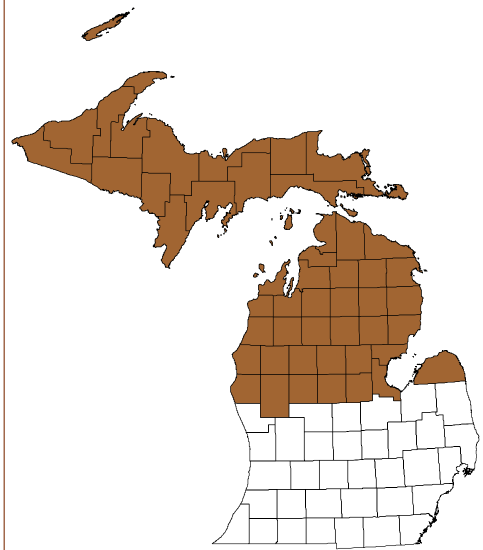
Poor Fen — Community Abstract

Photo by Joshua G. Cohen



Overview: Poor fen is a sedge-dominated wetland found on very strongly to strongly acidic, saturated peat that is moderately influenced by groundwater. The community occurs north of the climatic tension zone in kettle depressions and in flat areas or mild depressions on glacial outwash and glacial lakeplain.

Global and State Rank: G3G5/S3

Range: Poor fen is a peatland type of glaciated landscapes in 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). Poor fens may also occur in parts of the northeastern United States (i.e., Maine, New Hampshire, and New York) and range south into northern Illinois and Iowa (NatureServe 2007). In Michigan, poor fens occur predominantly in the northern Lower Peninsula and throughout the Upper Peninsula. 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 non-forested, natural peatland communities also occur in Michigan and can be distinguished from weakly minerotrophic poor fens, based on careful comparisons of nutrient levels, flora, canopy closure, distribution, and groundwater influence. Additional open wetlands occurring on organic soils include bog, northern fen, prairie fen, intermittent wetlands, northern wet meadow, and southern wet meadow (Kost et al. 2007). 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). In comparison, 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 (Zoltai and Vitt 1995, Bedford and Godwin 2003). Both poor fens and northern fens are dominated by sedges, rushes, and grasses, with poor fens containing a higher coverage of ericaceous shrubs and sphagnum mosses than northern fens (Mitsch and Gosselink 2000). Like northern fen and poor fen, prairie fens are graminoid-dominated and groundwater-influenced; however, prairie fens are geographically restricted to south of the climatic tension zone in southern Lower Michigan and typically support several grasses and forbs commonly associated with prairie communities. Intermittent wetlands are herb- or herb-shrub–dominated wetlands that experience fluctuating water levels seasonally and yearly. The soils of intermittent wetlands are very strongly acid to strongly acid and range from loamy sand and peaty sand to peaty muck. Northern and southern wet meadows are groundwater-influenced wetlands that occur north and south of climatic tension zone, respectively, and are dominated by sedges and grasses, particularly *Carex stricta* (tussock sedge) and *Calamagrostis canadensis* (bluejoint grass). Wet meadows occur primarily on organic soils that can range from strongly acid to strongly alkaline.

Photo by Joshua G. Cohen

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

Rank Justification: Poor 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 poor 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 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 *Thuja occidentalis* (northern white-cedar), *Picea mariana* (black spruce) and *Larix laricina* (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, ORVs, quarrying, creation of drainage ditches and dams, sedimentation and runoff from logging has led to the significant changes in peatland floristic composition and structure (Schwintzer and Williams 1974, Schwintzer 1978b, 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 poor fens can result in the shift to less minerotrophic wetlands such as bog. Conversion to more eutrophic wetlands has occurred as the result of nutrient enrichment and raised water levels, which cause increased decomposition of peat soils. 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 1998). 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 wetlands 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 peatlands (Almendinger and Leete 1998). Increased shrub and tree canopy cover typically results in decreased species richness of fen systems (Bowles et al. 1996). The sensitivity of fens to changes in water chemistry 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 (Boelter and Verry 1977). Poor fen occurs on flat areas and shallow depressions of sandy glacial outwash and glacial lakeplain, and 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). The overall topography of fens is flat with microtopography often characterized by hummocks and hollows (Heinselman 1963, Vitt and Slack 1975, Wheeler et al. 1983, Siegel 1988, NatureServe 2007). Poor fens found in kettle depressions are associated with active or extinct glacial lakes (Vitt and Slack 1975). Within kettle depressions, poor fens can occupy the entire basin or occur as a floating mat along the margin of the remaining glacial lake above the level of seasonal flooding (Vitt and Slack 1975, Schwintzer 1978a, NatureServe 2007). 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). 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).

