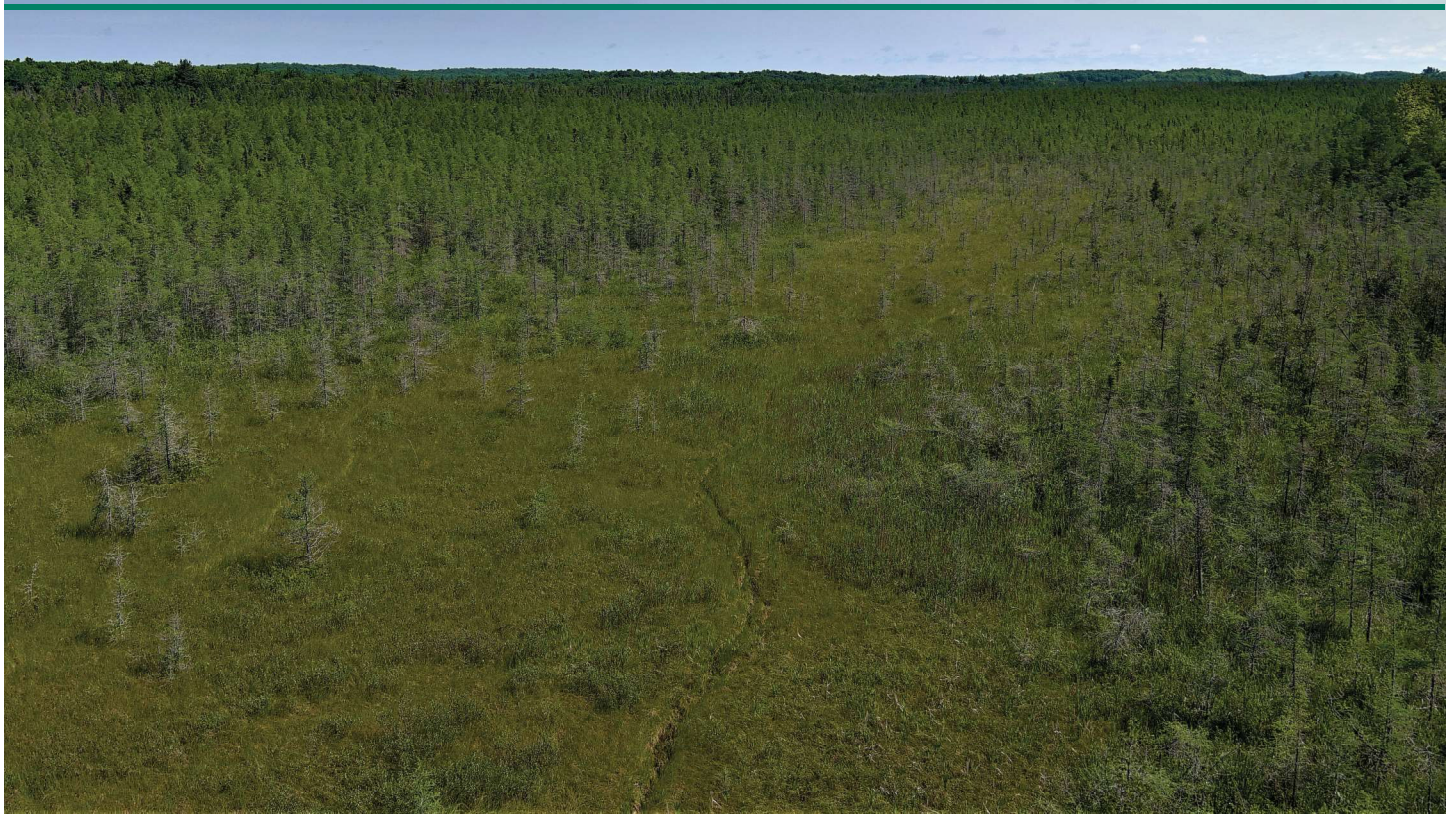
An Ecological Evaluation of Carney Fen in Escanaba State Forest



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"Nature is not something out there, remote in the Rockies or deep in the Amazon rain forest. She is rather our continuous and ever present ambient, vitally present or fading, in every flourishing or splintered woodlot, in every green or ruined marsh or stream, lake and river. There is no hierarchy of value here, nor is one segment of ultimately more value than the other – not when you consider life as a continuum circling the globe. They and we are all one. She is within us, stamped in our brains, and on our hands, swirling about wherever we may be. Here's the system that brought us into being and has always in the past and present sustained us. Our future is her future.

Think of it – if we could grasp this most elemental of facts what it would mean to assure a quality of lives for ourselves and generations to come."

From We Are All Epigeans, LeRoy Lintereur

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Cover Photo: Carney Fen (Northern Opening). Photo by Jesse M. Lincoln, 2021. All pictures by Jesse M. Lincoln unless otherwise noted.

Acknowledgements

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Thank you to the Friends of Carney Fen who were gracious in helping me understand the history of the site; especially Kip Knudson, Dale Leitzke, and Phyllis Carlson.

This report relies on data collected by many former Michigan Natural Features Inventory field scientists, especially Dennis Albert, Mike Penskar, Bradford Slaughter, and Joshua Cohen. Maps for this report were prepared by our GIS team of Becca Rogers, Courtney Ross, and Helen Endander. For their support and assistance throughout this project, I thank MNFI colleagues, Mike Monfils, Michael Sanders, Ashley Adkins, Phyllis Higman, Rachel Hackett, Kraig Korroch, Sarah Carter, Scott Warner, Clay Wilton, and Brian Klatt and especially Tyler Bassett and Elizabeth Haber for providing comments on this report.

Nathan Martineau provided pictures of orchids that enhanced the report.

Many people love this place and several Friends of Carney Fen were kind enough to show me around.

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Introduction

Carney Fen is in the central portion of Menominee County in the southcentral Upper Peninsula of Michigan. The site occurs within the Escanaba State Forest Management Unit (FMU) on land owned and managed by the Michigan Department of Natural Resources (DNR) and administered by Forest Resources Division (FRD). With over 4 million acres, State Forest constitutes a significant portion of the Upper Peninsula and Northern Lower Peninsula of Michigan. State Forests are jointly managed by the FRD and Wildlife Division (WLD) of the DNR for long-term forest health, sustainable forest products, wildlife habitat, recreational opportunities, and ecosystem services. The FRD and WLD are responsible for assuring that management activities do not harm threatened and endangered species, and through dual forest certification, the DNR maintains a network of ecological reference areas composed of high-quality and representative natural communities.

LeRoy Lintereur (1920-1995) was an Area Game Manager in the Wisconsin Department of Natural Resources. He was a famed naturalist and inducted into the Wisconsin Conservation Hall of Fame in 2016. His appreciation of wetlands, love of conservation, and need to explore led him to find the complex known as Carney Fen and describe the wetland and unusually rich concentration and abundance of orchid species. He initially tried to maintain the fen's low profile: making anybody he took there promise not to tell anyone about it. Ultimately he inspired conservationists to organize to protect it (Gjestson 2016).

Carney Fen remained a secret until someone dumped their dilapidated cottage, or "camp", on a population of the rare ram's-head ladyslipper orchid (Wolfe 2009). In response, Friends of Carney Fen was formed in 2002. After cleaning up the camp, the group partnered with the DNR to secure the site as a dedicated Natural Area in 2009, the last site in Michigan to be dedicated as such. Sites designated as Natural Areas are parcels of public land that have sites that possess characteristics of a wilderness area that have retained their natural character, have unusual flora and fauna, or similar features of educational or scientific value. These areas are maintained or restored to preserve its natural values and silvicultural operations are limited to restoration to the exclusion of commercial timber harvests (Act 451 1995).

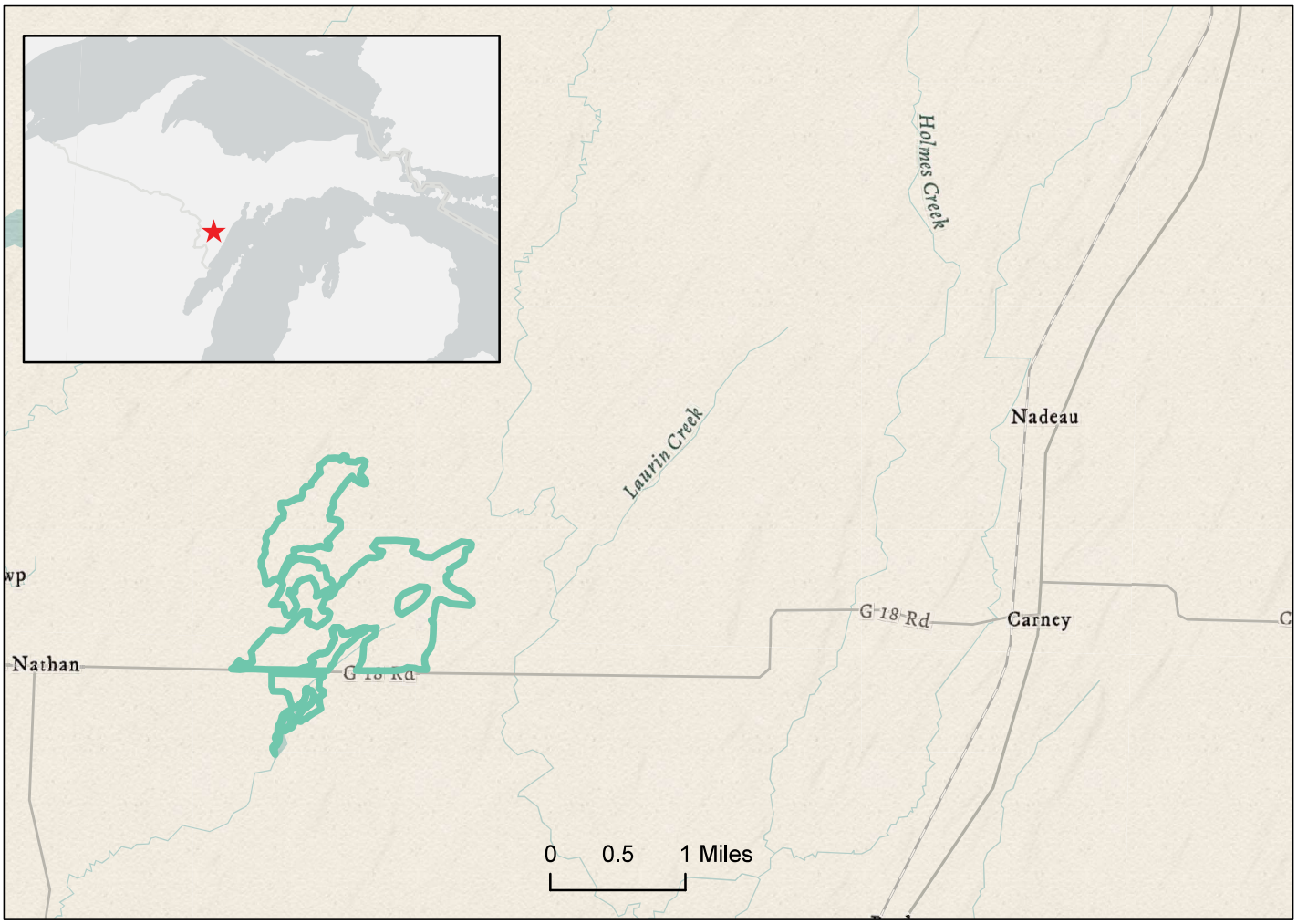


Figure 1. Carney Fen and the surrounding swamp (outlined in green) are in the south-central Upper Peninsula of Michigan, just west of the town of Carney in Menominee County.

The Carney Fen and surrounding forested wetland were designated as a State Natural Area in 2009 (Herman 2009). Despite the legal protection of the site, Friends of Carney Fen noticed that orchid populations appeared to be declining. In 2020, The group alerted DNR Biologists to their concern (Appendix 1) and a plan was developed for an ecological evaluation by Michigan Natural Features Inventory (MNFI). MNFI is Michigan's natural heritage program and maintains a geospatial database of populations of rare and declining plants and animals and benchmark ecosystems. MNFI Ecologist Kim Chapman documented Carney Fen in the natural communities database in 1985. MNFI Botanist Bradford Slaughter conducted a follow-up surveys in 2007. The surrounding swamp was surveyed by MNFI Ecologist Joshua G. Cohen in 2012. These previous surveys were used as supporting materials for the site's designation as a Natural Area.

Yellow lady-slipper (*Cypripedium parviflorum*) was one of the orchid species encountered during surveys of 2021.

The Central Opening is extremely diverse. Several orchid species were found here historically.

Landscape Context

The fen and surrounding swamp (Figure 3) occur in central Menominee County which is moderately to highly fragmented by agriculture, rural residences, and logging outside of the boundaries of state land. This portion of the county features an extensive drumlin field and the wetland complex occurs within poorly drained areas between drumlins (Figure 2), with numerous small drumlins occurring within the swamp. Drumlins are groups of elliptically shaped hills primarily composed of glacial till. These hills often occur as "drumlin fields" where glaciers receded at fairly rapid rates and through that process created the repeating features (Eschman and Dorr, 1970). In this part of Menominee county, the drumlins overlie dolomitic limestone bedrock and that bedrock can be 40 to 28 inches below the soil surface at the margins of the drumlins (Lorenz 2009).

The drumlins within the Natural Area, are vegetated with second-growth mesic northern forest. Pine stumps occur throughout the drumlins and white pine was likely more prevalent prior to European colonization. Some of the mesic northern forests on the drumlins are relatively high-quality, dominated by native vegetation, and featuring forests of an age (110 years old) and condition that is absent from most of the surrounding landscape.

The drumlins within the Carney Fen Natural Area feature mature, second-growth mesic northern forest. Old white pine stumps from the initial clearing events persist in some locations. Deer herbivory is heavily altering composition.

