from underlying calcareous parent material with acid bog water is sufficient to raise the peatland pH from 3.6 to 6.8 (Glaser et al. 1990). Fens and bogs are very sensitive to changes in pH and subsequent availability of nutrients; fen vegetation can replace bog flora when pH increases above 4.5 (Siegel 1988).

Natural disturbance factors influencing northern fens include constant saturation by cold, mineral-rich groundwater, fire, flooding, windthrow, and outbreaks of tree insects and parasites. Open conditions within fens are maintained primarily by hydrologic and chemical conditions that limit the establishment and growth of woody plants. Within fire-prone landscapes, fire also contributes to the open physiognomy of northern fens. Numerous fens contain charcoal within their peat profile (Curtis 1959, Heinselman 1963) and many researchers have reported fire as a prevalent part of fen’s disturbance regime (Gates 1942, Curtis 1959, Vitt and Slack 1975). Surface fire can contribute to the maintenance of fens by killing encroaching trees and shrubs without completely removing the peat, which is normally saturated (Curtis 1959, Vitt and Slack 1975). Graminoid dominance of fen systems can be perpetuated by surface fires (Bowles et al. 1996). In addition, many of the ericaceous plants that thrive in fens are fire-adapted and often grow densely following fire (Wheeler et al. 1983). In the absence of fire, a thick layer of leaf litter can develop, which stifles seed bank expression and seedling establishment. Fire severity and frequency in fens is closely related to fluctuations in water level and landscape context. Fens bordering dry-mesic northern forest or dry northern forest likely experienced occasional fires, while those embedded within rich conifer swamps burned very infrequently. Prolonged periods of lowered water table can allow the surface peat to dry out enough to burn (Schwintzer and Williams 1974). When the surface peat of fens burns, the fire releases organic matter from the peat, kills seeds and latent buds, stimulates decay, and slows peat accumulation (Damman 1990, Jean and Bouchard 1991). Such peat fires can result in the conversion of peatland to mineral soil wetland.

Photo by Michael A. Kost

In fire-suppressed fens, a thick layer of leaf litter can develop, which stifles seed germination and limits seedling establishment.

Flooding, often caused by beaver activity, can contribute to the maintenance of fens or result in the conversion of fens to bogs. Roots of trees in peatlands are physiologically active near the surface and are killed during prolonged flooding (Glaser and Janssens 1986). Within kettle fens, flooding-induced tree mortality is likely greater on grounded mats compared to free floating mats; free mats float with the rising water table while grounded mats become inundated and have shallower aerobic zones (Schwintzer 1978a, Schwintzer 1978b, Schwintzer 1979). In addition to flooding, kettle fens can be influenced by wave and ice action, which can prevent the expansion of fen mats by eroding shoreline vegetation (Gates 1942).

The natural disturbance regime in fens is also influenced by wind. The Great Lakes region is one of the most active weather zones in the northern hemisphere, with polar jet streams positioned overhead much of the year. More cyclones pass over this area than any other area in the continental United States (Frelich and Lorimer 1991). Trees growing in fens are particularly susceptible to windthrow because peat provides a poor substrate for anchoring trees (Burns 1906). The living roots of woody peatland plants occur in a shallow rooting zone, generally restricted to the uppermost few centimeters where there is sufficient oxygen to maintain aerobic respiration (Glaser and Janssens 1986). The superficial rooting of trees results in numerous windthrows (Dansereau and Segadas-Vianna 1952). Tree survival in fens is also limited by insects and parasites. Insect outbreaks of *Pristiphora erichsonii* (larch sawfly) cause heavy mortality of *Larix laricina* (tamarack), while the plant parasite *Arceuthobium pusillum* (dwarf mistletoe) kills *Picea mariana* (black spruce) (Coburn et al. 1933, Gates 1942, Heinselman 1963).

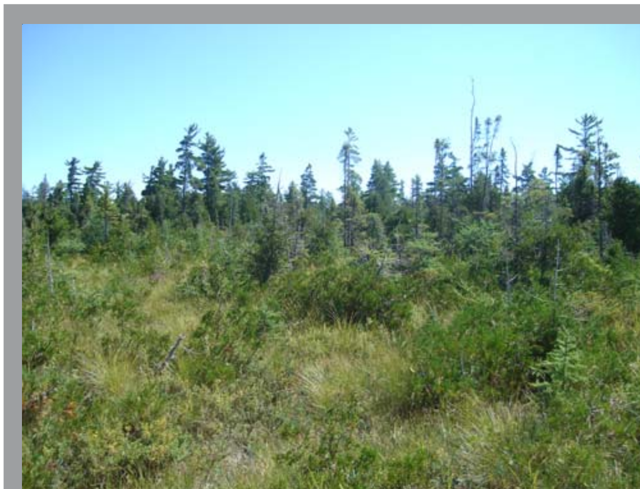

Photo by Joshua G. Cohen

Northern fens are graminoid-dominated wetlands characterized by diverse herbaceous and shrub layers and scattered or clumped stunted conifers.