Poor fens occur adjacent to other peatland communities, often grading into bog, poor conifer swamp, and muskeg. More minerotrophic systems such as northern fen, northern shrub thicket, northern wet meadow, and rich conifer swamp can occur along the outer margins of poor fens where groundwater seepage from the adjacent uplands is prevalent. Upland community types neighboring poor fen typically include fire-adapted communities such as pine barrens, dry northern forest, and dry-mesic northern forest.

Photo by Joshua G. Cohen

Poor fens occurring on lakeplains (above) are typically more extensive than those found in kettle depressions (below). In addition, poor fens on lakeplains are typically part of diverse wetland complexes while kettle depression fens are often isolated wetlands.

Photo by Michael A. Kost

Hydrology: Poor fens are weakly minerotrophic peatlands, receiving inputs of water and nutrients from both ion-poor precipitation and low exposure to nutrient-rich groundwater (Heinselman 1970, Boelter and Verry 1977, Siegel and Glaser 1987, Siegel 1988, Bedford et al. 1999, Gignac et al. 2000, Bedford and Godwin 2003, NatureServe 2007). Low levels of groundwater input combined with the high water-retaining capacity of fibric peat produce continuously saturated conditions in the rooting zone of poor fens. The water table of poor fens is stable, typically at the soil surface with the peat soils saturated but seldom flooded (Heinselman 1970, Schwintzer 1978b, Riley 1989, Amon et al. 2002, Bedford and Godwin 2003, NatureServe 2007). The surface waters of poor fens are characterized by very strong to strong acidity, low available nutrients, low specific conductivity, cool temperatures, anaerobic conditions, and moderate levels of dissolved organic matter (Verry 1975, Boelter and Verry 1977, Schwintzer 1978b, Glaser et al. 1981, Glaser et al. 1990, Bedford et al. 1999, Bedford and Godwin 2003, NatureServe 2007). The limited amount of groundwater that enters poor fens is telluric (rich in mineral ions), having moved over or percolated through base-rich bedrock, calcareous glacial deposits, or mineral soil (Heinselman 1970, Schwintzer 1978b, Mitsch and Gosselink 2000, Bedford and Godwin 2003). The groundwater entering poor fens typically passes through materials with low solubility or low buffering capacity (Bedford and Godwin 2003). The poorly mineralized or poorly buffered groundwater input of poor fens typically contains low concentrations of dissolved mineral nutrients (Heinselman 1970, Boelter and Verry 1977, Glaser et al. 1981, Glaser et al. 1990, Bedford and Godwin 2003, NatureServe 2007). The acidity of poor fens limits the availability and uptake of essential mineral, plant nutrients. Poor fens are characterized by low concentrations of available calcium, magnesium, nitrogen, and phosphorous in the surface water and peat (Heinselman 1970, Glaser et al. 1981, Schwintzer 1981, Glaser et al. 1990, Mitsch and Gosselink 2000). Scientists studying poor fens in the Great Lakes have reported pH values to range between 4.1 to 5.9 (Heinselman 1970, Boelter and Verry 1977, Glaser et al. 1981, Glaser et al. 1990, Almendinger and Leete 1998, Bedford et al. 1999, NatureServe 2007). 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 and its chemistry; the 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; and the thickness and character of the peat (Heinselman 1963, Heinselman 1970, Boelter and Verry 1977, Siegel and Glaser 1987, Amon et al. 2002, Bedford and Godwin 2003). Poor fens often occur in basins with small watersheds, which minimize groundwater input from the surrounding uplands (NatureServe 2007). Groundwater flow is likely limited in many poor fens where the bedrock is buried under thick glacial deposits.