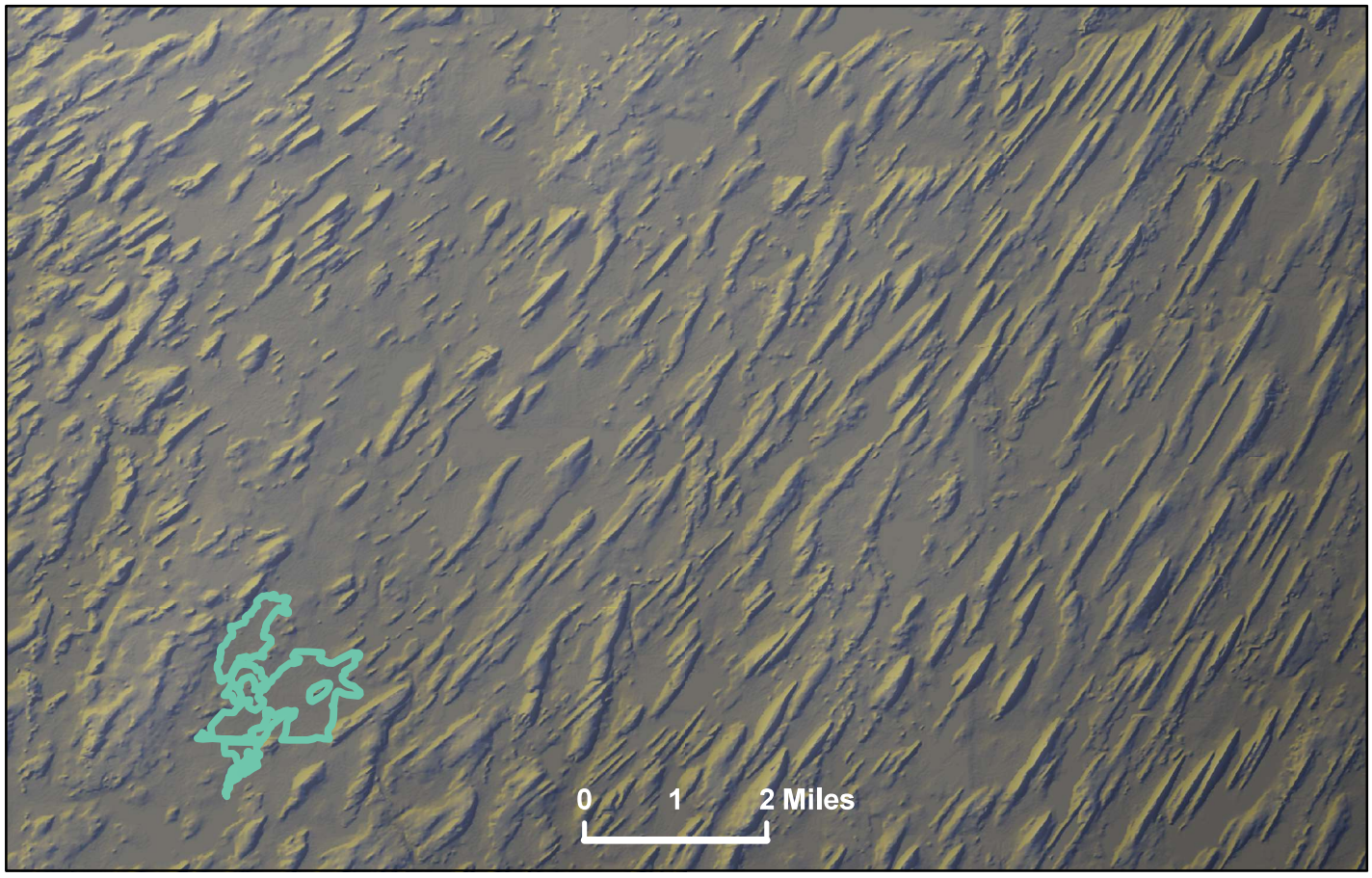


Figure 2. The landscape position of the Carney Fen and surrounding Carney Swamp within the drumlin fields of Menominee County.

The headwaters of the Shakey River occur in the swamp and water flows to the southwest, with substantial flow near the fen zones. While there is generally standing water in the fen and the hollows of the swamp throughout the growing season, no obvious streams occur north of the road near the fen. The river essentially starts in a ditch where the road crosses the swamp and persists from the ditch, gradually increasing in size as it approaches Wiregrass Lake. The river appears to be at least twice as large upon exiting Wiregrass Lake, suggesting a substantial spring feeding the lake.

The impact of fire on northern fens is often landscape dependent. Carney Fen does not have any nearby natural communities that would indicate a high frequency of fire return interval. The Shakey Lakes oak-pine barren complex is the closest documented natural community with a high-frequency return interval of fire. The area between Shakey Lakes and the Sixty Islands region 15 km southwest of Carney Fen was home to the Menominee Tribe for millennia. Despite the proximity of Carney Fen to those areas, the immediately surrounding landscape does not have any obvious fire-adapted communities, sugesting fairly low frequency fire return interval for the fen - potentially with centuries between fires.

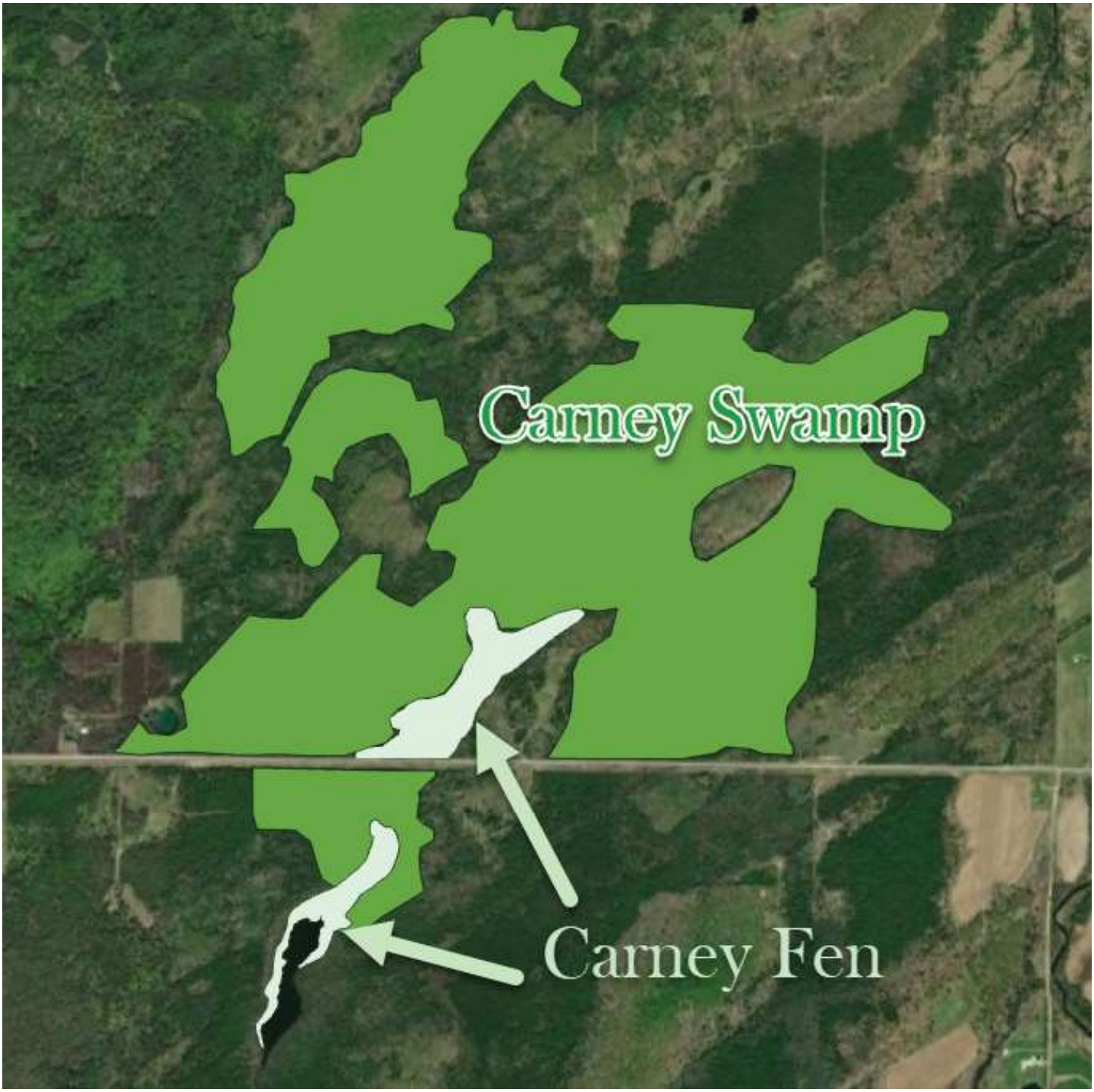


Figure 3. The Carney Fen is mapped as two polygons within a large rich conifer swamp complex. The highest quality portions of the Carney Swamp are mapped as four polygons. Descriptions of each area are provided in the results section.

Natural Community Description

The following description of the northern fen community type was adapted from the MNFI description (Cohen et al. 2022).A natural community is an assemblage of interacting plants, animals, and other organisms that repeatedly occurs under similar environmental conditions across the landscape. They are predominantly structured by natural processes rather than modern anthropogenic disturbances such as timber harvest, hydrological alteration, and fire suppression (Kost et al. 2007, Cohen et al. 2015, Cohen et al. 2020). Historically, Indigenous Peoples were an integral part of Michigan's natural communities with many natural community types being maintained by Indigenous management practices such as prescribed fire.

Carney Fen has been referred to by names: Carney Bog, Carney Swamp, Wiregrass Lake Fen. For simplicity, this report will refer to the non-forested areas as Carney Fen and the surrounding forested wetland as Carney Swamp. The distinction between fen and bog, is that fens are characterized by neutral to moderately alkaline peats, often where a constant flow of cold, calcareous groundwater seeps from the base of adjacent glacial features. In contrast, bogs feature peats that are strongly acidic and are influenced primarily by rainwater and surface water flow (Kost et al. 2007; Cohen et al. 2022). The boundaries between Carney Fen and Carney Swamp are not always obvious because the fen gradually transitions from a sedge-dominated, non-forested system towards a sparsely canopied forested wetland. The boundary was established where canopy coverage is greater than 50% and the characteristic fen vegetation becomes sparse.

Northern fens are sedge- and rush-dominated wetlands occurring north of the climatic tension zone (Figure 4). They feature neutral to moderately alkaline saturated peat and/or marl where groundwater percolates through calcareous bedrock that underlies a thin mantle of glacial drift on flat areas or shallow depressions of glacial outwash. Within outwash channels, fens are typically found where a constant flow of cold, calcareous groundwater seeps from the base of adjacent moraines and in the case of Carney Fen, from the base of adjacent drumlins. The overall topography of fens is flat to gently undulating with microtopography characterized by hummocks and hollows.

Fens frequently occur as a floating mat on the margins of lakes, as is the case along the margins of Wiregrass Lake. Floating mats of sedges such as wiregrass sedge (*Carex lasiocarpa*) pioneer open water and emergent marsh. 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. Over time, fen mats are often invaded by shrubs and transition to northern shrub thickets. Northern fens often occur within large wetland complexes, where they grade into other natural communities such as northern shrub thicket and rich conifer swamp.

Saturated and inundated conditions inhibit organic matter decomposition and allow for the accumulation of peat. The organic soils of northern fens are composed of peat and/or marl, which are typically one to three meters deep. The surface peats may range from sapric to fibric, and like the surface water, are neutral to alkaline.

Drone imagery is useful for understanding and describing the complex site. This view looking northeast, shows the fen margins at the northern edge of Wiregrass Lake, then the Central Opening, and finally the Northern Opening furthest from the lake. The blue arrows indicate groundwater flow from the drumlin that is east of the fen openings. The groundwater input moderates chemistry of the substrate and maintains the open conditions of the fen.

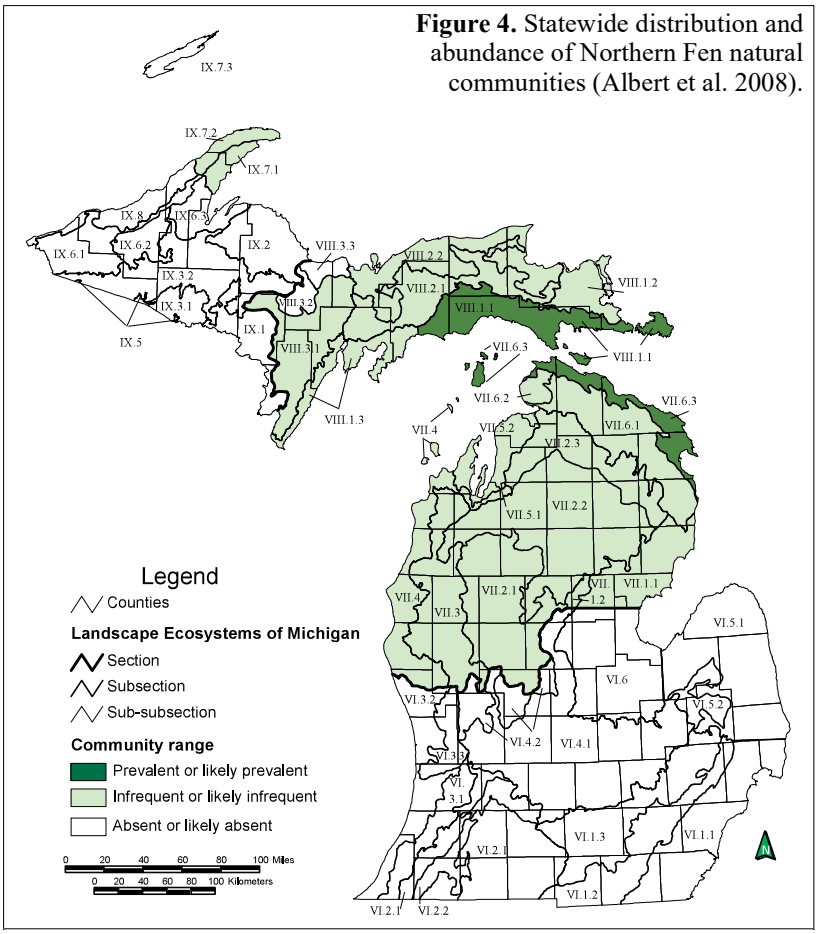


Figure 4. Statewide distribution and abundance of Northern Fen natural communities (Albert et al. 2008).

Northern fens are minerotrophic peatlands, receiving constant inputs of cold groundwater that is rich in calcium and magnesium carbonates from having moved over or percolated through base-rich bedrock or calcareous glacial deposits. Because groundwater is the primary source of water input, the hydro-period of fens is relatively stable; the soils remain saturated throughout the year but are seldom inundated by more than a few centimeters of water. 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.

Natural disturbance factors influencing northern fens include constant saturation by cold, calcareous groundwater, fire, flooding, windthrow, and outbreaks of tree parasites and insects. Open conditions within fens are maintained primarily by hydrologic and chemical conditions that limit the establishment and growth of woody plants. Surface fires can contribute to the maintenance of fens by killing encroaching trees and shrubs without removing the peat, which is normally saturated. In the absence of fire, a thick layer of leaf litter can develop, which stifles seed bank expression and seedling establishment.

This drone image of a northern fen in Mackinac County shows extensive zones of marl development. This feature is absent in the Carney Fen.

Fire severity and frequency in fens is closely related to fluctuations in water level and landscape context; fens bordering fire-prone pine and oak-pine systems likely experience occasional fires, whereas those embedded within rich conifer swamps or mesic northern forests burn very infrequently. Prolonged periods of lowered water table can allow the surface peat to dry out sufficiently to burn. 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. In such a circumstance, northern fen can succeed to rich conifer swamp or northern shrub thicket. Flooding, often caused by beaver activity, can contribute to maintaining the open condition of fens.

Roots of trees in peatlands are physiologically active near the surface and are killed during prolonged flooding. Trees growing in fens are particularly susceptible to windthrow because peat provides a poor substrate for anchoring trees. Tree survival in fens is also limited by insects and parasites. Insect outbreaks of the larch sawfly (*Pristiphora erichsonii*) and larch casebearer (*Coleophora laricella*) cause heavy mortality of tamarack (*Larix laricina*), while the plant parasite dwarf mistletoe (*Arceuthobium pusillum*) and eastern spruce budworm (*Choristoneura fumiferana*) kills black spruce (*Picea mariana*).