Photo by Bradford S. Slaughter

**Vegetation Description:** Northern fens are characterized by a unique and diverse heliophilus (sun-loving) flora with a rich herbaceous layer dominated by graminoids, a patchy to continuous moss carpet with brown mosses (*Amblystegiaceae*) more prevalent than sphagnum mosses (*Sphagnaceae*), low shrubs, and widely scattered or clumped, stunted conifer trees (Gates 1942, Curtis 1959, Vitt and Slack 1975, Mitsch and Gosselink 2000, Amon et al. 2002, Bedford and Godwin 2003, NatureServe 2007). Floristically fens are among the most diverse of all wetland types in the United States, exhibiting high within-plot species diversity and high site-level species richness, and also supporting numerous rare and uncommon bryophytes and vascular plants, particularly calciphiles (Almendinger and Leete 1998a, Almendinger and Leete 1998b, Bedford and Godwin 2003, NatureServe 2007). Species richness of fens is related to geographical location, climatic factors, nutrient availability, and habitat heterogeneity (Glaser et al. 1990, Glaser 1992). Floristic diversity within northern fens is correlated with high levels of available nutrients and microtopography (Riley 1989, Glaser et al. 1990). The high degree of small-scale environmental heterogeneity results in strong vegetational zonation (Amon et al. 2002, Bedford and Godwin 2003).

Vegetational zones that frequently occur within northern fens include sedge lawns, sparsely-vegetated marl flats, shrub thickets, which often occur as narrow bands on the upland margin, and low peat mounds dominated by sphagnum mosses, ericaceous shrubs, and scattered clumps of coniferous trees. 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, Glaser et al. 1990, Siegel 1988, Anderson et al. 1996, Bedford et al. 1999). The mean number of vascular species per 1 m$^2$ p plot in northern fens in the northern Lower Peninsula of Michigan was found to be 29 by Vitt and Slack (1975) and 30 by Schwintzer (1978b) with a range of 10 to 53. For northern fens within Michigan Natural Features Inventory's database (2007), the mean number of species per northern fen is approximately 48. Very few introduced, weedy species are able to establish within bogs and fens, likely because of the unique growing conditions and competition from the adapted flora. Northern fens are dominated by plants that thrive under minertrophic conditions. Ombrotrophic indicators may be present in fens at low cover. The tops of hummocks and peat mounds can support sphagnum mosses and an acidic micro-environment where these acidophilic species can occur isolated from the influence of mineral-rich groundwater (Wheeler et al. 1983, Amon et al. 2002). While most fen plants are adapted to growing in alkaline conditions (i.e., calcicolous species), the vegetation assemblage growing on the sphagnum hummocks and isolated, low peat mounds resembles an ombrotrophic peatland system, with a continuous carpet of sphagnum mosses, low ericaceous, evergreen shrubs, and widely scattered or clumped, stunted conifer trees.

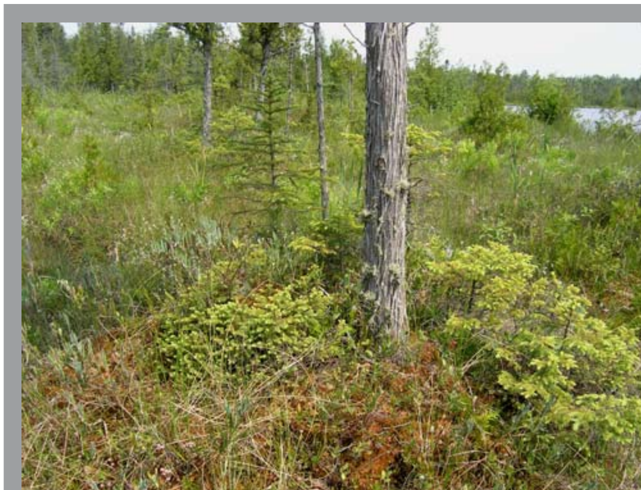

**Photo by Joshua G. Cohen**

Sphagnum hummocks (above) and peat mounds (below) provide microhabitat heterogeneity that increases the species richness of northern fens. These microsites are characterized by the prevalence of acidophilic species including sphagnum mosses, ericaceous shrubs, and scattered and stunted conifer trees.

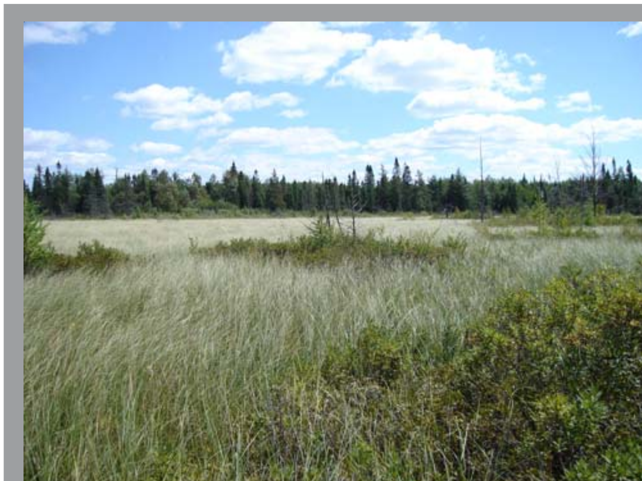

**Photo by Joshua G. Cohen**

The patchy to continuous surface carpet of mosses in northern fens is dominated by calcicolous brown mosses of the family *Amblystegiaceae* (Glaser et al. 1990, Zoltai and Vitt 1995, Swinehart and Parker 2000, Amon et al. 2002). Typical minerotrophic bryophytes of northern fen include the following brown mosses: *Calliergon trifarium*, *Campylium stellatum*, *Drepanocladus revolvens*, and *Scorpodium scorpoides* (Crum 1983, Riley 1989, Glaser et al.