Soils: The organic soils of poor fens are composed of peat, which frequently forms a shallow, continuous mat and is typically one to three meters in depth (Glaser et al. 1981). Peat is a fibrous network of partially decomposed organic material that is formed under anaerobic conditions (Heinselman 1963, Almendinger et al. 1986). The surface peats of poor fens are saturated, fibric peats, and like the surface waters, are very strongly to strongly acidic and characterized by low nutrient availability (NatureServe 2007). Fibric peat, which is loosely compacted, contains partially-decomposed sphagnum moss with fragments of wood and occasionally sedge. Fibric peat has high water-retaining capacity and large intercellular pores that permit rapid water movement (Boelter and Verry 1977, Miller 1981, Swanson and Grigal 1989, Amon et al. 2002). Peats of fens tend to have lower water-retaining capacity and higher levels of organic decomposition compared to the peats of bogs (Boelter and Verry 1977, Miller 1981). Peats of poor fens tend to be less decomposed with higher water-retaining capacity compared to peats of northern fen. Peat composition changes with depth and is strongly influenced by 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).

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 poor 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 the 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 1998, Mitsch and Gosselink 2000). Saturated and inundated conditions inhibit organic matter decomposition and allow for the accumulation of peat (Almendinger and Leete 1998, 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 their weakly minerotrophic waters. As a result, organic matter decays faster, and thus, peat accumulates more slowly in fens versus bogs (Heinselman 1970). 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 peat accumulation (Almendinger and Leete 1998). 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). 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 form a floating mat in the lake or a grounded mat along the water's edge (Gates 1942, Bay 1967, Curtis 1959, Heinselman 1963, Mitsch and Gosselink 2000, Swinehart and Parker 2000). Floating mats of fen sedges, such as *Carex lasiocarpa* (wiregrass sedge), pioneer open water and submergent and emergent marshes. *Carex lasiocarpa* possesses rhizomes that can grow out into open water. The interlacing of rhizomes and roots forms a floating mat that is buoyed by the 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).


Photo by Bradford S. Slaughter

Poor fens develop through lake-filling in kettle depressions.

The invasion of sphagnum moss into rich fen systems such as northern fen often results in conversion to more acidic communities such as poor fen or bog. Succession in lake-filled basins typically proceeds from lake to marsh to northern 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, 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, Zoltai and Vitt 1995). 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, Zoltai and Vitt 1995). 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).

Poor fens can also succeed to poor conifer swamp or northern shrub thicket. 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, Miller 1981, Schwintzer 1981, Riley 1989, Almendinger and Leete 1998, 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 poor fens include fire, flooding, windthrow, and outbreaks of tree insects and parasites. Numerous fens contain charcoal within their peat profile (Curtis 1959, Heinselman 1963), indicating a prolonged association with fire, and many researchers have reported fire as a prevalent part of fen disturbance regimes (Gates 1942, Curtis 1959, Vitt and Slack 1975). As periodic fires move through adjacent upland pine and oak-pine communities, they occasionally burn into and across poor fens, especially those areas dominated by fine-leaved sedges such as *Carex oligosperma* (few-seed sedge) and *Carex lasiocarpa* (wiregrass sedge). By reducing accumulated leaf litter, fire in open wetlands helps facilitate seed germination and seedling establishment and thus, helps maintain long-term seed bank diversity (Warners 1997, Kost and De Steven 2000). Fire also plays an integral role in preventing declines in species richness by creating micro-niches for establishment of small species, plants with small seeds such as orchids, and nitrogen-fixing plants (Leach and Givnish 1996). Another critically important attribute of fire for maintaining open wetlands such as poor fen is its ability to temporarily reduce the cover of woody plants (Reuter 1986). 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 also be perpetuated by surface fires (Bowles et al. 1996). In addition, many of the ericaceous plants that thrive in fens are adapted to fire and often grow densely following fire (Wheeler et al. 1983).

Photo by Michael A. Kost

Wildfires are most prevalent in poor fens that occur adjacent to fire-prone ecosystems, such as pine barrens.

Fire severity and frequency in fens is closely related to fluctuations in water level and landscape context. Fens bordering pine barrens or dry northern forest likely experienced occasional fires, while those embedded within peatland complexes burned very infrequently. Prolonged periods of lowered water table can allow the surface peat to dry out sufficiently to burn (Schwintzer and Williams 1974). When the surface peat of fens and bogs 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. Peat fires within bogs can also release enough nutrients to favor succession to more minerotrophic peatlands such as poor fen or intermittent wetland.

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 when the water table rises 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 region 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).