Northern fens are characterized by a unique and diverse flora with a rich herbaceous layer dominated by graminoids, and a patchy to continuous moss carpet, with brown mosses (*Amblystegiaceae*) more prevalent than sphagnum mosses (Sphagnaceae). While most fen plants are adapted to growing in alkaline conditions (i.e., calcicolous species), the vegetation assemblage growing on the isolated, low peat mounds resembles a bog habitat, with a continuous carpet of sphagnum mosses, low ericaceous, evergreen shrubs, and widely scattered or clumped, stunted conifer trees. Sedges dominate the herbaceous layer of fens. The most prevalent species in northern fens is wiregrass sedge (*Carex lasiocarpa*), which can form extensive lawns.

The low shrub layer is usually less than one meter high and locally dominant. The tall shrub layer of northern fens, typically one to three meters tall, is often restricted to the periphery of the fen. Trees within fens are widely scattered, often occurring in clumps on low peat mounds, and are typically of low stature. Tree cover is typically below 10%. The most common dominants of the open canopy are tamarack (*Larix laricina*), northern white-cedar (*Thuja occidentalis*), and occasionally black spruce (*Picea mariana*).

Carney Fen was first described as a natural community by MNFI Ecologist Kim Chapman in 1985. MNFI Botanist Bradford Slaughter reevaluated the site again in 2007. The surrounding Carney Swamp was first described by MNFI Ecologist Joshua Cohen in 2012. The surveys this report is based on were conducted between June 30 and July 3 of 2021 and resulted in a thorough examination of the northern fen and surrounding rich confer swamp. These surveys were aimed at evaluating the entire fen and surrounding swamp complex with the goals of assessing ecological integrity, articulating threats to the communities and plants therein, and proposing and prioritizing management goals for the site.

This image from the Northern Opening in Carney Fen shows characteristic northern fen vegetation and structure with stunted spruce, cedar, and tamarack; an extensive shrub layer of bog birch, leatherleaf, and mountain fly honeysuckle, among others; and a dense thatch of wiregrass sedge with sparse cat-tail and marsh fern.

Orchids

Orchids are a charismatic group of plants that garner substantial attention because they are often beautiful, frequently rare, and have specific habitat requirements (Knapp 2014). There have been 25 species of orchid observed at Carney Fen (Appendix 2) and the unusual concentration of orchids and large populations were central to it becoming a dedicated Natural Area. Despite the evolutionary success of the Orchid family, many orchid species have restricted distribution and many species face decline due to several factors (Evans et al. 2020). Climate change and deer herbivory are frequently pointed to as a cause for the decline. This ecological review was to evaluate the wetland system and see if there were obvious causes to the decline of the orchids. Because fully elucidating the issue would take substantial, long-term research, this report is a cursory part of the process. A comprehensive understanding will require a standardized, continuous monitoring effort. Possible explanations for the decline of orchids are provided in the discussion, as are managment recommendations and potential future steps.

Carney Fen is an important place and efforts to understand it are critical, not just for protecting what is at this site but for understanding the processes that are shaping the rest of the region but perhaps only detectible in a system as sensitive as Carney Fen.

Ram's head ladyslipper (*Cypripedium arietinum*) is a rare species of orchid that is in decline at Carney Fen.

The Central Opening is in the foreground and a small trail connects this opening to the fen margins around Wiregrass Lake, to the south. The Shakey River is visible to the right of the fen.

Methods

Throughout this report, a documented occurrence of a high-quality natural community or rare species at a specific location is referred to as an "element occurrence" (EO). The Carney Fen Northern Fen and Carney Rich Conifer Swamp EOs were evaluated employing Natural Heritage and MNFI methodology, which considers three factors to assess a natural community's ecological integrity or quality: size, landscape context, and condition (Faber-Langendoen et al. 2008, 2015).

If a site meets defined requirements for these three criteria (MNFI 1988), it is categorized as a high-quality example of that specific natural community type, entered into MNFI's database as an EO, and given a rank of A to D – good to poor – based on how well it meets the above criteria. To assess natural community size and landscape context, a combination of field surveys, aerial photographic interpretation, and Geographic Information System (GIS) analysis was employed.

Ecological field surveys were conducted between June 30 and July 3 of 2021 in Compartment 33004 of the Escanaba Forest Management Unit. Qualitative meander surveys were conducted to assess the natural community classification, ecological boundaries, and ranking of the fen and swamp. These surveys also focused on a careful documentation and framing of the threats to develop management recommendations that will serve to protect the high-quality examples of natural communities on the landscape and the rare taxa therein. Vegetative structure and composition, soils, landscape and abiotic context, threats, management needs, and restoration opportunities were all assessed.

The primary goal of this survey effort was to provide resource managers and planners with updated information on Carney Fen and the surrounding rich conifer swamp. Evaluating these natural communities would ideally provide insight into the loss of orchid species at the site and inform management of this important Natural Area. The survey time was selected to see common species of orchids, catch early-blooming species before they senesce, observe late-blooming species before they bloom, and get a broad picture of the entire flora, including grasses and sedges which dominate the fen habitat. This evaluation was not a comprehensive survey of all orchid species. Limited funding and the remote location of Carney Fen limited the assessment to a single visit. Ecological evaluations are important for facilitating site-level decisions about prioritizing management objectives to conserve native biodiversity, evaluating the success of restoration actions, and informing landscape-level planning efforts.

Keir Wefferling of the University of Wisconsin was examining moss communities of Carney Fen at the same time as this ecologcial evaluation was taking place.

Methods employed during this survey followed the methodology developed during the initial evaluation of ecological reference areas on state forest land by MNFI ecologists (Cohen et al. 2008; 2009).

This ecological field survey involved:

- compiling plant species lists and noting dominant and representative species
- describing site-specific structural attributes and ecological processes
- measuring tree diameter at breast height (dbh) of representative canopy trees and aging canopy dominants
- analyzing soils
- noting current and historical anthropogenic disturbances
- evaluating potential threats to ecological integrity
- ground-truthing aerial photographic interpretation using GPS
- taking digital photos
- surveying adjacent lands to assess landscape context
- analyzing various imagery including historic images and recent satellite imagery
- evaluating the natural community classification and mapped ecological boundaries
- evaluating the EO rank
- updating EO data for rare plants
- evaluating past and current management activities

Following completion of the field surveys, the collected data were analyzed and transcribed to update the existing EO record in MNFI's statewide biodiversity conservation database (MNFI 2022). Natural community boundaries were revised and information from this survey was used to update the site description, threat assessments, and management recommendations.

Floristic data were compiled into the Universal Floristic Quality Assessment Calculator (Reznicek et al. 2014, Freyman et al. 2016) to determine the Floristic Quality Index (FQI). Michigan sites with an FQI of 35 or greater possess sufficient conservatism and richness considered floristically important from a statewide perspective. FQI scores greater than 50 indicate exceptional sites with extremely high conservation value (Herman et al. 2001). Mean C values may represent a less biased indicator of relative conservation value and is provided with conservation metrics in the appendix (Matthews et al. 2005; Slaughter et al. 2015).

Loesel's twayblade (*Liparis loeselii*, top) and rose pogonia (*Pogonia ophioglossoides*, bottom) were both observed in Carney Fen during the 2021 ecological evaluation.

Results

Description of the Carney Fen – Northern Fen

At 45 acres, this is a large northern fen. This site is best thought of as three separate zones of open fen within an expansive conifer swamp (Figure 5). Species lists were developed for each of the three openings and the surrounding swamp to give a clear picture of the vegetative composition of the site. The 2021 surveys, lists, and descriptions include habitat at the margins of the openings where the system transitions to rich conifer swamp. Sedges and low shrubs are dominant and small, stunted trees occur along the margins of the fen openings. These openings are characterized by a continuous layer of sphagnum peats that form large hummocks, especially in the northern opening. A comprehensive list of mosses was compiled by Keir M. Wefferling, Curator of the University of Wisconsin - Green Bay, who was surveying the fen one of the days this ecological evaluation was taking place (Appendix 4).

The open fen is dominated by native vegetation, very diverse, and appears to be influenced largely by natural processes, especially a substantial flow of ground water. However, the entire swamp complex was logged in the late 1800s or early 1900s as no trees over 126 years old were found. The open zones of fen vegetation are resisting successional trajectory towards closed-canopy swamp because of complex hydrological influences. The swamp appears to be fed by rainwater and small surface streams from uplands along its margins. Substantial springs associated with drumlins are maintaining the open fen conditions within the swamp as the continuous, cold, minerotrophic groundwater slows the growth of trees, prolonging the open conditions of the non-forested successional phase. Invasive species are essentially absent from the fen openings.

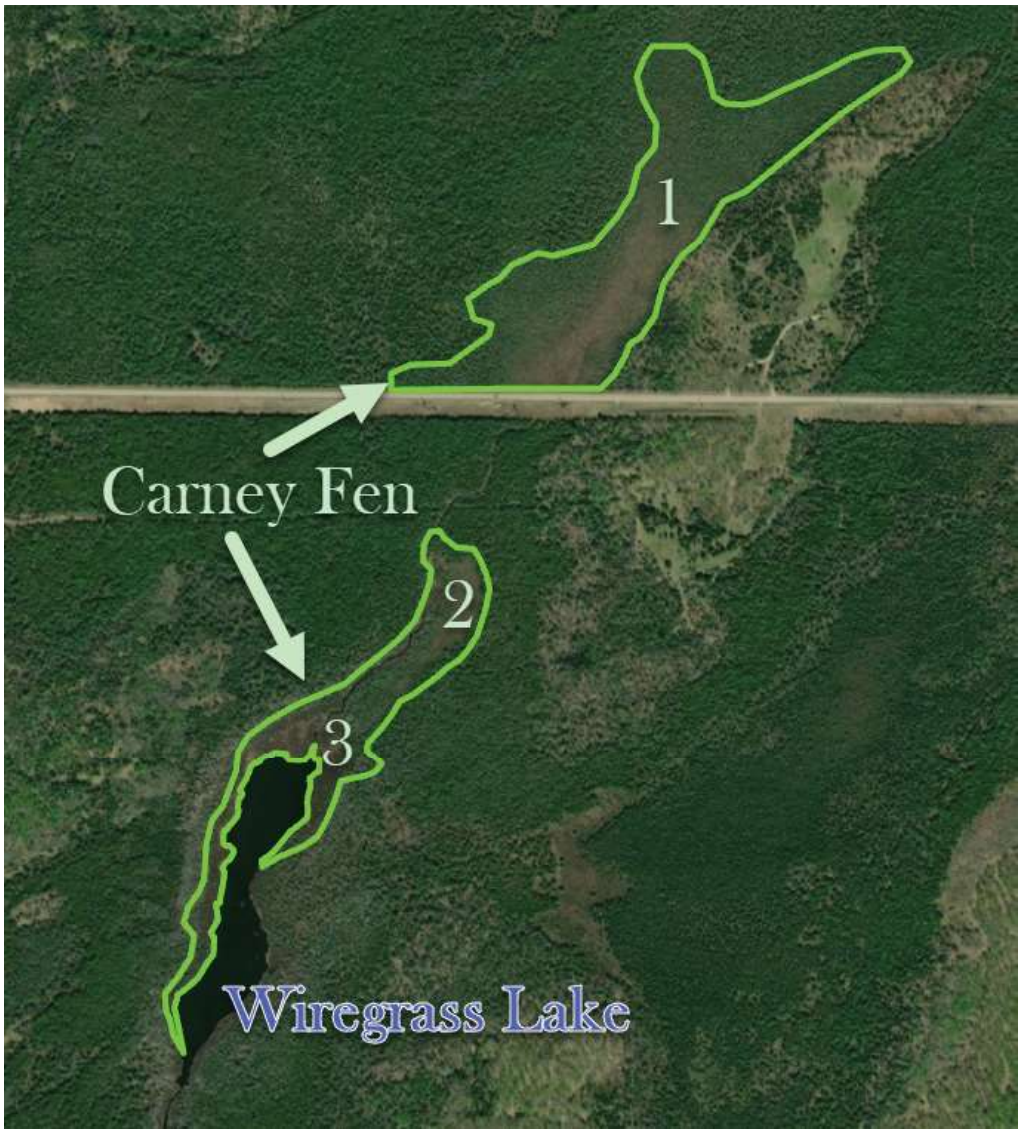


Figure 5. The Carney Fen EO consists of two polygons. The northernmost polygon consists of 1) the "Northern Opening" and the southern polygon features 2) the "Central Opening" and 3) the fen at the margins of Wiregrass Lake.

Top: Looking northeast from Wiregrass Lake to the other two zones of open fen.
Bottom: Looking southwest from the Northern Opening towards Wiregrass Lake.

The two northernmost fen zones in particular appear to be associated with significant seepage from the adjacent drumlin feature. The seepage from the drumlin may flow through limestone bedrock that is beneath the drumlins. The calcium-rich nature of the glacial till in the drumlins and underlying limestone bedrock account for the neutral to slightly alkaline peats in the fen and surrounding swamp. Soils are mounding fibric peats over hemic peats breaking down to sapric peats at depths around 20 to 30 cm, pH of all were 7.0 to around 7.5. Sometimes gravel substrate below was attached to the peat and occurred at depths of about 1 m. Other times the peat formed a floating mat and the underlying substrate was at depths greater than 1.5 m and was not detectable. The mat appears to become disassociated from the underlying substrate towards the road and quakes like a bog. It is not clear if this is due to the road backing water up, causing the mat to separate from the substrate or if it is due to the flow of groundwater from the adjacent drumlin to the east.

1) Northern Opening – This opening is north of the road that bisects the swamp complex. Of the three fen zones, this features the highest density of trees (10 to 30% coverage), primarily tamarack (*Larix laricina*), though these are generally very short ~15 to 25 ft tall and stunted. One 11.2 cm dbh tamarack had 69 rings observed. A 16.5 cm dbh white cedar (*Thuja occidentalis*) had 98 rings observed. Shrubs are abundant (~50% coverage) especially on hummocks and feature leatherleaf (*Chamaedaphne calyculata*), bog birch (*Betula pumila*), alder-leaved buckthorn (*Rhamnus alnifolia*), Labrador-tea (*Rhododendron groenlandicum*), speckled alder (*Alnus incana*), bog-rosemary (*Andromeda glaucophylla*), chokeberry (*Aronia prunifolia*), mountain fly honeysuckle (*Lonicera villosa*), sweet gale (*Myrica gale*), slender willow (*Salix petiolaris*), low sweet blueberry (*Vaccinium angustifolium*), and stunted tamarack and black spruce (*Picea mariana*).

The Northern Opening of Carney Fen. Looking north, northwest from the road.

The herbaceous layer of the northern opening is variable with composition shifting dramatically from the open fen zone as it transitions towards conifer swamp. Much of this transition zone is mapped as northern fen, even as it approaches 50% canopy coverage. Within the open fen, wildlife trails form linear features of deep water with common bladderwort (*Utricularia vulgaris*). Wiregrass sedge (*Carex lasiocarpa*) is the most dominant sedge with throughout the fen with tussock sedge (*Carex stricta*), *Carex diandra*, *Carex interior*, bulrush (*Trichophorum alpinum*), green-keeled cotton-grass (*Eriophorum viridi-carinatum*), and *Carex oligosperma* as other important sedges.