1990). *Bryum pseudotriquetrum* can also occur within northern fen. Sphagnum mosses are either absent from northern fens or subordinate to the Amblystid mosses and locally restricted (Schwintzer 1978). *Sphagnum teres* thrives in alkaline conditions and is often found in association with *Carex lasiocarpa* (wiregrass sedge) (Vitt and Slack 1975). Other sphagnum mosses that may occur within northern fens include *Sphagnum angustifolium*, *S. capillifolium*, *S. centrale*, *S. magellanicum*, *S. subsecundum*, and *S. warnstorfii* (Vitt and Slack 1975, Glaser et al. 1990, NatureServe 2007). Hummock and hollow microtopography often occurs in northern fens and allows for high levels of bryophyte diversity since individual species of moss can occur at specific elevations (Vitt and Slack 1975, Wheeler et al. 1983, Riley 1989). The vertical zonation of species corresponds to gradients in pH and moisture with the hollows being wetter and more alkaline than the drier and more acidic tops of the hummocks (Vitt et al. 1975, Wheeler et al. 1983). As noted above, acidophilic sphagnum mosses can occur on the tops of hummocks (Amon et al. 2002) and low peat mounds scattered throughout marl flats.

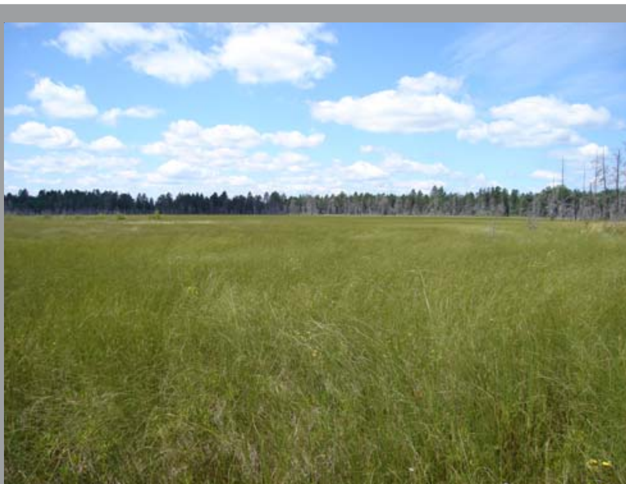

**Photo by Joshua G. Cohen**

Sedge lawns in northern fens are often dominated by wiregrass sedge (*Carex lasiocarpa*).

Cyperaceous graminoids dominate the herbaceous layer of fens. The most prevalent plant in northern fens is *Carex lasiocarpa* (wiregrass sedge), which can form extensive sedge lawns (NatureServe 2007). Additional sedges that are characteristic of northern fens include *Carex aquatilis* (water sedge), *C. chordorrhiza* (creeping sedge), *C. leptalea* (bristly-stalked sedge), *C. limosa* (mud sedge), *C. livida* (livid sedge), and *C. sterilis* (dioecious sedge). Other sedges that often occur in northern fens are *Carex buxbaumii* (Buxbaum's sedge), *C. capillaris* (hair-like sedge), *C. exilis* (coastal sedge), *C. interior* (inland sedge), *C. lacustris* (lake sedge), *C. rostrata* (beaked sedge), *C. stricta* (tussock sedge), and *C. viridula* (little green sedge). Typical grasses occurring in northern fen include *Calamagrostis canadensis* (bluejoint grass), *C. stricta* (reedgrass), *Muhlenbergia glomerata* (marsh wild-timothy), and *Panicum lindheimeri* (panic grass). Additional graminoids that thrive in the calcareous environment of northern fens include *Cladium marisicoides* (twig-rush), *Dulichium arundinaceum* (three-way sedge), *Eleocharis elliptica* (golden-seeded spike-rush), *E. rostellata* (beaked spike-rush), *Eriophorum angustifolium* (narrow-leaved cotton-grass), *E. spissum* (sheathed cotton-grass), *Rhynchospora alba* (white beak-rush), *R. capillacea* (needle beak-rush), *Scirpus cespitosus* (tufted bulrush), *S. hudsonianus* (Hudson's Bay bulrush), and *Typha latifolia* (broad-leaved cat-tail). Northern fens frequently contain sparsely vegetated marl flats that support twig-rush, beak-rushes, spike-rushes (i.e., *Eleocharis rostellata*), rushes, bulrushes, sedges such as *C. sterilis*, and grasses like *Deschampsia cespitosa* (hair grass).