Vegetation Description: Poor fens have a unique flora that is intermediate between bog and northern fen. Poor fens are characterized by a graminoid-dominated herbaceous layer of low to moderate diversity. While sedges remain dominant, many poor fens also support a continuous carpet of sphagnum mosses and widely scattered, slightly raised peat ridges or mounds with low ericaceous, evergreen shrubs, and stunted conifer trees (Gates 1942, Curtis 1959, Verry 1975, Vitt and Slack 1975, Glaser et al. 1991, Bedford and Godwin 2003, NatureServe 2007). The harsh growing conditions of poor fens (i.e., strong acidity, low nutrient availability, and saturated peat) results in a distinct flora of low to moderate diversity. Relatively few species have evolved the necessary adaptations to cope with ombrotrophic and weakly minerotrophic conditions (Siegel 1988, Glaser 1992, Mitsch and Gosselink 2000). Very few introduced, weedy species are able to establish within bogs and fens because of the unique growing conditions and competition from the adapted flora (Riley 1989). Poor fen plants have developed a diversity of adaptations to cope with low nutrient availability including carnivory, evergreen leaves, sclerophylly (thick epidermal tissue), tight nutrient cycles, and high root biomass and root to shoot ratios (Bridgham et al. 1996, Mitsch and Gosselink 2000).

Photo by Joshua G. Cohen

Poor fens are typically dominated by sedges with patches of low shrubs and scattered and stunted coniferous trees.

Poor fens are dominated by plants that thrive under moderately ombrotrophic to weakly minerotrophic conditions. Occasionally, minerotrophic indicators may be present in poor fen at low cover. Plants found typically in more alkaline habitat such as *Betula pumila* (bog birch), *Carex aquatilis* (water sedge), *Carex rostrata* (beaked sedge), and *Carex stricta* (tussock sedge), can occur sporadically in poor fen when their roots extend beneath the surface mat to minerotrophic peat influenced by groundwater (NatureServe 2007). The tops of hummocks support sphagnum mosses and a more acidic micro-environment within poor fens where acidophilic species can occur isolated from the influence of groundwater. Species richness of poor fens is related to geographical location, climatic factors, nutrient availability, and habitat heterogeneity (Glaser et al. 1990, Glaser 1992). Floristic diversity within poor fens is strongly correlated with levels of available nutrients and microtopography (Riley 1989, Glaser et al. 1990). Small-scale environmental heterogeneity can result in vegetational zonation (Amon et al. 2002, Bedford and Godwin 2003). Gradients in pH, light, soil moisture, and cation concentrations (i.e., nutrient availability) determine floristic composition of poor fens (Heinselman 1970, Vitt and Slack 1975, Schwintzer 1978a, Glaser et al. 1981, Anderson et al. 1986, Siegel 1988, Glaser et al. 1990, Bedford et al. 1999).

Photo by Joshua G. Cohen

Peat mounds provide microhabitat heterogeneity that increases the species richness of poor fens. These microsites are characterized by the prevalence of acidophilic species including sphagnum mosses, ericaceous shrubs, and scattered and stunted conifer trees.

Bryophytes play a critical role in determining the vegetation patterning and composition of peatlands, by affecting soil thermal regimes, hydrology, and nutrient availability (Bisbee et al. 2001). Where a continuous moss layer occurs in poor fens, it is dominated by sphagnum mosses, especially *Sphagnum magellanicum*, *S. angustifolium*, *S. capillaceum*, *S. capillifolium*, *S. recurvum*, *S. papillosum*, and *S. fuscum* (Schwintzer 1978b, Crum 1983, Riley 1989, NatureServe 2007). In comparison, the moss layer of 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). Where hummock and hollow microtopography is developed in poor fens, it allows for high levels of bryophyte diversity since individual species of sphagnum occur at specific elevations, exhibiting habitat partitioning (Vitt and Slack 1975, Wheeler et al. 1983, Riley 1989). Hollows support *S. cuspidatum*, *S. magellanicum*, and *S. papillosum* (Heinselman 1970, Vitt and Slack 1975, Vitt et al. 1975, Wheeler et al. 1983, Riley 1989). The lower, moist slopes of hummocks often support *S. magellanicum* and *S. recurvum* while the drier hummock crests are dominated by *S. fuscum*, *S. capillaceum*, and *S. cappillifolium* (Vitt et al. 1975, Wheeler et al. 1983, Riley 1989). The vertical zonation of species or niche diversification 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).