Grasses are typically much less abundant than sedges and are often associated with ant mounds. The grass species include blue-joint (*Calamagrostis canadensis*), fowl meadow grass (*Poa palustris*), slender wedgegrass (*Sphenopholis intermedia*), slender wheatgrass (*Elymus trachycaulus*), fowl manna grass (*Glyceria striata*), and wood reedgrass (*Cinna latifolia*) with slender wedgegrass and slender wheatgrass appearing exclusively on ant mounds. *Phragmites* occurs near the road and is sparse with red stems and has a habit and characteristics of the native (*Phragmites australis var. americanus*).

Common forbs include pitcher-plant (*Sarracenia purpurea*), swamp valerian (*Valeriana uliginosa*), dwarf raspberry (*Rubus pubescens*), bog goldenrod (*Solidago uliginosa*), bunchberry (*Cornus canadensis*), grass-pink (*Calopogon tuberosus*), buckbean (*Menyanthes trifoliata*), marsh cinquefoil (*Comarum palustre*), and false mayflower (*Maianthemum trifolium*). Marsh fern (*Thelypteris palustris*) is locally dominant in both the open fen and the transition zone.

This image from the Northern Opening in Carney Fen shows characteristic northern fen vegetation and structure with stunted spruce, cedar, and tamarack; an extensive shrub layer of bog birch, leatherleaf, and mountain fly honeysuckle, among others; and a dense thatch of wiregrass sedge with sparse cat-tail and marsh fern.

The transition zone between northern fen and rich conifer swamp is a very gradual ecotone, especially in this northern section. The system appears to fully transition to swamp where white cedar is dominant, the canopy is over 50% coverage, and the herbaceous layer dissipates such that sphagnum is overwhelmingly exposed with little herbaceous cover, though it is not always an obvious transition. Sometimes dramatic shifts in plant composition occur within only a few feet. The transition zone features greater abundance of alder than the open fen, while bog birch, leatherleaf, sweet-gale, slender willow and chokeberry substantially decrease. Wiregrass sedge, *Carex diandra*, *Carex interior*, bulrush, and cat-tail are much less abundant while *Carex disperma*, *Carex leptalea*, *Carex pseudo-cyperus*, and *Carex aurea* increase in abundance. Wood reedgrass and fowl manna grass become more abundant. Water horsetail (*Equisetum fluviatile*), crested shield fern (*Dryopteris cristata*), sensitive fern (*Onoclea sensibilis*), and royale fern (*Osmunda regalis*) increase in abundance. Forbs also increase in abundance and diversity, with marsh-marigold (*Caltha palustris*), pink lady-slipper (*Cypripedium acaule*), bunchberry, tufted loosestrife (*Lysimachia thyrsiflora*), Canada mayflower (*Maianthemum canadense*), naked miter-wort (*Mitella nuda*), pink pyrola (*Pyrola asarifolia*), star-flower (*Trientalis borealis*), rose pogonia (*Pogonia ophioglossoides*), yellow lady-slipper (*Cypripedium parviflorum*), wintergreen (*Gaultheria procumbens*), and kidney-leaved violet (*Viola renifolia*) becoming more common when all are nearly absent from the open fen.

Atypical white variety of grass-pink was observed in the transition zone around the Northern Opening.

The transition from open fen to rich conifer swamp in the northern opening of the fen. This transition zone is especially diverse. The open fen is maintained by a constant flow of cold, mineral rich ground water and as the influence of groundwater diminishes, the system transitions to closed canopy swamp.

The above pictures were taken about 20 feet apart in the transition zone around the northern opening. This shows how quickly and dramatically the composition can shift in this zone, depending on canopy coverage and groundwater influence.

2) Central Opening – The central opening is south of the road and east of the Shakey River (Figure 5). It is characterized by a much lower abundance of small trees than the northern opening. Within the fen a 12.5 cm dbh tamarack had 53 rings observed. At the margin was a 47.0 cm dbh white pine (*Pinus strobus*) with 82 rings observed and a 30.7 cm dbh white cedar with 93 rings observed. Stunted black spruce (Picea mariana), white cedar, and tamarack occur along the margins. Lichens were observed growing on a young tamarack and tentatively identified as *Lecanora circumborealis* and *Evernia mesomorpha*.

Shrubby cinquefoil (*Dasiphora fruticosa*) is the overwhelmingly dominant shrub with mountain fly honeysuckle, bog-laurel (*Kalmia polifolia*), bog rosemary, alder-leaved buckthorn, sweet-gale, small cranberry (*Vaccinium oxycoccos*), and bog birch occurring throughout and are locally abundant to dominant. Sedges are the dominant herbaceous component with wiregrass sedge, *Carex interior*, bulrush (*Trichophorum alpinum*), *Carex sterilis*, tussock sedge (*Carex stricta*), *Carex oligosperma*, and *Carex flava* being dominant to common. Other characteristic graminoids include blue-joint, hardstem bulrush (*Schoenoplectus acutus*), broad-leaved cat-tail, beak-rush (*Rhynchospora capillacea*), common bog arrow-grass (*Triglochin maritima*), green-keeled cotton-grass, golden-seeded spike-rush (*Eleocharis elliptica*), fowl manna grass, and leafy satin grass (*Muhlenbergia mexicana*) but only on ant mounds. Marsh fern is common to locally dominant. Forbs include swamp valerian, dwarf raspberry, pitcher-plant, bog goldenrod, grass-pink, swamp milkweed (*Asclepias incarnata*), grass-of-parnassus (*Parnassia glauca*), bunchberry, yellow lady-slipper, dragons mouth (*Arethusa bulbosa*), and Canada goldenrod (*Solidago canadensis*).

Portions of this opening are floating peat mat that is unattached to the gravel substrate below. Hardstem bulrush and beak-rush seem to correspond strongly with this floating zone. In this area, the depth from the surface to gravel or bedrock was approximately 5ft and was estimated by plunging a walking stick into the sapric peats. The non-native marsh thistle (*Cirsium palustre*) was found in the northernmost portion of this central opening, at the margins of rich conifer swamp near the Shakey River.

The Central Opening is in the foreground and a small trail connects this opening to the fen margins around Wiregrass Lake, to the south. The Shakey River is visible to the right of the fen.

Top: The Central Opening is characterized by a dense, low shrub layer dominated by shrubby cinquefoil.
Bottom: The transition zone from fen to swamp at the eastern edge of the fen opening.

3) Margins of Wiregrass Lake – The southernmost fen occurs as a floating fibric peat mat along the margins of Wiregrass Lake (Figure 5). This zone has few, stunted tamarack and black spruce. It is dominated by shrubs, including speckled alder, bog birch, shrubby cinquefoil, sweet-gale, leatherleaf, slender willow, hoary willow (Salix candida), and bog-rosemary. Other common species include wiregrass sedge, marsh fern, blue-joint, *Carex oligosperma*, *Carex stricta*, hardstem bulrush, and marsh cinquefoil. Wiregrass sedge is involved in the lake-filling process by developing mats in open water that are later colonized by additional species.

The fibric mat was thin and non-contiguous in places, with a mat of floating decaying sapric peats between lobes of the mounding fibric mat. These mucky mats featured sweet-scented waterlily (*Nymphaea odorata*), yellow pond-lily (*Nuphar variegata*), and spike-rush (*Eleocharis obtusa*). These were very difficult to traverse and crossing them posed serious risk of sinking and becoming trapped beneath the mat. The open mat transitions towards impenetrable northern shrub thicket towards the margins and at the southern end of the lake.

Water levels around Wiregrass Lake appear to be much higher than in 2007, based on photographs from the previous survey. This may be an artifact of recent rains in 2021 or part of a trend in increased rainfall. The Shakey River also appeared much higher in 2021 than depicted in photos from the 2007 survey. Areas around the Shakey River and the trail to Wiregrass Lake appear more open in 2007 and are gradually transitioning to a more closed-canopy state.

Carney Fen was surveyed from June 30th through July 3rd of 2021. There were 86 plant species observed from all three fen openings with 85 native species and one non-native species. The total combined Floristic Quality Index was 55.6 and the Total Mean C was 6. Sites are considered regionally significant to the conservation of biodiversity if their FQI is over 35. FQI scores greater than 50 indicate exceptional sites with extremely high conservation value. Mean C values may represent a less biased indicator of relative conservation value and is provided here (Matthews et al. 2005; Slaughter et al. 2015). Species lists were developed for each of the openings and an additional list compiling the information for all three openings is also provided in the Appendix (Apendecies 6 through 9). A survey conducted by Bradford Slaughter in 2007 documented 104 native species in the fen and one non-native species. The FQI was 59.5 and the Total Mean C was 5.8. The species list from the 2007 survey is provided in Appendix 12 and the conservation metrics are available in Appendix 13.

The fen margins along the northern shoreline of Wiregrass Lake looking to the south during surveys in 2021. The lake levels in 2021 appear to be much higher than in 2007.


The Shakey River north of Wiregrass Lake appeared to be much higher in 2021 (left) than 2007 (right; photo by Bradford Slaughter). It is unclear if this is a trend or simply due to recent rains.

A photo from 2007 of the fen margins along the northern shoreline of Wiregrass Lake looking to the south. The lake levels appear to be much lower than was observed 2021 (photo by Bradford Slaughter).

A photo from 2007 of the fen margins along the northern shoreline of Wiregrass Lake looking to the north. Wiregrass sedge is overwhelmingly dominant and the tree mortality is pronounced from flooding caused by a beaver dam at the south end of the lake (photo by Bradford Slaughter).

A photo from 2021 of the fen margins along the northern shoreline of Wiregrass Lake looking to the north. Alder has increased in dominance as succession of the system transitions from fen to shrub thicket.

Description of Carney Swamp – Rich Conifer Swamp
At 778 acres, this is a large rich conifer swamp in an extensive drumlin field in southcentral Upper Peninsula. It is mapped as four separate polygons (Figure 6). There are numerous small drumlins occurring within the swamp. The swamp is characterized by a continuous layer of saturated mosses that create hummock-hollow topography with large mounds forming at the base of trees and deep hollows with standing water and floating sapric peat in other areas. Soils were neutral (pH 7.0) fibric peat over hemic peats to a depth of 1 ft, then alkaline sapric peats (pH 8.0) to 3 ft deep over limestone cobble or gravel. Depth to gravel is highly variable with some areas having gravel 30 cm below the surface and others over 1 m below. The calcium-rich nature of the drumlins, glacial till, and underlying limestone account for the neutral to slightly alkaline nature of the peats in the fen and surrounding swamp.

The entire swamp complex was logged in the late 1800s or early 1900s as no trees over 126 years old were found. Winter-cut stumps from the original clearing events still occur throughout swamp. Some of the stumps have bigger diameters than the current canopy trees (i.e., 40-50cm of cut stumps compared to 10-30 cm current canopy cohort).

Cut stumps from logging events were observed throughout the swamp. Some stumps were from recent events (above) others were older and likely from first clearing event the late 1800s.

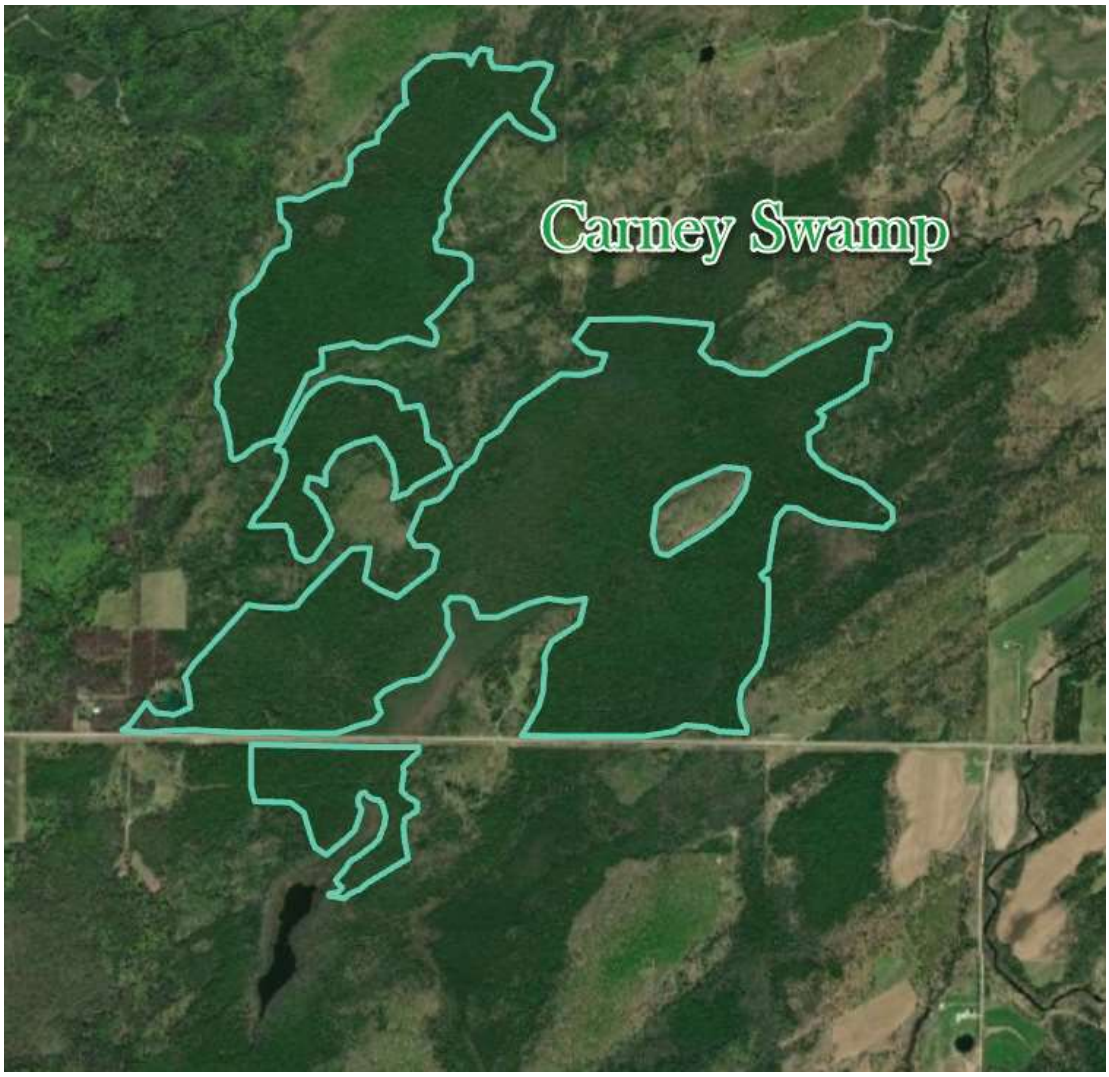


Figure 6. The Carney Swamp EO consists of four polygons.

Several old logging trails occur within the swamp. Some of the oldest stumps had charring, suggesting the swamp was burned following cutting. The swamp is mostly even-aged and the uniform age creates a relatively dense canopy that will become more varied in structure as the system trends towards late succession. Spruce budworm appears to be killing spruce and fir and the canopy is locally sparse as a result. Factors influencing canopy coverage and composition are spruce budworm, degree of saturation, proximity to Shakey River or springs feeding the river, proximity to the northern fen, windthrow, beaver flooding, and past logging events which appear to have preceded fires within the swamp.