The following is a list of prevalent northern fen herbs: *Aster borealis* (rush aster), *Campanula aparinoides* (marsh bellflower), *Decodon verticillatus* (whorled loosestrife), *Euthamia graminifolia* (grass-leaved goldenrod), *Iris versicolor* (wild blue flag), *Lobelia kalmii* (Kalm's lobelia), *Lycopus uniflorus* (northern bugleweed), *Lysimachia terrestris* (swamp candles), *Menyanthes trifoliata* (bog buckbean), *Parnassia glauca* (grass-of-Parnassus), *Potentilla anserine* (silverweed), *P. palustris* (marsh cinquefoil), *Scheuchzeria palustris* (arrow-grass), *Solidago ohioensis* (Ohio goldenrod), *S. uliginosa* (bog goldenrod), *Tofieldia glutinosa* (false asphodel), *Triadenum fraseri* (marsh St. John's-wort), and *Triglochin maritimum* (common bog arrow-grass). The fern ally *Equisetum fluviatile* (water horsetail) is also typical. Insectivorous plants, *Drosera rotundifolia* (roundleaf sundew), *D. intermedia* (spoon-leaf sundew), *Sarracenia purpurea* (pitcher-plant), and *Utricularia intermedia* (flat-leaved bladderwort), are common features of fens. Forbs within the sparsely vegetated marl flats include silverweed, false asphodel, arrow-grass, grass-of-Parnassus, Kalm's lobelia, Ohio goldenrod, and pitcher-plant.

Photo by Joshua G. Cohen

Marl flats are often sparsely vegetated with clumps of sedges, spike-rushes, bulrushes, beak-rushes, rushes, and scattered forbs such as pitcher-plant.

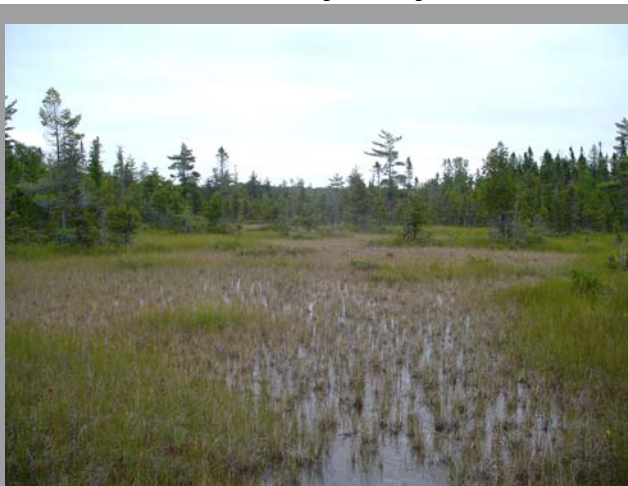

Photo by Michael A. Kost

Northern fens contain both a tall shrub layer and a low shrub layer. Typically shrub cover is at least 25%. Some areas of fen can contain dense thickets of shrubs (over 60% cover), particularly along the upland margins and where fire and/or flooding have failed to limit shrub encroachment (NatureServe 2007). The low shrub layer is usually less than one meter high with *Potentilla fruticosa* (shrubby cinquefoil), *Myrica gale* (sweet gale), and *Betula pumila* (bog birch) often being the most prevalent species. Other important associates of the low shrub layer include *Hypericum kalmianum* (Kalm's St. John's-wort), *Rhamnus alnifolia* (alder-leaved buckthorn), *Salix pedicellaris* (bog willow), and *Spiraea alba* (meadowsweet). Ericaceous shrubs occur within the low shrub layer of northern fens but with far lesser frequency and density than in bogs and poor fens. The following are common heath shrubs of northern fens that occur on sphagnum hummocks and low peat mounds: *Andromeda glaucophylla* (bog rosemary), *Chamadaephne calyculata* (leatherleaf), *Ledum groenlandicum* (Labrador tea), *Kalmia polifolia* (bog laurel), and *Vaccinium oxycoccos* (small cranberry). The tall shrub layer of northern fens, typically one to three meters tall, is less dense than the low shrub layer and is often restricted to the periphery of the fen. Common tall shrubs of northern fens include *Alnus rugosa* (speckled alder or tag alder), *Cornus stolonifera* (red-osier dogwood), and *S. petiolaris* (slender willow). Bog birch, meadowsweet, and bog willow can occur in both the tall and low shrub layers.

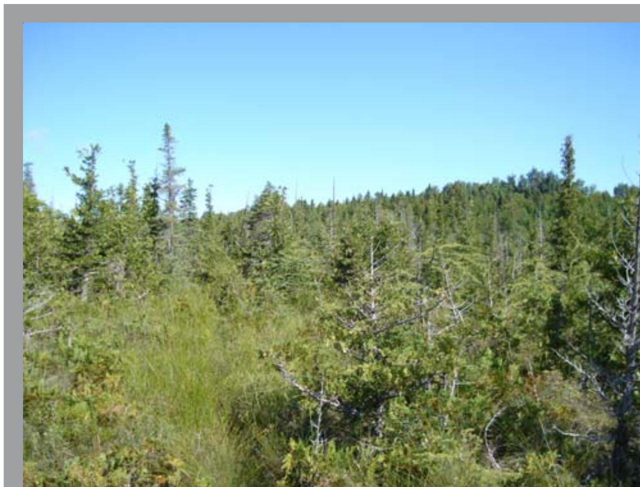

Photo by Joshua G. Cohen

Scattered, stunted, and misshapen conifers, especially northern white-cedar, are characteristic of northern fen.