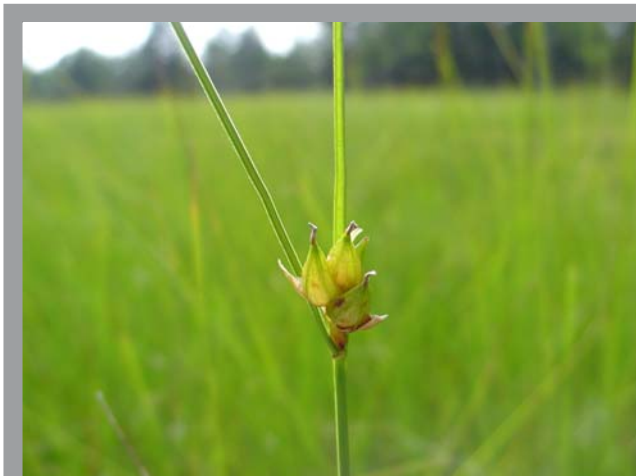


Photo by Michael A. Kost

Few-seed sedge (*Carex oligosperma*) often occurs as a dominant species in poor fens.

Sedges dominate the species-poor herbaceous layer of poor fens. *Carex oligosperma* (few-seed sedge) and *Carex lasiocarpa* (wiregrass sedge) are typically dominant. Sedges that are characteristic of poor fens include *Carex chordorrhiza* (creeping sedge), *C. exilis* (coastal sedge), *C. livida* (livid sedge), *C. pauciflora* (few-flower sedge), and *C. limosa* (mud sedge). Other sedges that often occur in poor fens are *Carex paupercula* (boreal bog sedge), *C. rostrata* (beaked sedge), and *C. trisperma* (three-seeded sedge). Additional graminoids that thrive in poor fens include *Cladium marisicoides* (twig-rush), *Dulichium arundinaceum* (three-way sedge), *Eriophorum angustifolium* (narrow-leaved cotton-grass), *Eriophorum spissum* (sheathed cotton-grass), *E. virginicum* (tawny cotton-grass), *Lysimachia terrestris* (swamp candles), *Rhynchospora alba* (white beak-rush), *Scheuchzeria palustris* (arrow-grass), and *Scirpus cespitosus* (tufted bulrush). The following is a list of prevalent poor fen herbs: *Aster borealis* (rush aster), *Epilobium angustifolium* (fireweed), *E. ciliatum* (fringed willow-herb), *Euthamia graminifolia* (grass-leaved goldenrod), *Iris versicolor* (wild blue flag), *Menyanthes trifoliata* (bog buckbean), *Potentilla palustris* (marsh cinquefoil), *Smilacina trifolia* (false mayflower), *Solidago uliginosa* (bog goldenrod), and *Triglochin maritimum* (common bog arrow-grass). The fern ally *Equisetum fluviatile* (water horsetail) is often found in poor fens. Insectivorous plants are common features of poor fens and may include *Drosera rotundifolia* (round-leaved sundew), *D. intermedia* (spoon-leaf sundew), *Sarracenia purpurea* (pitcher-plant), *Utricularia cornuta* (horned bladderwort), and *U. intermedia* (flat-leaved bladderwort).

Photos by Joshua G. Cohen

Insectivorous plants such as pitcher-plants (top left), bladderworts (top right), and sundews (bottom) have developed carnivorous adaptations to cope with the low nutrient availability of ombrotrophic peatlands.

Photo by Adrienne L. Bozic

The patchy shrub layer of poor fens is dominated by low, ericaceous shrubs, with *Chamaedaphne calyculata* (leatherleaf) often being the most prevalent. In addition to leatherleaf, the following heath shrubs are important in the low shrub layer: *Andromeda glaucophylla* (bog rosemary), *Kalmia polifolia* (bog laurel), *Ledum groenlandicum* (Labrador tea), *Vaccinium macrocarpon* (large cranberry), and *V. oxycoccos* (small cranberry). Other important associates of the low shrub layer include *Myrica gale* (sweet gale), *Salix pedicellaris* (bog willow), and *Spiraea alba* (meadowsweet). The tall shrub layer of poor fens is less dense than the low shrub layer and is often restricted to the periphery. Tall shrubs typical of poor fens include *Aronia prunifolia* (black chokeberry), *Nemopanthus mucronata* (mountain holly), *Salix discolor* (pussy willow), *Viburnum cassinoides* (wild-raisin), and *Spirea tomentosa* (steeplebush). As noted, more minerotrophic shrubs, like *Betula pumila* (bog birch), *Hypericum kalmianum* (Kalm's St. John's-wort), and *Potentilla fruticosa* (shrubby cinquefoil), can occur in poor fens when their roots extend beneath the surface mat to minerotrophic peat. Bog birch, meadowsweet, and bog willow can occur in both the tall and low shrub layers.