Floristic composition of the swamp is influenced by extent of deer herbivory, degree of saturation, proximity to the fen, infestations of invasive species, canopy composition, and presence of ant mounds. Sphagnum hummock and hollow microtopography, sedge hummocks, and tip ups from windthrow generate fine scale gradients in soil moisture, and soil chemistry. Blowdown is prevalent throughout the swamp. In addition to blowdown, coarse woody debris in the swamp is generated by senescence or self-thinning of white cedar (*Thuja occidentalis*) and balsam fir (*Abies balsamea*).

Ants appear to be important drivers of diversity and plant composition. The floristic composition found on the ant mounds is highly variable. Myrmecochory is the ant-mediated secondary dispersal of seeds and this process

Ant mounds occured throughout the swamp and fen and had vegetation not seen elsewhere in the swamp or fen. These ant mounds were frequently observed after being excavated by bears.

Spruce budworm is causing areas of extensive tree mortality within the swamp.

appears to be having strong influences on vegetation patterns within the fen. The seeds of these plants were likely collected by ants, the edible material of the seed consumed, and then remaining portions of the seed removed to the exterior of the ant mounds where the seeds germinated. The ant mounds were made of fine, black organic material and typically 2ft high, 2ft across with some over 4 ft across. All mounds featured golden ants that may be in the genus *Lasius*. Bears appear to be excavating the mounds for ant larvae and in the process are scattering moss and plants across large areas.

Herbivory from white-tailed deer (*Odocoileus virginianus*) was apparent throughout the swamp complex and was noted in previous surveys conducted in 1985, 2007, and 2012. Menominee County is known to have the highest density of deer in the Upper Peninsula. Deer scat and trails were ubiquitous throughout the swamp and fen and deer are likely altering plant community composition substantially. Deer browse was heavy with herbaceous vegetation often nearly absent and herbivory damage apparent on several species, especially marsh-marigold (*Caltha palustris*), red maple (*Acer rubrum*), white pine (*Pinus strobus*), and in general a lack of cedar regeneration.

The canopy of the swamp is highly variable in composition and coverage.

Browse from white-tailed deer is obvious throughout the swamp and is having dramatic impacts on vegetation, including red maple (left) and white pine (right). Many tree species are unable to reach the subcanopy and many herbaceous species are unable to reproduce and are disappearing from the community.

Within the swamp, canopy coverage is generally 60 to 80% with the majority of the swamp dominated by white cedar. Tamarack (*Larix laricina*) and white and black spruce (*Picea glauca* and *P. mariana*) are infrequent to locally dominant. Paper birch (*Betula papyrifera*), balsam fir, and white pine are generally infrequent and black ash (*Fraxinus nigra*) is rare in the canopy. Diameters of canopy trees are generally 15 to 30 cm dbh with some trees up to 50 cm. Tree ages were mostly less than 100 (Appendix 5). Much of the swamp appears to be impacted by spruce budworm (*Choristoneura fumiferana*) which is defoliating areas where spruce and fir are dominant.

The subcanopy is typically sparse, frequently less than 20% coverage, with white cedar, fir, and black ash as common to locally abundant. The understory is patchy, locally absent in some areas to around 60% coverage in other area, and characteristic species include alder (*Alnus incana*), balsam fir, red maple, and black ash. The low shrub layer is generally sparse, around 15 – 30% coverage. Characteristic species in the low shrub layer are alder-leaved buckthorn (*Rhamnus alnifolia*), Canada blueberry (*Vaccinium myrtilloides*), Labrador-tea (*Rhododendron groenlandicum*), balsam fir, and Canadian fly-honeysuckle (*Lonicera canadensis*).

Throughout the swamp, coverage of herbaceous species ranges from sparse (< 5% coverage) to extensive (~60%) and the extent of the herbaceous layer appears to correspond with canopy coverage and hummock-hollow topography of the sphagnum layer. Species include dwarf raspberry (*Rubus pubescens*), several sedges (*Carex disperma*, *Cx interior*, *Cx stricta*, *Cx magellanica*, *Cx aurea,* and *Cx eburnea*) marsh fern (*Thelypteris palustris*), fringed loosestrife (*Lysimachia ciliata*), marsh-marigold, wintergreen (*Gaultheria procumbens*), twinflower (*Linnaea borealis*), naked miterwort (*Mitella nuda*), bunchberry (*Cornus canadensis*), wild sarsaparilla (*Aralia nudicaulis*), crested shield fern (*Dryopteris cristata*), marsh thistle (*Cirsium palustre*), reed canary grass (*Phalaris arundinacea*), Canada mayflower (*Maianthemum canadense*), wood reedgrass (*Cinna latifolia*), sensitive fern (*Onoclea sensibilis*), royal fern (*Osmunda regalis*), bluebead-lily (*Clintonia borealis*), bluejoint (*Calamagrostis canadensis*), fragrant bedstraw (*Galium triflorum*), creeping-snowberry (*Gaultheria hispidula*), gay-wings (*Polygala paucifolia*), fowl meadow grass (*Poa palustris*), false melic (*Schizachne purpurascens*), northern shorthusk (*Brachyelytrum aristosum*), star-flower (*Trientalis borealis*), goldthread (*Coptis trifolia*), oak-fern (*Gymnocarpium dryopteris*), small enchanters-nightshade (*Circaea alpina*), king devil (*Hieracium caespitosum*), pink pyrola (*Pyrola asarifolia*), false mayflower (*Maianthemum trifolium*), swamp aster (*Symphyotrichum puniceum*), and common wood rush (*Luzula multiflora*) among others.

Much of the herbaceous layer of the swamp is sparse and dominated by a few species, particularly swamp dewberry, *Carex disperma*, and often little else. The low diversity is presumabely a result of deer herbivory and simplified structure of the second-growth cedar forest.

Typical composition within the swamp. Characteristic species include swamp dewberry, *Carex disperma*, royal fern, gold thread, Canada mayflower, bunchberry, gay-wings, star-flower, sensitive fern, Canadian fly honeysuckle, balsam fir, and fowl mana grass.

The herbaceous layer of the swamp is locally quite depauperate or frequently with European swamp thistle as a dominant. This lack of vegetation seems to be a result of deer herbivory and the dense canopy that is characteristic of second growth. As the swamp matures, the canopy will likely become more variable, due to continual windthrow and mortality of trees from old age or insect outbreaks.

The transition towards northern fen is gradual and the transition zones are especially diverse compared to the rest of the swamp. The system appears to fully transition to fen when tamarack is dominant, the canopy is less than 50% coverage, and the herbaceous layer becomes much more dominant than the exposed sphagnum carpet, though it is not always an obvious transition. Sometimes dramatic shifts in vegetation occur within only a few feet.

Compared to the swamp, the transition zone features greater abundance of alder, Labrador-tea, bog birch, bog-rosemary and alder-leaved buckthorn. Graminoids such as *Carex stricta*, bluejoint, *Carex pseudo-cyperus*, bulrush (*Trichophorum alpinum*), wood reedgrass, and fowl mana grass become more abundant. Forbs also increase in abundance and diversity, including swamp valerian (*Valeriana uliginosa*), false mayflower, swamp milkweed (*Asclepias incarnata*), pink pyrola, fringed loosestrife, round-leaved sundew (*Drosera rotundifolia*), pitcher-plant (*Sarracenia purpurea*), and kidney-leaved violet (*Viola renifolia*) are much more dominant in the transitional zone from swamp to fen.

Carney Swamp was surveyed June 30 to July 3 of 2021. A total of 103 plants species were observed with 97 native species and 6 non-native species. The total floristic quality index is 52.8 and the Total Mean C is 5.2. Sites are considered regionally significant to the conservation of biodiversity if their FQI is over 35. FQI scores greater than 50 indicate exceptional sites with extremely high conservation value. Mean C values may represent a less biased indicator of relative conservation value and is provided here (Matthews et al. 2005; Slaughter et al. 2015). An additional species list is provided in Appendix 10.

Orchids

The majority of orchids observed in 2021 were found in the transitional zones near the fen or within the fen and include, grass-pink (*Calopogon tuberosus*), dragon's mouth (*Arethusa bulbosa*), pink lady-slipper (*Cypripedium acaule*), yellow lady-slipper (*Cypripedium parviflorum*), showy lady-slipper (*Cypripedium reginae*), Loesel's twayblade (*Liparis loeselii*), rose pogonia (*Pogonia ophioglossoides*) and early coral-root (*Corallorhiza trifida*). This transitional zone around the northernmost opening is one of the locations where calypso (*Calypso bulbosa*) and ram's head lady-slipper (*Cypripedium arietinum*) were previously described but these were not observed in 2021. Less than 10 clumps of each of the following species were observed in 2021: dragon's mouth, twayblade, yellow lady-slipper, pink lady-slipper, and rose pogonia. Most of those were north of the road in the transition between fen and swamp.

Hundreds or potentially thousands of grass pink were blooming in the transition zone around the fen and within the fen. Several other species occurred in and around the central fen zone and the transition area between the central fen and the southernmost fen around Wiregrass Lake. There were 18 ram's head lady-slippers found, 10 in fruit, on the drumlin adjacent to the swamp, on the south side of the road but not within the swamp during the 2021 surveys.

The transition zone from swamp to fen on the east side of the Central Opening.




Orchids were most abundant in the transition zones around the fens. Several species were encountered, though apparantly at densities and frequencies much lower than historic numbers, based on accounts of individuals familiar with the fen. Species include showy lady-slipper (top left), dragon's mouth (top middle), grass-pink (top right), and rose pogonia (bottom). Most orchids were relatively infrequent but grass-pink was in peak bloom during surveys in early July of 2021. Hundreds or thousands were blooming. All species were absent from areas of swamp with densest canopy.

Invasive Species

Within the areas of high-quality swamp, densities of invasive species ranges from locally absent to severe infestations. The two most problematic species are European swamp thistle (*Cirsium palustre*) and reed canary grass (*Phalaris arundinacea*). Thistle is locally dominant and crowds out native vegetation, sometimes appearing to smother it with extensive basal rosettes. The distribution of the thistle does not correspond to an obvious past disturbance. Thistle occurs in a patchy distribution throughout the swamp complex and is rare in the fen openings. The swamp thistle is generally innocuous when encountered in other areas of the state, but Carney Swamp has a severe infestation that appears to be having substantial negative consequences on the flora. The thistle may be fully realizing its invasive potential at Carney Swamp and the area may serve as a harbinger for other wetlands. Reed canary grass is locally dominant within the swamp system and seems to be more concentrated along historic logging roads, especially where hydrology has been altered by small ditches or where pooling occurs due to the logging road blocking the flow of water. It was also noted south and west of Wiregrass Lake where beaver flooding had locally killed the canopy trees. Reed canary grass is not limited to these areas, only most concentrated there and it occurs throughout the swamp complex and is likely to be a major problem. King devil (*Hieracium caespitosum*) is locally abundant to common but never dominant. Non-native Phragmites was found just west of Wiregrass Lake and should be treated as soon as possible as it poses substantial risk to the long-term integrity of the system. It was also observed growing along the powerline corridor just east of the fen along road (G-18).

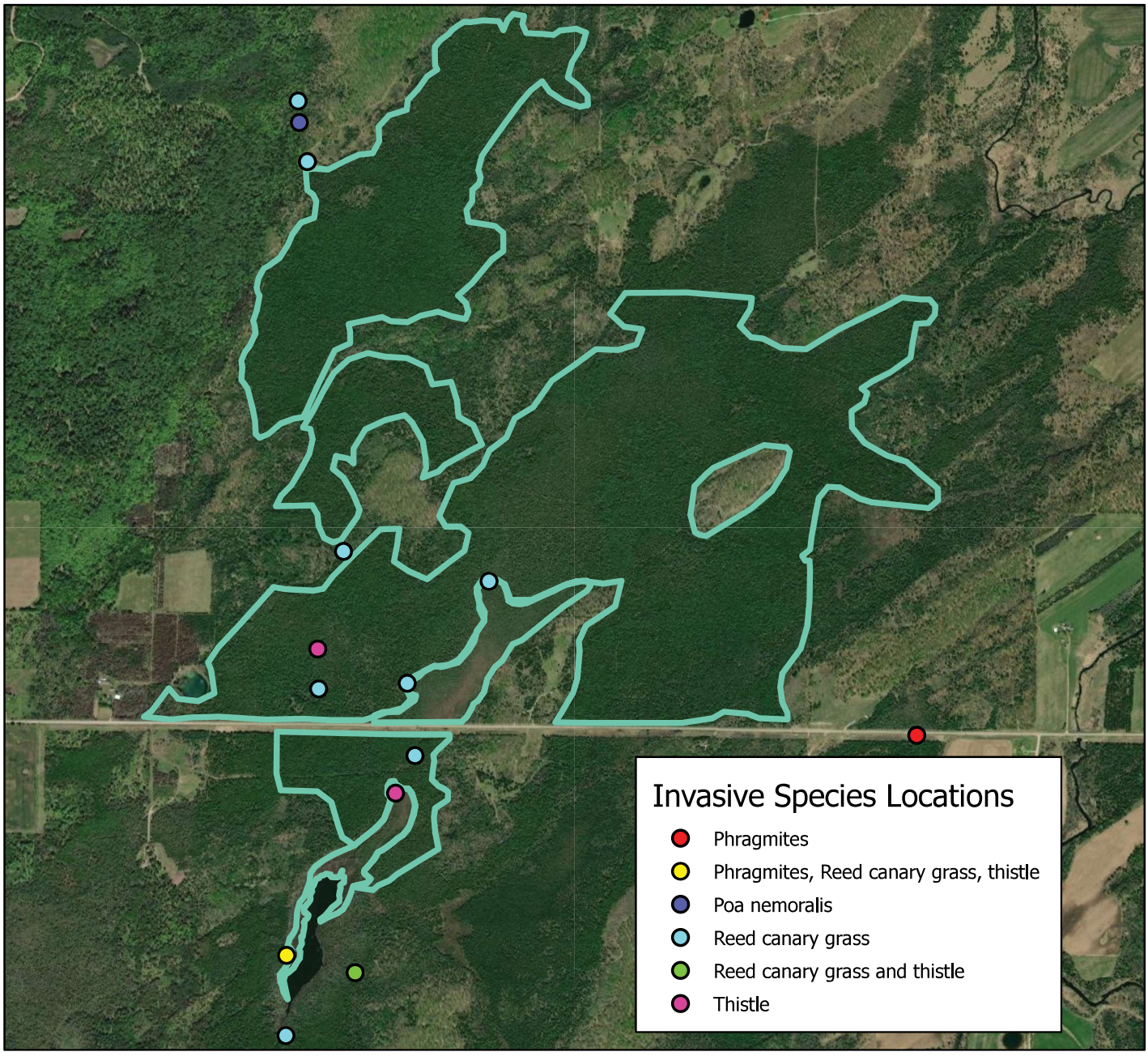


Figure 7. Location of invasive species in the Carney Fen and surrounding Carney Swamp.

European swamp thistle (*Cirsium palustre*) occurs within Carney Swamp at high densities not observed anywhere else in the state. This is a serious infestation and the large rosettes occupy substantial space and appears to easily outcompete native vegetation. Its success is likely due to a combination of factors, including intense pressures on native vegetation from deer herbivory and nutrient deposition from fossil fuel combustion. Populations are much more extensive than what is mapped in Figure 7.