Trees within fens are widely scattered, often occurring in clumps on low peat mounds, and are typically of low stature (ranging from two to ten meters but seldom reaching six meters) (Wheeler et al. 1983, NatureServe 2007). Tree cover is typically below ten percent. The most common dominants of the open canopy are *Larix laricina* (tamarack) and *Thuja occidentalis* (northern white-cedar). Infrequent associates include *Picea mariana* (black spruce), *Pinus banksiana* (jack pine), and *P. strobus* (white pine) which are typically restricted to the scattered sphagnum hummocks and peat mounds. Stunted, misshapen northern white-cedars occur scattered throughout the marl flats. (Above species lists were compiled from Gates 1942, Curtis 1959, Heinselman 1963, Heinselman 1965, Heinselman 1970, Schwintzer and Williams 1974, Vitt and Slack 1975, Schwintzer 1978a, Glaser et al. 1981, Schwintzer 1981, Schwintzer and Tomberlin 1982, Wheeler et al. 1983, Richardson and Marshall 1986, Riley 1989, Glaser et al. 1990, Glaser 1992, Eggers and Reed 1997, Mitsch and Gosselink 2000, Swinehart and Parker 2000, Lee et al. 2006, Michigan Natural Features Inventory 2007, NatureServe 2007)

**Michigan Indicator Species:** bog birch, *Carex chordorrhiza, C. lasiocarpa , C. limosa, C. leptalea, C. sterilis,* northern white-cedar, shrubby cinquefoil, and tamarack (Heinselman 1970, Wheeler et al. 1983, Anderson et al. 1996).

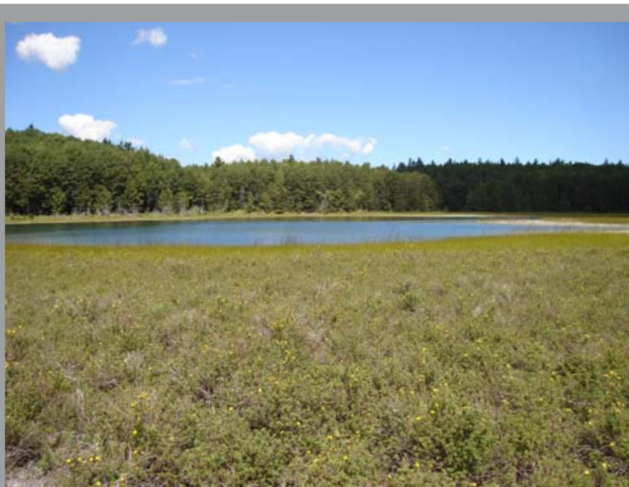

**Photo by Joshua G. Cohen**

Shrubby cinquefoil, a minerotrophic indicator, is one of the most prevalent low shrubs found in northern fens.

**Other Noteworthy Species:** Northern fens provide habitat for numerous rare insect species including *Appalachia arcana* (secretive locust, state special concern), *Merolonche dollii* (Doll's merolonche moth, state special concern), *Phyciodes batesii* (tawny crescent, state special concern), *Somatochlora hineana* (Hine's emerald dragonfly, federal/state endangered), and *Somatochlora incurvata* (incurvate emerald dragonfly, state special concern). Many butterflies and moths are restricted to bogs and fens because their food plants occur within these peatlands (Riley 1989). Numerous tiny land snails are associated with calcareous fens (Bedford and Godwin 2003). Snail populations of northern fens includes numerous rare species such as *Catinella exile* (Pleistocene catinella, state special concern), *Euconulus alderi* (land snail, state special concern), *Hendersonia occulta* (cherrystone drop, state threatened), *Planogyra asteriscus* (eastern flat-whorl, state special concern), *Vertigo elatior* (tapered vertigo, state special concern), *Vertigo morsei* (six-whorl vertigo, state special concern), and *Vertigo pygmaea* (crested vertigo, state special concern). Rare herptiles that utilize northern fens include *Clemmys guttata* (spotted turtle, state threatened), *Emydoidea blandingii* (Blanding's turtle, state special concern), *Pseudacris triseriata maculata* (boreal chorus frog, state special concern), *Sistrurus catenatus catenatus* (eastern massasauga, federal candidate species and state special concern), and *Terrapene carolina carolina* (eastern box turtle, state special concern).