Photo by Bradford S. Slaughter

Shrubs commonly found growing with leatherleaf in poor fens include shrubby cinquefoil (above), and sweet gale (below).

Photo by Joshua G. Cohen

Trees within poor fens are widely scattered, stunted (seldom reaching six meters), and are often restricted to scattered, low peat mounds (Wheeler et al. 1983, NatureServe 2007). Overall tree cover is typically less than ten percent (NatureServe 2007). The most commonly occurring trees in poor fens are *Picea mariana* (black spruce) and *Larix laricina* (tamarack). Additional associates include *Pinus banksiana* (jack pine) and *Pinus strobus* (white pine). (Above species lists were compiled from Gates 1942, Dansereau and Segadas-Vianna 1952, Curtis 1959, Heinselman 1963, Heinselman 1965, Bay 1967, Heinselman 1970, Schwintzer and Williams 1974, Vitt and Slack 1975, Schwintzer 1978, Glaser et al. 1981, Schwintzer 1981, Wheeler et al. 1983, Riley 1989, Glaser et al. 1990, Glaser 1992, Eggers and Reed 1997, Mitsch and Gosselink 2000, Swinehart and Parker 2000, Michigan Natural Features Inventory 2007, NatureServe 2007.)

Michigan Indicator Species: bog birch, *Carex chordorrhiza*, *C. lasiocarpa*, *C. limosa*, *C. livida*, *C. oligosperma*, northern white-cedar, shrubby cinquefoil, and tamarack (Heinselman 1970, Wheeler et al. 1983, Anderson et al. 1996). In a study of peatland flora in northern Minnesota, Wheeler et al. (1983) concluded that *Carex livida* is a poor fen indicator and that the presence of this species readily distinguishes sites as weakly minerotrophic.

Other Noteworthy Species: Poor fens provide habitat for numerous rare insect species including *Appalachia arcana* (secretive locust, state special concern), *Boloria freija* (Freija fritillary, state special concern butterfly), *Boloria frigga* (Frigga fritillary, state special concern butterfly), *Erebia discoidalis* (red-disked alpine, state special concern butterfly), *Merolonche dollii* (Doll's merolonche moth, state special concern), *Phyciodes batesii* (tawny crescent, state special concern), *Somatochlora incurvata* (incurvate emerald dragonfly, state special concern), and *Williamsoni fletcheri* (ebony boghaunter, state special concern dragonfly). Numerous butterflies and moths are restricted to bogs and fens because their food plants occur within these open peatland systems (Riley 1989). Rare herptiles that utilize poor fens include *Clemmys guttata* (spotted turtle, state threatened), *Emydoidea blandingii* (Blanding's turtle, 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 may utilize poor 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), *Falcipennis canadensis* (spruce grouse, state special concern), 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 a variety peatland habitats. Poor 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 cause blocked drainage in fens and the subsequent succession of fens to bogs.

Rare plants associated with poor fen include *Carex nigra* (black sedge, state endangered), *Carex wiegandii* (Wiegand's sedge, state threatened), *Eleocharis nitida* (slender spike-rush, state endangered), and *Petasites sagittatus* (sweet coltsfoot, state threatened).

Photo by Joshua G. Cohen

Poor fens contribute to the native biodiversity of Michigan by providing habitat for a unique suite of flora and fauna.

Conservation and Biodiversity Management: Poor fen is a widespread 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 poor fens. By storing high levels of sequestered carbon and serving as carbon sinks, poor fens and related peatlands play an important role in global geochemical cycles. Poor 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. Paleo-ecologists may be able to provide crucial information for successful restoration of peatland ecosystems (Chapman et al. 2003).