This population of non-native Phragmites occurs east of Carney Fen on road G-18 and is an existential threat to the fen. It should be treated immediately and the area under the powerline monitored in perpetuity.

Discussion

Overall Rank

Carney Fen is a large northern fen in good condition within a landscape that features extensive natural cover. The overall rank is maintained at B, or "Good". The surrounding swamps have been protected from logging, composition and structure appear to have been minimally impacted by a road crossing, invasive species occur in relatively high abundance in the surrounding forest but are essentially absent within the fen, and diversity is quite high. Intense deer herbivory is likely having a substantial impact on composition, especially in orchid decline.

Carney Swamp is a large, second-growth rich conifer swamp in fair condition within a moderately fragmented landscape that features extensive natural cover. The Overall Rank is BC, or "Good to Fair". Logging is prohibited across large areas of the swamp to protect the fen. A road and powerline crossing cuts through the swamp and may facilitate invasion by non-native species but structure and composition near the crossing appears to have been minimally impacted. The swamp has many areas of high plant diversity but intense deer herbivory is having a substantial impact on groundlayer composition and recruitment of white cedar. This is evidenced by several areas with a continuous carpet of sphagnum and almost no herbaceous vegetation. The swamp is even-aged and the uniform age creates a relatively dense canopy that will become more varied in structure as the system trends towards late succession. The areas of densest canopy also tend to have the sparsest herbaceous component. Past land clearing, degree of saturation, successional stage, and herbivory by deer are leading to complex interactions influencing plant composition.

The ecological evaluation of Carny Fen found no obvious, human-caused, direct actions that have caused degradation within Carney Fen and the surrounding swamp since its dedication as a Natural Area in 2009. The fen was given an Overall Rank of B in 2007 and the rank was not adjusted after the 2021 surveys. Despite the high-quality, diverse nature of the fen and surrounding swamp, there appears to be a substantial decline in the abundance and diversity of orchid species. Numerous causes for this were proposed by Friends of Carney Fen at the time of survey, but without careful, long-term population monitoring, speculation is the best that we can offer.

The open fen structure is being maintained by constant flow of cold, mineral-rich ground water. This hydrology is governing the successional transition from open wetland to closed-canopy swamp. Some of the most diverse areas of the wetland occur along the transition between fen to swamp.

The successional phase of the swamp may impact composition. The structure of the second-growth forest creates a continuous canopy that limits the amount of light that can reach the herbaceous layer (top photo of Carney Fen). Old growth cedar swamps are highly variable with a much sparser canopy (bottom photo, Marquette County).

Orchid Decline

Orchidaceae is the most diverse family of plants with over 24,000 known species (Dressler 2005). This report is not intended to be a thorough review of the enormous complexity of orchid biology and can only provide an introductory description of this group of plants to identify potential relevant risks to the populations of orchids at Carney Fen. We relied on reviews by Waterman and Bidartondo (2008) and Bernhardt et al. (2017) for introductory information on orchid biology for this report. Additional citations are provided throughout but this is a very large topic with specialized research on the numerous genera. Relevant research may have been missed but we provide a cursory treatment of the group.

Orchids have especially complex biology. They typically rely on symbiotic relationships with fungi, requiring fungal infection for germination and early growth as orchid seeds have virtually no energy reserve and therefore obtain resources from the fungal symbionts. Some orchids can be extremely specific in their symbionts, preferring a narrow range of fungi with which they partner.

Orchids also have unusual floral morphology that can limit pollinator compatibility. Additionally, they frequently do not reward pollinators and rely on pollinator deception. Pollinators that visit orchids and receive no nectar reward tend to stop visiting orchids after a few visits. Therefore, orchid reproduction depends on the density of other flowering species for successful pollination. This makes their life cycle especially susceptible to factors influencing abundance of other flowering plant species, such as deer herbivory. Orchids are also especially impacted by factors that negatively influence native pollinator abundance, such as insecticides and diseases spread by honeybees, which are non-native.

Many orchids historically found at Carney Fen and the surrounding swamp are now absent, including purple-fringed orchid (top left), ragged fringed orchid (top right), heartleaf twayblade (bottom left, photo by Nathan Martineau), green adder's-mouth (bottom right, photo by Nathan Martineau), and round-leaved orchis (left, photo by Nathan Martineau).

Many orchids species are declining across their range. Many of the species of orchids that were once abundant at Carney Fen have seen massive declines in Michigan. Calypso was once described as widespread across the Upper Peninsula (MNFI 1996, Schmidt 2003). The species was historically reliably found at several locations across the the Northern Lower Peninsula and the Upper Peninsula but it is now absent at almost every known site in the lower peninsula and generally occurs at low densities at the majority of sites across the Upper Peninsula (Tony Reznicek, personal communication 2022). It is however, still widespread on Isle Royale, where there are no deer and where calypso occurs in massive colonies in high-quality habitat and along foot trails. It was also historically described as widespread on St. Martin Island, in northern Lake Michigan, close to Menominee County, in the 1980s. At the time it occurred across the entire island. Surveys of the island in 2013 and 2021 found no calypso, likely a result of the high deer levels (Judziewicz et al. 2016, Bassett et al. 2022). Similarly, round-leaved orchis was historically known from several locations in the Upper Peninsula and in the Northern Lower Peninsula. All sites in the Northern Lower Peninsula have been absent of the species for decades (Tony Reznicek, personal communication 2022). Populations of many species of orchids have been reported across Eastern North America and the trend is clear: many species of orchid are in serious decline.

We suggest several potential factors influencing orchid populations at Carney Fen. These include climate change, deer herbivory, and invasive species. We also provide recommendations for moving forward to clarify the trends with data collected through monitoring, protect what remains, and potentially reverse trends in collapse if possible.

Calipso has disappeared from several locations across its historic range. It is now absent from many areas it was once described as widespread. However, it is still widespread in areas where deer are absent, such as Isle Royale.

Climate Change

Since 1951, the Great Lakes region is experiencing an increased average temperature of 2.3 F, 16 more frost-free days every year, 14% increase in total precipitation, and 35 % increase in heavy precipitation events (Great Lakes Integrated Sciences and Assessments 2022). In Northeastern Wisconsin - the region that most closely matches Menominee, Michigan - the average winter temperature has increased by 4.4 F (2.5 C) since 1951. The seasonal precipitation has increased by 17.4% in winter and 20.2% in fall (Tables 1 and 2).

It is impossible to know how each species will respond to climate change and several are likely more susceptible to it than others. However, research predicting species response to climate change suggests that range shifts are probable. As temperatures and precipitation increases, suitable habitat might expand at the northern extent of species' ranges but disappear at the southern extent of the species' range (Evans et al. 2020). Several orchid species observed in Carney Fen are at the southern extent of their range in Michigan and these species tend to be the species that have the most dramatic declines at the site. These include round-leaved orchis, calypso, and ram's-head orchid (Figure 9a, 9b, and 9c). Conversly, species that were found in greatest abundance had ranges that extend much further south of the Upper Peninsula (Figure 10a, 10b, 10c), suggesting that climate change is impacting some orchid species more than others.

The mechanism by which increased winter temperatures influence orchid species is unclear. While increased winter precipitation might mean more snow, the increased average temperature could also cause variability in snowpack. Intermittent snowpack causes increased susceptibility to extreme cold temperatures, potentially negatively impacting survivorship. Further, the increased spring temperatures alters emergence of orchids and other species and cause a mismatch in flowering time and presence of pollinators. Because of the complex reliance on pollinator abundance, anything altering insect abundance would have a dramatic negative consequence on orchid reproduction.

Additionally, increased precipitation may be reducing suitable habitat for calypso and other orchids. It grows in the shaded duff with little or no herbaceous competition over bedrock. However, in wetlands, it does not occur in soggy soils (Case 1987; Schmidt 2003). The water levels of Wiregrass Lake and the Shakey River do appear to be substantially higher than when the site was surveyed in 2007 and it seems reasonable to assume that some of the species may be negatively impacted by increased precipitation.

Nitrogen deposition may be another mechanism causing orchid declines. While not a driver of climate change, atmospheric nitrogen is a biproduct of fossil fuel combustion which is driving climate change. Nitrogen deposition rates are currently an order of magnitude greater than in preindustrial times and these pose a major ecological threat as "availability of nutrients is a key factor in determining plant community composition" (Phoenix et al. 2006). Orchids are often characteristic of low nutrient systems, relying on fungal symbionts for access to nutrients. However, the combustion of fossil fuels is leading to increased deposition of bio-available nitrogen. This increased nitrogen content of rainwater is apparently shifting the competitive advantage away from conservative orchids and towards weedy, fast-growing species. See Phoenix et al. (2006) for a more comprehensive review and additional references.

Table 1. Change in annual precipitation in Northern Wisconsin since 1951. Data compiled by Great Lakes Integrated Sciences and Assessments. Accessed 2022.

CHANGES IN PRECIPITATION

	in.	%
Annual	2.6	8.51
Winter	0.6	17.42
Spring	0.1	1.78
Summer	0.3	2.25
Fall	1.6	20.15

Show cm.

Linear best-fit changes are calculated over the period 1951-2021. Percentage changes are calculated relative to the 1951-1980 historical reference period.

Table 2. Change in annual temperature in Northern Wisconsin since 1951. Data compiled by Great Lakes Integrated Sciences and Assessments. Accessed 2022.

CHANGES IN TEMPERATURE

	°F	°C
Annual	3.0	1.7
Winter	4.4	2.5
Spring	2.8	1.6
Summer	2.3	1.3
Fall	2.5	1.4

Linear best-fit changes are calculated over the period 1951-2021.

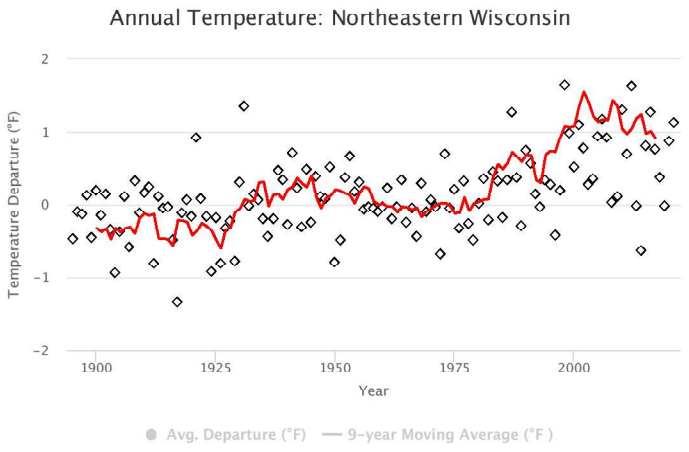
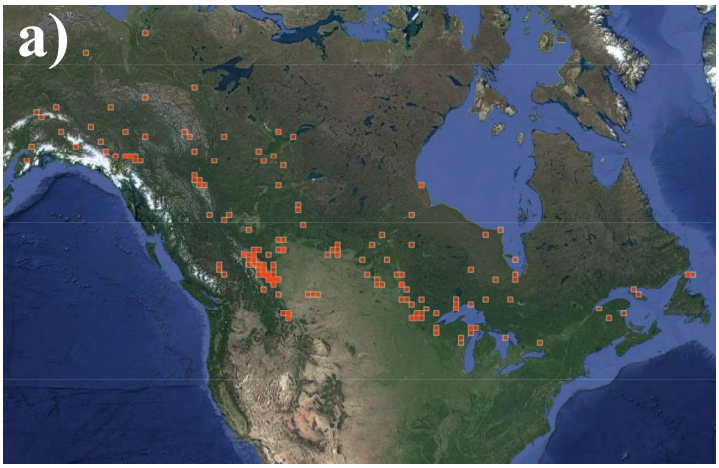
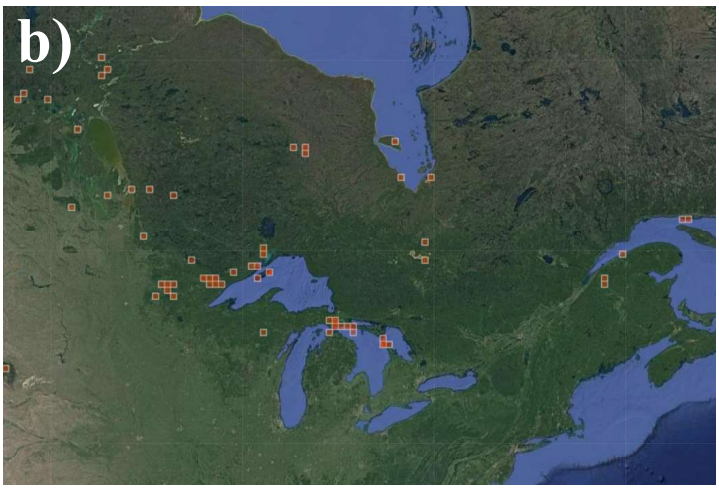


Figure 8. Annual temperatures of Northern Wisconsin since 1951. Data compiled by Great Lakes Integrated Sciences and Assessments. Accessed 2022.





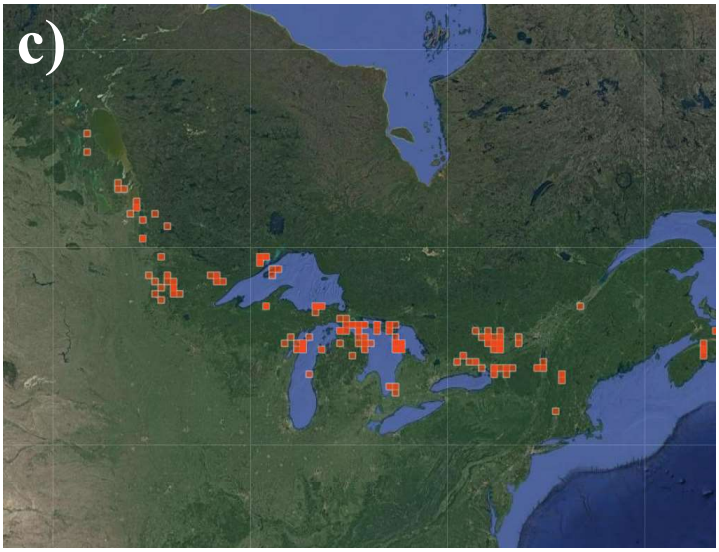
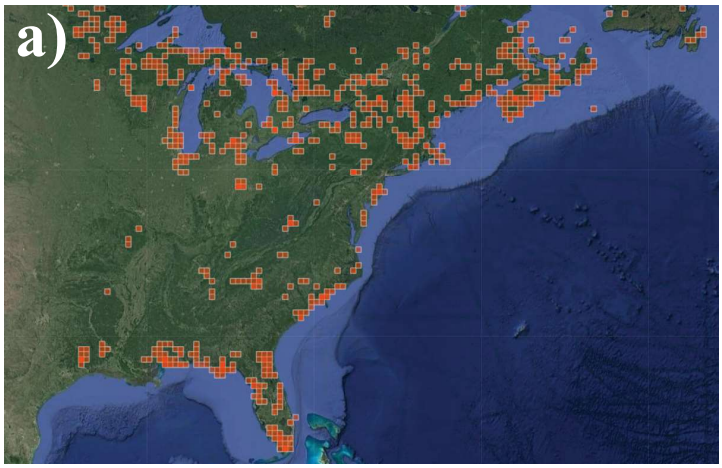
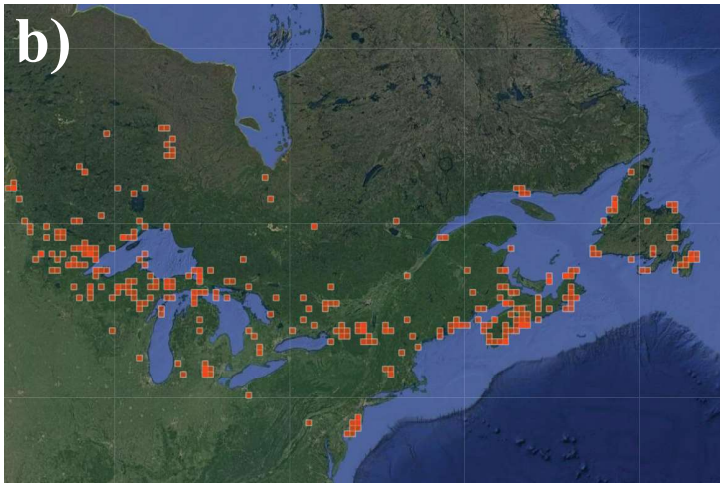


Figure 9. Recent iNaturalist observations of orchid species with Michigan at the southern extent of their range, including round-leaved orchis (9a), calypso (9b), and ram's-head orchid (9c) These orchid species are uncommon throughout their range.