If suitable nesting trees or snags are available, *Falco columbarius* (merlin, state threatened), *Haliaeetus leucocephalus* (bald eagle, state threatened), and *Pandion haliaetus* (osprey, state threatened) can be found nesting in these systems and *Ardea herodias* (great blue heron, protected by the Migratory Bird Treaty Act of 1918) can establish rookeries. Other rare birds that could occur in northern fens are *Asio flammeus* (short-eared owl, state endangered), *Botaurus lentiginosus* (American bittern, state special concern), *Circus cyaneus* (northern harrier, state special concern), *Coturnicops noveboracensis* (yellow rail, state threatened), and *Picoides arcticus* (black-backed woodpecker, state special concern). *Alces alces* (moose, state threatened), *Canis lupus* (gray wolf, state threatened), and *Lynx canadensis* (lynx, state endangered) utilize peatland habitat. Northern fens provide important habitat for small mammals such as *Blarina brevicauda* (short-tailed shrew), *Castor canadensis* (beaver), *Microtus pennsylvanicus* (meadow vole), *Mustela vison* (mink), *Ondatra zibethicus* (muskrat), and *Sorex cinereus* (masked shrew). Both muskrats and beaver can profoundly influence the hydrology of peatlands. Muskrats create open water channels through the peat and beavers can cause substantial flooding through their dam-building activities (Gates 1942, Heinselman 1963). Beaver dams can also cause blocked drainage in fens and the subsequent succession of fens to bogs (Heinselman 1963, Heinselman 1970).

Northern fens support a large number of rare plants, including many calciphilic species (Almendinger and Leete 1998, Bedford and Godwin 2003). Compared to other wetland types, fen systems support a disproportionate number of threatened and endangered rare plant species (Eggers and Reed 1997). Rare plants associated with northern fens include *Amerorchis rotundifolia* (round-leaved orchis, state endangered), *Cacalia plantaginea* (Indian plantain, state special concern), *Carex heleonastes* (Hudson Bay sedge, state endangered), *Carex scirpoidea* (bulrush sedge, state threatened), *Drosera anglica* (English sundew, state special concern), *Empetrum nigrum* (black crowberry, state threatened), *Erigeron hyssopifolius* (hyssop-leaved fleabane, state threatened), *Juncus stygius* (moor rush, state threatened), *Pinguicula vulgaris* (butterwort, state special concern), *Rubus acaulis* (dwarf raspberry, state endangered), and *Solidago houghtonii* (Houghton's goldenrod, federal/state threatened).

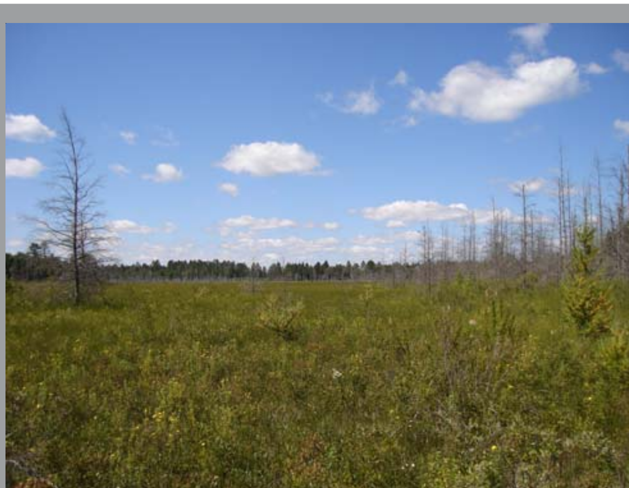

Photo by Joshua G. Cohen

Protection of northern fens and their associated fauna and flora can be achieved by maintaining the hydrology.

**Conservation and Biodiversity Management:** Northern fen is a widely distributed but 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 precipitate. In addition to their high levels of biodiversity, fens also contribute numerous ecosystem services. Fens modulate water temperature of connecting surface waters, serve as critical buffers between downstream waters and nutrients and other pollutants from the surrounding uplands, and maintain water quality and flows to streams (Bedford et al. 1999, Bedford and Godwin 2003). By storing high levels of sequestered carbon and functioning as carbon sinks, fens and related peatlands play an important role in global geochemical cycles. In addition, fens are characterized by high rates of denitrification and phosphorous sorption. Fens also preserve paleo-environmental records; a wealth of information is stored in the remains of plants, animals, and atmospheric particles deposited and stored in fen peat profiles (Chapman et al. 2003).

The primary mechanism for preserving fens is to maintain their hydrology. As noted, peatland systems are sensitive to slight changes in water chemistry; modifications in fen hydrology result in significant shifts in vegetation. Perhaps the greatest threat to northern fens comes from off-road vehicle (ORV) traffic, which can destroy populations of sensitive species and drastically alter fen hydrology through rutting. Reduction of access to peatland systems will help decrease detrimental impacts caused by ORVs. 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.

This can be accomplished by establishing no-cut buffers around fens and avoiding road construction and complete canopy removal in stands immediately adjacent to fens. In addition, road construction through fen should be prohibited to prevent hydrologic alterations; roads can impede surface flows and result in complete changes in species composition and structure as a result of sustained flooding on one side of a road while the other side becomes drier and subject to increased shrub and tree encroachment.