The primary mechanism for preserving poor fens is to maintain their hydrology. As noted, peatland systems are sensitive to slight changes in water chemistry; modification in fen hydrology result in significant shifts in vegetation. A serious threat to poor fens is posed by off-road vehicle (ORV) traffic, which can destroy populations of sensitive species and drastically alter fen hydrology through rutting. Reducing access to peatland systems will help decrease detrimental impacts caused by ORVs. Resource managers operating in uplands adjacent to poor fens should take care to minimize the impacts of management to hydrologic regimes, especially increased surface flow and alteration of groundwater discharge. This can be accomplished by establishing no-cut buffers around fens and avoiding road construction and complete canopy removal in stands immediately adjacent to poor 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. In fire-prone landscape, 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 within poor fen. Silvicultural management of poor fens to preserve open canopy conditions should be employed during winter to minimize damage to the peat and impacts to the hydrologic regime.

Poor fens often occur adjacent to upland communities such as dry-mesic northern forest, dry northern forest, and pine barrens, which are dependent on periodic fires for long-term maintenance. As fire moves through these upland systems, it occasionally carries into and across poor fens unless impeded by firebreaks such as moats, lakes, streams, or other areas of sparse vegetation. When managing surrounding fire-dependent uplands with prescribed fire, managers should allow fires to burn across poor fens. In addition, wildfires that spread through the uplands should also be allowed to carry across poor fens when it does not pose serious safety concerns or threaten other management objectives.

Photo by Joshua G. Cohen

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

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of poor fen. Particularly aggressive invasive species that may threaten the diversity and community structure of poor fen include *Lythrum salicaria* (purple loosestrife), *Typha angustifolia* (narrow-leaved cat-tail), *Typha* x*glauca* (hybrid cat-tail), *Phragmites australis* (reed), *Phalaris arundinacea* (reed canary grass), *Cirsium palustre* (European marsh thistle), *Rhamnus frangula* (glossy buckthorn), and *Rosa multiflora* (multiflora rose).

Research Needs: Poor 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, Fitzgerald and Bailey

1975, Barnes et al. 1982, Amon et al. 2002). Poor fens and related community types (i.e., bog, northern fen, northern wet meadow, 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 poor fens and related peatlands are needed to help prioritize conservation and management efforts. More research is needed to elucidate the relationship of chemical factors and nutrients to floristic community structure of peatlands (Amon et al. 2002).

Photo by Joshua G. Cohen

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

Little is known about the fire regimes of poor fens and the interaction of 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 poor 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 (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, Bedford and Godwin 2003). 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 Communities: bog, coastal fen, intermittent wetland, muskeg, northern fen, northern wet meadow, patterned fen, poor conifer swamp, prairie fen, rich conifer swamp.

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; *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; *Larix laricina / Chamaedaphne calyculata / Carex lasiocarpa* Shrubland; Tamarack / Leatherleaf / Wiregrass Sedge Shrubland; Tamarack Scrub Poor Fen

IV.A.1.N.g; *Chamaedaphne calyculata* Saturated Dwarf-shrubland Alliance; *Chamaedaphne calyculata – Carex oligosperma / Sphagnum* spp. Poor Fen Dwarf-shrubland; Leatherleaf / Few-seed Sedge / Peatmoss species Poor Fen Dwarf-shrubland; Leatherleaf Poor 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 oligosperma - Carex lasiocarpa* Saturated Herbaceous Alliance; *Carex lasiocarpa - Carex oligosperma / Sphagnum* spp. Herbaceous Vegetation; Wiregrass Sedge - Few-seed Sedge / Peatmoss Species Herbaceous Vegetation; Northern Sedge Poor Fen

V.A.5.N.m; *Carex oligosperma - Carex lasiocarpa* Saturated Herbaceous Alliance; *Carex lasiocarpa - Carex oligosperma* - (*Lysimachia terrestris*) / *Sphagnum* spp. / *Spiraea tomentosa* Herbaceous Vegetation; Wiregrass Sedge - Few-seed Sedge - (Swamp-candles) / Peatmoss Species / Hardhack Herbaceous Vegetation; Midwestern Graminoid Poor Fen

Related Abstracts: American bittern, black-backed woodpecker, Blanding's turtle, bog, eastern box turtle, eastern massasauga, great blue heron rookery, incurvate emerald, intermittent wetland, merlin, northern fen, northern harrier, northern wet meadow, osprey, poor conifer swamp, prairie fen, rich conifer swamp, secretive locust, short-eared owl, spotted turtle, sweet coltsfoot, and yellow rail.

Photo by Joshua G. Cohen

Poor fen often occurs adjacent to poor conifer swamp.

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Photo by Michael A. Kost

Poor fens often occur adjacent to fire-dependent, upland pine communities in Crawford County, northern Lower Michigan.

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