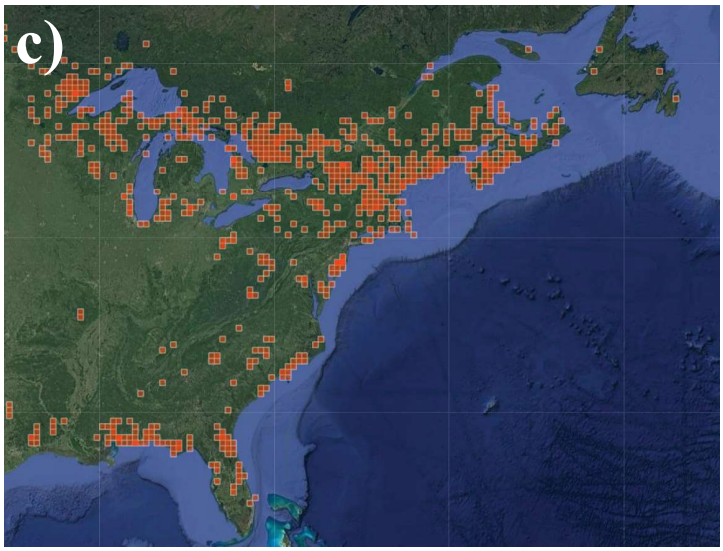


Figure 10. Recent iNaturalist observations of orchid species with a more southerly distribution, including grass-pink (10a), dragon's mouth (10b), and rose pogonia (10c). These species have ranges that extend much further south than Michigan, suggesting they may not be as impacted by climate change at this part of their range.

Deer Herbivory

The paper 'Forests Too Deer: Edge Effects in Northern Wisconsin' by Alverson et al. (1988) provides a starting point for understanding impacts of deer herbivory in the region. It is especially relevant because of its regional focus and the conclusions have been supported by additional research. They state that "deer densities as low as 4 deer/ km^2 may prevent regeneration of once common woody species… as well as several herbaceous species". Their review also concludes that several orchids are also "favored by deer, including the showy and yellow lady's-slipper orchids, the blunt-leaf orchid, the tall northern bog orchid, and the purple fringed orchid" - all of which are species or genera dissapearing from Carney Fen. Subsequent work on the topic only strengthens their conclusions: through a 41-year study, Knapp and Wiegand (2014) conclude that proper management of deer is critical for continuation of orchids in the Eastern United States.

Deer browse was obvious during the ecological evaluation of 2021 and occurred across the entirety of the site and surrounding uplands. Menominee County deer densities are high, with over 5 antlered deer harvested per square mile and an estimated density of 7.3 deer/km^2. This high deer density has likely altered the herbaceous vegetation throughout the site since the first MNFI surveys in the 1980s. The south-central Upper Peninsula contains a major farm belt with interspersed forests in the farm fields. This mosaic of farms and forests in western Menominee county creates ideal deer habitat and combined with milder winters than the rest of the Upper Peninsula, leads to high deer densities (MDNR 2022).

Severe deer browse is likely the greatest threat to the orchid populations and potentially the single most degrading force acting on Carney Fen. Because high deer densities are likely impacting populations of flowering plants associated with orchids, the threat to orchids is not just through direct browse, but also through reducing of populations of flowering plants that are required attract a high density of pollinators required for successful orchid reproduction. Using camera traps to better estimate deer densities may clarify the extent of the problme of deer herbivory. However, the evidence for the superabundance of deer is already apparent and spending time and money on additional monitoring of herbivory would be a concerning loss of resources.

An image from above clearly shows that many deer trails cross the fen.

Invasive Species

Invasive species are already a major problem in Carney Swamp. Nearby populations of Phragmites, narrow-leaf cat-tail, and reed canary grass have the potential to permanently degrade the fen. The reason for their increasing abundance is multifaceted and different for each species. The three most concerning invasive species are reed canary grass (*Phalaris arundinacea*), European swamp thistle (*Cirsium palustre*), and reed or phragmites (*Phragmites australis var. australis*). Phragmites was observed in two places near the wetland complex (Figure 7, Pg. 29). One occurrence is along the road just east of the fen and should be treated immediately as it can easily continue down the powerline corridor. This area should also be surveyed for narrow-leaved cat-tail as it can also easly invade the fen and treating it in the fen would inflict collateral damage. The other Phragmites occurence was on the west side of Wiregrass Lake and could potentially be accessed from the west. This population near the lake might be difficult to get to but has real potential to invade the entire lake margin and should be a top priority for erradication. The reed canary grass was frequently observed along logging roads but there were occurrences throughout the swamp and near the fen.

European swamp thistle was most common in the swamp but occurred near the fen in a couple of places. This species was in much greater abundances at Carney Swamp than at any other location known in the state. It is likely increasing in abundance as a result of nutrient deposition from combustion of fossil fuels, reduction of competition from native vegetation as a result of deer herbivory, and destabilization of the community from climate change.

Other Factors Impacting the Site

Additional topics worth investigation include pollinator decline due to insecticide application in the area, increased abundance of non-native slugs, historic frequency of fire within the fen, poaching of orchids, and trampling by photographers. Carney Fen is a well-known site and people were there to see orchids every one of the 4 days of the ecological evaluation. Almost everybody encountered said they were part of the group that protected the wetland and all said they had been sworn to secrecy with regards to the location of the fen. Two people had told me they heard about poaching of orchids near the road but did not think it had occurred in a very long time and that the size of the site seemed to be prohibitive for largescale poaching. Camera traps may be a valuable tool in understanding how many people visit the site and the extent to which poaching is an issue.

The basal rosettes of European swamp thistle outcompete native vegetation.

Management Recommendations
We believe the main management needs in order of practicality are to: 1) establish a formal program to monitor populations of orchids; 2) treat invasive species; 3) follow guidelines for stands adjacent to the Natural Area; 4) investigate protecting private land north of the road; 5) install deer fencing; 6) investigate the possibility of reducing deer densities; and 7) explore other areas in the county for similar habitat to protect. While reducing deer densities would doubtless provide substantial and immediate benefit to the orchids and many other native plants in the wetland complex, we recognized it is a politically fraught recommendation and therefore placed more accessible recommendations ahead of it.

Monitoring
While MNFI tracks the integrity of the communities and populations of rare plants, this can only be done opportunistically as funding allows. The Friends of Carney Fen have a much deeper understanding of the site garnered over decades of careful attention. Much of MNFI's locational information and population estimates are comparatively lacking. For this reason, we encourage the Friends of Carney Fen to develop a more comprehensive monitoring approach and then share the data. There are various methodologies for accomplishing this but it would ideally start with an agreed upon map of the fen with specific site names and descriptions of the species that grow there. Some of this information was provided in a letter to the DNR (Appendix 1) but a universal map should be developed and attached to this and future reports. Similarly, developing a list of orchid species that includes location, phenology, abundance, and reproductive success would also provide critical information for understanding relevant trends. A list of orchid species mentioned in various reports and correspondences is provided in Appendix 2. Once the map is established, an agreed upon methodology is required to provide the most valuable data for long-term monitoring. A potential data form is provided in Appendix 16. This form could be developed on a program like Survey123. Organizing data collection around specific sites is critical for standardizing data collection. Such a form would also make it possible to transcribe any existing data from previous years to capture as much information about orchid decline as possible.

Invasive Species Treatment
Treating invasive species should be immediately undertaken. Treating the Phragmites along the road east of the fen and also the population west of Wiregrass Lake are top priorities. Treatment actions should then focus on reed canary grass and thistle within the fen and then focus on the populations closest to the fen. A thorough survey for invasive species in the swamp surrounding the fen should take place to produce detailed locations and abundances of invasive species. Surveys, treatment, and monitoring should be a continual and ongoing process. Because of the sensitivity of the wetland, abundance of rare species, and risk of collateral damage, herbicide applicators should be highly trained and familiar with native vegetation.

Follow Guidelines for Adjacent Lands
The Conservation Area Management Guidelines for Carney Fen had several recommendations for stands adjacent to the northwest corner of Carney Swamp. These include avoiding impacts to groundwater, avoid surface water inputs to the fen, avoid activities that may promote non-native plants, and avoid activities that will encourage deer herbivory. Currently, there are timber harvests planned for this area within the protective buffer northwest of the swamp. The execution of these timber plans has a strong potential to undermine all of these stated goals. Avoid timber harvest and logging road development in the buffer, especially in the swamps with seepage that feeds streams that course directly into the swamp. Within the buffer area, there are too many areas of saturated soils, too many populations of invasive species that will respond positively to disturbance caused by loging, and already too many deer in the area which will respond positively to timber harvests.

Land Protection
Much of the Northern Opening is on private property. Fortunately, the owner does not appear to be doing anything that would damage the fen, but the state and Friends of Carney Fen should investigate purchasing portions of the fen and adjacent drumlins for immediate protection. It is important to investigate this early because subsequent recommendations for managing deer numbers may make acquiring this property politically untenable as the landowner may prefer high deer densities.

Deer Exclosure Fencing
To protect the existing vegetation and to provide an understanding of the impact of deer herbivory, we recommend investigating deer exclosure fencing. To have obvious, detectable impacts, the area protected by fence needs to be relatively large: ideally over 1 acre with fencing about 10 ft tall. It would be best to place the fencing in areas of the fen and extend it into the transition zone and the surrounding swamp. Ideally two fenced areas would be established, one in the Northern Opening north of the road and one in the Central Opening south of the road. Final placement of the fence should be determined with the help of Friends of Carney Fen based on their understanding of the most orchid-rich areas in the complex.

Adjusting Deer Numbers
Carney Fen could benefit from a special deer hunt to manage the population for conflicts. This currently happens in several areas throughout the state. This should be investigated with the DNR.

Future Work
Open wetlands have a specific signature in satellite imagery. Based on the appearance of Carney Fen, we did cursory review of this portion of the county to identify other areas to focus surveys for other species of orchids. Coordinates for additional sites of interest are also provided in Appendix 17, including two sites within the Carney Swamp complex.

Conclusions

This report is based on the ecological evaluation of Carney Fen and the surrounding Carney Swamp. It is not an intended to provide conclusive proof of what is causing the decline in orchids but offer a line of reasoning that can inform land managers on potential options for protecting the orchids and other native biodiversity at the site. The decline of orchids at this site famous for orchids cannot be blamed on climate change, deer herbivory, or invasive species alone. Instead, it is the confluence of many factors interacting together in complex ways. There is little anybody reading this report can do about climate change on a time scale that will reverse the decline of orchid populations at Carney Fen. But there are several important actions that can be taken to help protect what remains and limit the decline of orchids and other plants in the wetland complex.

Conservation efforts aimed at expanding orchid populations should be centered on factors that influence orchid reproductive success. This includes protecting habitat, which has been done in the Carney Fen Natural Area. However, because many orchids are pollinator-limited reproductive systems that depend on limited visits by individual pollinators, this model requires protecting a range of flowering species. Because many flowering plant species decline under such high deer densities, lowering deer densities around the fen and protecting critical areas with deer exclusion fences are a top priority.

Friends of Carney Fen accomplished a remarkable feat by protecting the wetland complex and the surrounding swamp as a Natural Area. The protection of Carney Fen was a victory for the conservation of regional biodiversity and should have served as a template. Instead, no further areas in Michigan will be protected in such a way for the indefinite future. The protection of Carney Fen and the surrounding swamp is meaningful for the wetland complex. As biodiversity collapses across the landscape, the designation as a Natural Area may locally prevent common things from becoming rare and protect some rare species from becoming regionally extinct.

The future of native biodiversity often looks bleak and the loss of orchids at Carney Fen is certainly concerning. However, with well-funded and prolonged intervention, there is real potential to stop and potentially reverse some of the loss. The Friends of Carney Fen have accomplished so much and the determination that led to the protection of this place is again needed to address the swarm of threats now plaguing the populations of orchids.

The dedication of the Carney Fen Natural Area was a significant win for regional conservation efforts.

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Appendix 1. Letter to DNR from Friends of Carney Fen, August 2020.

Carney Fen Update

This is an informational update on the proliferation of orchid species at the Carney Fen Natural Area. Prior to the dedication of the Carney Fen, members of the Friends of the Carney Fen spent roughly 500 hours of field investigation of the area. I personally spent about 100 hours in the field. My involvement led to a level of expertise that allowed me to do this update. Key the update is knowledge of orchid species identification, very specific locational knowledge about where the orchids occurred and knowledge about seasonal bloom times for each species. Each orchid can be identified by the presence of plants at all stages of development and not just flowering plants.

The update included about eight fen visits during 2020. Each visit consisted of a one to two hour orchid search. The first search was in late May and the last search was in Early August.

The search was informal. All but one of the searches was conducted alone. The search for the Ragged-fringed Orchid was assisted by Phyllis Carlson and Lee Anderson. Both have extensive orchid identification experience.

Of the roughly native orchid species identified at the Carney Fen during our pre-dedication searches, only eight species were found. In addition one new species was found. It is my estimation that in years prior to the dedication of the Fen, a similar search would have discovered 18 to 22 species.

Specific species were sought with each search but other species were also noted. I did not take GPS coordinates for orchid locations. Some of the other members of the Friends of the Carney Fen may have some GPS coordinates in file. A formal study of Ram's Head lady slipper was completed by Yarrow Wolfe. Her data may include many GPS coordinates for that species of special concern.

General Locations

Main Fen - a sedge meadow located about ¼ mile south of the parking area.

Parking area – a two track driveway on Co Rd G-18 located about 150 yards east of the easterly Carney Fen sign.

The island – a small ridge about 50 yard north of the road and about 100 yard east of the westerly Carney Fen sign.

Orbiculata patch - an area in a large swamp complex located about ¼ mile north of the island. Several years of searching found about 17 orchid species in an area of several acres.