Photo by Bradford S. Slaughter

Within fire-prone landscapes, fire should be allowed to burn from surrounding uplands across northern fens.

Where shrub and tree encroachment threatens to convert open wetlands to shrub-dominated systems or forested swamps, prescribed fire or selective cutting can be employed to maintain open conditions (Bowles et al. 1996). Silvicultural management of fens to preserve open canopy should be employed during the winter to minimize damage to the organic soils and impacts to the hydrologic regime.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of northern fen. Particularly aggressive invasive species that may threaten the diversity and community structure of northern fens include *Rhamnus frangula* (glossy buckthorn), *Rosa multiflora* (multiflora rose), *Elaeagnus umbellata* (autumn olive), *Lythrum salicaria* (purple loosestrife), *Typha angustifolia* (narrow-leaved cat-tail), *Typha* x*glauca* (hybrid cat-tail), *Phalaris arundinacea* (reed canary grass), and *Phragmites australis* (reed). These non-native plants have colonized similar habitats such as prairie fen in southern Lower Michigan and thus have the potential to detrimentally impact northern fen, as well.

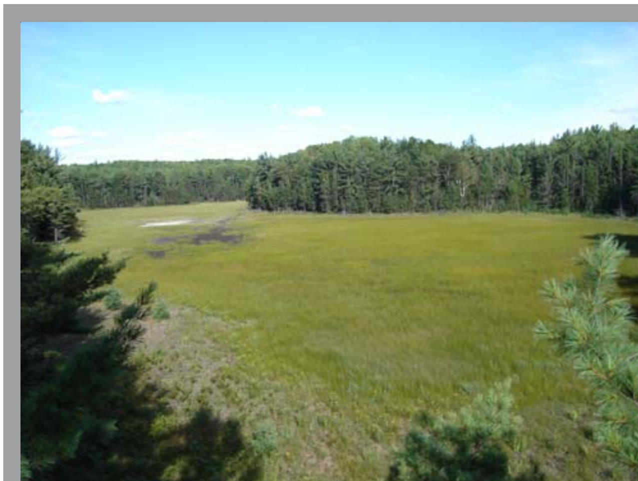

Photo by Joshua G. Cohen

An important research need is to ascertain how landscape context influences fire regimes of northern fens.

**Research Needs:** Northern fen has a broad distribution and exhibits numerous regional, physiographic, hydrologic, and edaphic variants. The diversity of variations throughout its range demands the continual refinement of regional classifications that focus on the inter-relationships between vegetation, physiography, and hydrology (Heinselman 1963, Barnes et al. 1982). Northern fens and related community types (i.e., poor fen, bog, and intermittent wetland) are frequently difficult to differentiate (Heinselman 1963, NatureServe 2007). Research on abiotic and biotic indicators that help distinguish similar peatlands would be useful for field classification. Systematic surveys for northern fens and related peatlands are needed to help prioritize conservation and management efforts.

Little is known about the fire regimes of northern fens and the interaction of natural disturbance factors within these systems. As noted by Hammerson (1994), beaver significantly alter the ecosystems they occupy. An important research question to examine is how the wetland ecosystems of the Great Lakes have been and continue to be affected by fluctuations in populations of beaver. Experimentation is needed to determine how best to prevent shrub and tree encroachment of fens that are threatened by conversion to shrub thicket or conifer swamp. A better understanding is needed of the influence of direct and indirect anthropogenic disturbance on peatlands (Amon et al. 2002). Effects of management within fens should be monitored to allow for assessment and refinement. Monitoring should also focus on how fen succession and management influence populations of rare species. The examination of non-native plant establishment in northern fens and means of controlling invasive species is especially critical. Scientific understanding of the microbes and invertebrates that thrive in the organic soils of fens is lacking. More research is needed to elucidate the relationship of chemical factors and nutrients to floristic community structure of peatlands (Amon et al. 2002). Given the sensitivity of peatlands to slight changes in hydrology and nutrient availability, it is important for scientists to predict how peatlands 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). Peat deposits are of great scientific interest because they contain historical ecological records in the form of fossils of plants, animals, and organic matter that contributed to the deposit. Stratigraphical analysis of peat cores provides insights into past climatic change and associated vegetation change, floristic distribution, the development of wetland ecosystems, and the successional pathways of peatlands (Heinselman 1963, Glaser et al. 1981, Miller 1981, Glaser and Janssens 1986, Riley 1989, Gignac et al. 2000).

**Similar Natural Communities:** coastal fen, Great Lakes marsh, interdunal wetland, intermittent wetland, muskeg, patterned fen, poor fen, prairie fen, rich conifer swamp, and wooded dune and swale complex.

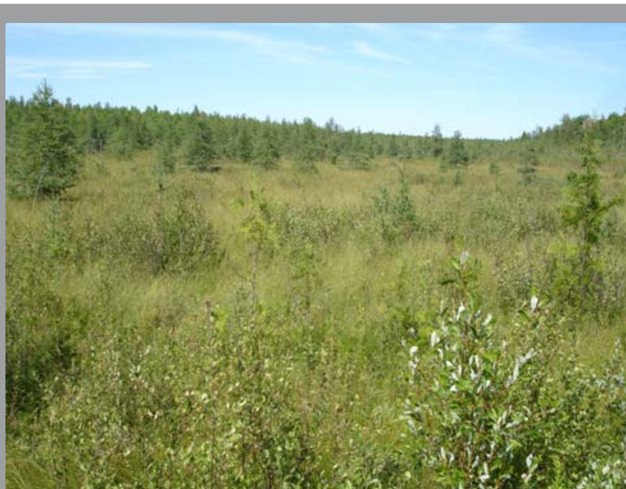

Photo by Bradford S. Slaughter

High levels of floristic diversity characterize this northern fen from Menominee County, Upper Michigan.

**Other Classifications:**

**Michigan Natural Features Inventory Circa 1800 Vegetation (MNFI):** Emergent Marsh (6221), Wet Meadow (6224), and Inland Wet Prairie (6227).

**Michigan Department of Natural Resources (MDNR):** D (treed bog), V (bog), and N (marsh).

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

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

III.B.2.N.g; *Betula pumila* – (*Salix* spp.) Saturated Shrubland Alliance; *Alnus incana* – *Salix* spp. - *Betula pumila / Chamaedaphne calyculata* Shrubland; Speckled Alder – Willow Species – Bog Birch / Leatherleaf Shrubland; Bog Birch-Willow Shore Fen

III.B.2.N.g; *Betula pumila* – (*Salix* spp.) Saturated Shrubland Alliance; *Betula pumila / Chamaedaphne calyculata / Carex lasiocarpa* Shrubland; Bog Birch / Leatherleaf / Wiregrass Sedge Shrubland; Bog Birch – Leatherleaf Rich Fen

III.B.2.N.g; *Betula pumila* – (*Salix* spp.) Saturated Shrubland Alliance; *Betula pumila – Dasiphora fruticosa* spp. *floribunda / Carex lasiocarpa – Trichophorum alpinum* Shrubland; Bog Birch – Shrubby-cinquefoil / Wiregrass Sedge – Alpine Cottongrass Shrubland; Bog Birch – Shrubby-cinquefoil Rich Boreal Fen

IV.A.1.N.g; *Chamaedaphne calyculata* Saturated Dwarf-shrubland Alliance; *Chamaedaphne calyculata – Myrica gale / Carex lasiocarpa* Dwarf-shrubland; Leatherleaf – Sweet Gale / Wiregrass Sedge Dwarf-shrubland; Leatherleaf – Sweet Gale Shore Fen

V.A.5.N.m; *Carex lasiocarpa* Saturated Herbaceous Alliance; *Carex lasiocarpa – Carex buxbaumii – Trichophorum caespitosum* Boreal Herbaceous Vegetation; Wiregrass Sedge – Brown Bog Sedge – Deerhair Bulrush Boreal Herbaceous Vegetation; Boreal Sedge Rich Fen

V.A.5.N.m; *Carex lasiocarpa* Saturated Herbaceous Alliance; *Carex lasiocarpa* –(*Carex rostrata*) – *Equisetum fluviatile* Herbaceous Vegetation; Wiregrass Sedge – (Swollen-beak Sedge) – Water Horsetail Herbaceous Vegetation; Wiregrass Sedge Shore Fen

**Related Abstracts:** American bittern, black-backed woodpecker, Blanding's turtle, bog, cherrystone drop, eastern box turtle, eastern massasauga, English sundew, great blue heron rookery, Great Lakes marsh, incurvate emerald, prairie Indian-plantain, intermittent wetland, Hine's emerald, Houghton's goldenrod, merlin, northern harrier, osprey, poor fen, prairie fen, rich conifer swamp, round-leaved orchis, secretive locust, short-eared owl, spotted turtle, wooded dune and swale complex, and yellow rail.

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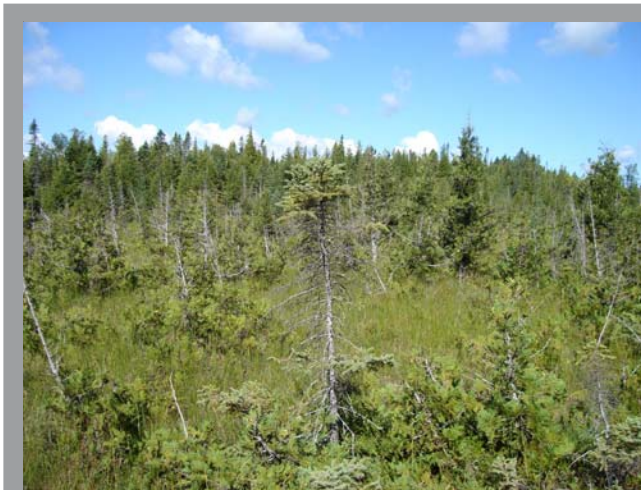

Photo by Joshua G. Cohen

Due to the underlying limestone and dolomite bedrock, the Mackinaw Straits region in northern Michigan harbors numeruos northern fens, such as this example from Alpena County.



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