Rose Garden - an area of about 10 acres located about ½ mile north of Co Rd G-18. Several years of searching found about 19 orchid species at this location.

Ram's Head Orchid – cypripedium arietinum – major decline. I have complete very limited searched for this orchid each of the last several years in its favorite places of occurrence.
This year I completed a comprehensive search of its favorite places. The orchid was found in these areas and scattered in other areas but the numbers were much smaller. Numbers were also smaller last year and the year before. Overall decline is estimated at 75% as comparted to pre-dedication years.

Calypso – Calypso bulbosa - not found. I personally discovered this orchid in the Rose Garden prior to dedication. Our group searched for this state-threatened species for several years and found as many as thirty plants in one year. Three locations were found in the larger swamp complex. Our most recent searches came up empty. The locations are remote. I did not search for this orchid during its flowering time due to the remote locations and lack of success of the most recent searches.

Heart-leaved Twayblade – Listera cordata – decline. A moderate search was completed during flowering time. Only two plants were found, one at a later search when the flowering was done. This orchid is scattered. The best locations produced few results.
Ragged Fringed Orchid – Platanthera lacera – not found An extensive search was conducted by three searchers in the area where it had been previously found at the best time of year. This cut-over black spruce habitat, located ½ mile south of the parking area, had grown over and changed substantially. The orchid was not found.

Early Coralroot – Corallorhiza trifida – decline This orchid is widely scattered. A moderate search was done in several areas where it had been seen previously. Fewer plants were found.

Yellow Lady-slipper – Cypripedium calceolus var. parviflorum - decline This previously common orchid was present in many locations. A moderate search revealed that it is now substantially less common.

Showy Lady-slipper – Cypripedium reginae – decline It was present at its favorite location near the parking area. But fewer plants occurred. It had previously been noted in scattered areas at the Fen. Aside from the favored locations, the occurrence of this orchid has become rare.

Pink Lady-slipper – Cypripedium acaule – not observed Many areas were searched for this orchid that was previously moderately common. Its plant leaves are distinctive even when they are small and the plant is not blooming. No evidence of this species was observed.

Liparis Loeselii – Loesel's Twayblade – not observed This orchid had been observed in various locations and in most years. It was moderately uncommon. Some of its best locations were not searched. It was not observed. The Rose Garden area was not searched.

Rattlesnake Plantain Goodyear repens var ophiodes – not observed A narrow ridge just south of the road near the westerly Carney Fen sign was a reliable place for observation of this species for many years. The plant is known to have eruptions at different location. Not all of the potential locations were searched. A very extensive search of the narrow ridge found no plants.

Helleborine Epicactus helleborine – newly discovered Two flowering plants were found along the trail south of the parking area. No other plants were found.

White Adder's-mouth – Malaxis monophylla var brachypoda- decline Two plants were found in the Orbiculata patch. Typically a moderate search would reveal more plants.

Green Adder's-mouth – Malaxis unifolia – not observed Limited occurrences of this species were observed for several years, but not in recent years. A moderate search of appropriate habitat was done.

Of all of the six or seven Platanthera species previously observed at the Fen, my moderate search found only two plants.

Club-spur Orchid – Platanthera clavellata – not observed Only one flowering plant had ever been observed. It was at the edge of the Main Fen many years ago. A moderate search did not uncover this species.

Blunt-leaf Orchid – Platanthera obtusata – **not observed** – In the past this was a relatively common orchid. In some areas it was subject to eruptions but it was also commonly found in many areas with proper habitat. It is notable that a moderate search found no plants.

Large Round-leaved Orchid – Platanthera orbiculata – not observed Observations have only occurred in one site area; the Orbiculata Patch. Several plants were observed on different years. A limited search of this area in the proper season found no plants.

Tall Northern Bog-Orchid – Platanthera hyperborean var hyperborean – major decline –
This orchid was once common along the edge of the Main Fen. It was also scattered throughout many other swamp locations. Only two plants were observed along the old railroad right-of-way south of G-18.

Tall White Bog-Orchid – Platanthera dilatata – not found This orchid was found at the southern end of the Main Fen and once seen at the Rose Garden. Many plants occurred in different years but an extensive search of the Main Fen found no plants.

Rose Pogonia – Pogonia ophioglossoides – not found - I did not search the Rose Garden because it was a long hike. This orchid was once noted at the Orbiculata Patch. This is the one orchid that would be most likely to be found with a more extensive mid-July search.

Dragon's Mouth – Arethusa bulbosa – slight increase – Just to the north of the Main Fen is an area where this orchid has always occurred. It still occurs there is large numbers and has also spread to a slightly larger area.

Grass Pink – **Calopogon tuberosis – unchanged -** This orchid occurs in the same area as Dragon's mouth. At this location the level of occurrence is steady. A much larger occurrence occurred north of Co Rd G-18 where the Shakey River goes through the culvert. At one time thousands of Grass Pink were scattered in that area. I did not search that area of occurrence.

Nodding Ladies Tresses – Spiranthes Cernua – not found - These occurred on a regular basis in the Main Fen. They were not found at other locations. An intense search at the right time of the year found no plants.

Appendix 1, continued. Letter to DNR from Friends of Carney Fen.

Slender Ladies Tresses -Spiranthes Lacera – not found - These occurred on a regular basis in the Main Fen. They were not found at other locations. An intense search at the right time of the year found no plants.

Summary

Overall, the decline in orchid occurrence at the Carney Fen for the year 2020 is estimated to be 70% as compared to the pre-dedication numbers. This is based on a limited to moderate survey of appropriate habitat in appropriate times of the year.

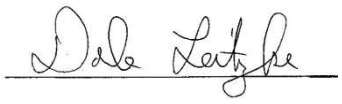
Nine species were found. A photo of the flowering plant of each of these species is on my phone. But I do not have the software necessary to transfer the photos into this report.

Personal speculation regarding the decline

Rainfall in this area has been at or near record highs for the last three years. But the decline in occurrence of Ram's Head started before that (most other species were not observed in years immediately prior to those three years). More mossy areas have an incursion of grasses. The Main Fen now has scattered young white cedar trees.

The Small Round leafed orchid was documented along the railroad right of way many years ago. That orchid was never found by our comprehensive search. Calypso has not been documented for many years. We are beginning to see a long-term pattern of orchid losses. If that pattern continues to be confirmed, it is hard to look past the effects of climate change.

Rainfall increases are certainly a factor to consider. But other factors may also be relevant. Temperature change may be a factor. With a two degree increase in temperature in summer and a five degree increase in winter, it's hard to rule out the effect on sensitive orchids. If today's rainfall is slightly more acidic and sensitive orchids like less acidic, even small changes could be a factor. A 50% increase in the carbon dioxide level in the atmosphere could also increase the level of competition for orchids, for example, grasses may be more competitive. Whatever the cause, decline in the occurrence of orchids at the Carney Fen is disappointing.



Friends of the Carney Fen
8/23/2020

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Appendix 2. List of all orchids that have been observed at Carney Fen

Common Name	Scientific Name	Last Seen	Mentioned in 1985 Report?	Seen in 2021	Habitat
round-leaved orchis	*Amerorchis rotundifolia*	1967?	Yes, not observed since 1967	No	Transition zone near middle fen
dragons mouth	*Arethusa bulbosa*	2021	Yes, throuhout	Yes	
grass-pink	*Calopogon tuberosus*	2021	Yes, throughout	Yes, thousands	Fen and transition zone
calypso	*Calypso bulbosa*	Early 2000s?	No	No	
spotted coral-root	*Corallorhiza maculata*	?	Yes, Throughout	No	
striped coral-root	*Corallorhiza striata*	?	No	No	
early coral-root	*Corallorhiza trifida*	?	Yes	Yes	Transition zone/swamp south of the road
pink lady-slipper	*Cypripedium acaule*	2021	No	Yes	Transition zone north side of road
rams head lady-slipper	*Cypripedium arietinum*	2021	yes	Yes	margins of drumlin, south of road
yellow lady-slipper	*Cypripedium parviflorum*	2021	yes	Yes	both sides of road. Especially along snowmobile trail to wiregrass lake. North of road in transition zone
showy or queens lady-slipper	*Cypripedium reginae*	2021	yes	Yes	Transition zone around northern opening
helleborine	*Epipactis helleborine*	?	No	No	
creeping rattlesnake plantain	*Goodyera repens*	?	yes	No	
loesels twayblade	*Liparis loeselii*	2021	yes	Yes	swamp, near transition zone
white adders-mouth	*Malaxis monophyllos*	?	no	No	
green adders-mouth	*Malaxis unifolia*		no	No	
auricled twayblade	*Neottia auriculata*	?	Yes	No	
heartleaf twayblade	*Neottia cordata*	?	Yes	No	
northern green orchid	*Platanthera aquilonis*	?	Yes, throughout	No	
small green wood orchid	*Platanthera clavellata*	?	No	No	margins of central opening
tall white bog orchid	*Platanthera dilatata*	?	Yes, 1 station	No	
green-fringed orchid	*Platanthera lacera*	?	Yes, throughout	No	
blunt-leaved orchid	*Platanthera obtusata*	?	Yes, throughout	No	
round-leaved orchid	*Platanthera orbiculata*	?	No	No	
purple fringed orchid	*Platanthera psycodes*	?	Yes, throughout	No	
rose pogonia	*Pogonia ophioglossoides*	2021	No	Yes	Infrequent in transition zone north of road
nodding ladies-tresses	*Spiranthes cernua*	?	Yes, throughout	No	
slender ladies-tresses	*Spiranthes lacera*	?	No	No	
cranefly orchid	*Tipularia discolor*	?	Yes, lists as unlikely	No	

Appendix 3. Location of species within the fen.

Scientific Name	Dale Litzke's 2020 Notes	Notes
Amerorchis rotundifolia		main fen, tamrack savanna, transition zone east of fen
Arethusa bulbosa	slight increase	
Calopogon tuberosus	unchanged, just ro the north of main fen. Larger concentration north of road	
Calypso bulbosa	"Rose Garden" north of road	
Corallorhiza maculata		
Corallorhiza striata		
Corallorhiza trifida	decline	patchy and mobile…
Cypripedium acaule	not observed	
Cypripedium arietinum	75% decline	
Cypripedium parviflorum	decline, common to rare	both sides of road. Especially along snowmobile trail to wiregrass lake. North of road in transition zone
Cypripedium reginae		
Epipactis helleborine	newly discovered	
Goodyera repens	not observed	likely increasing in abundance across range
Liparis loeselii	not observed	infrequent
Malaxis monophyllos	decline	
Malaxis unifolia	not observed in recent years	
Neottia auriculata		Unlikely! (1985 MNFI report)
Neottia cordata	decline	
Platanthera aquilonis	major decline, once common along edge of main fen and scattered throuhout swamp	
Platanthera clavellata	not observed; only one stalk had ever been found. At the edge of main fen many years ago	
Platanthera dilatata	not found; historically at southern end of main fen and once seen at rose garden	
Platanthera lacera	not found, 1/2 mile south of parking area	
Platanthera obtusata	not observe, common in the past.	
Platanthera orbiculata	not observed. Found only in one site north of road	
Platanthera psycodes		
Pogonia ophioglossoides	not found	
Spiranthes cernua	not found, occurred on a regular basis in the main fen and not at other locations	
Spiranthes lacera	not found. Occurred on a regular basis in main fen. Not found at other locations	
Tipularia discolor		Very unlikely (1985 MNFI report)

Appendix 4. Notes on mosses from Keir Wefferling.

Sphagnum wulfianum ("in Thuja swamps"), Sphagnum girgensonii ("in Thuja swamps; mesotrophic to eutrophic""), Sphagnum warnstorfii (? "a calciphile, common in rich fens and Thuja swamps"), Hylocomium splendens, Conocephalum salebrosum (thalloid liverwort), Bazzania trilobata (leafy liverwort). Hematocaulis vernicosus ("on wet soil or humus in calcareous fens"), Scorpidium scorpioides ("a calciphile, in shallow water and often submerged among sedges at the margins of pools in rich fens or swales"), Campylium stellatum (?), Sphagnum fallax (very common, in mesotrophic habitats, especially in the hollows of open mats or heaths or in the transition between bog and bog forest"), Sphagnum capillifolium ("very common, in open or shady, acid situations"), Sphagnum fuscum ("capping hummocks in older, drier, more acid parts of open bogs; distinctly oligotrophic"), Sphagnum magellanicum ("relatively oligotrophic"), S. warnstorfii ("a calciphile, common in rich fens and Thuja swamps").

Appendix 5. Tree size and age of specimens in Carney Swamp.

Species	Diameter (cm)	Age
Black ash	24.4	126
White cedar	16.5	82
White cedar	28.4	101
White cedar	30.7	93
White pine	47.0	82
White spruce	20.8	72

Appendix 6. Conservation metrics for Carney Fen, Northern Opening.

Carney Fen, North of Road 06/30/2021
Practitioner: Jesse M. Lincoln

Conservatism-Based Metrics:

Total Mean C:	6
Native Mean C:	6.1
Total FQI:	48.4
Native FQI:	48.8
Adjusted FQI:	60.5
% C value 0:	1.5
% C value 1-3:	13.8
% C value 4-6:	44.6
% C value 7-10:	40
Native Tree Mean C:	5
Native Shrub Mean C:	5.9
Native Herbaceous Mean C:	6.3

Species Richness:

Total Species:	65	
Native Species:	64	98.5%
Non-native Species:	1	1.5%

Species Wetness:

Mean Wetness:	-3.4
Native Mean Wetness:	-3.4

Physiognomy Metrics:

Tree:	3	4.6%
Shrub:	17	26.2%
Vine:	0	0.0%
Forb:	22	33.8%
Grass:	7	10.8%
Sedge:	11	16.9%
Rush:	0	0.0%
Fern:	5	7.7%
Bryophyte:	0	0.0%

Duration Metrics:

Annual:	0	0.0%
Perennial:	64	98.5%
Biennial:	1	1.5%
Native Annual:	0	0.0%
Native Perennial:	64	98.5%
Native Biennial:	0	0.0%

Appendix 7. Species list for Carney Fen, Northern Opening.

Common Name	Scientific Name	Acronym	Native?	C	W
speckled alder	Alnus incana; a. rugosa	ALNINC	native	5	-3
bog-rosemary	Andromeda glaucophylla	ANDGLA	native	10	-5
chokeberry	Aronia prunifolia	AROPRU	native	5	-3
bog birch	Betula pumila	BETPUM	native	8	-5
blue-joint	Calamagrostis canadensis	CALCAN	native	3	-5
wild calla	Calla palustris	CALPAU	native	10	-5
grass-pink	Calopogon tuberosus	CALTUB	native	9	-5
marsh-marigold	Caltha palustris	CALPAR	native	6	-5
sedge	Carex aurea	CXAURE	native	3	-3
sedge	Carex diandra	CXDIAN	native	8	-5
sedge	Carex disperma	CXDISP	native	10	-5
sedge	Carex interior	CXINTE	native	3	-5
sedge	Carex lasiocarpa	CXLASI	native	8	-5
sedge	Carex leptalea	CXLEPA	native	5	-5
sedge	Carex oligosperma	CXOLIS	native	10	-5
sedge	Carex pseudo-cyperus	CXPSEU	native	5	-5
sedge	Carex stricta	CXSTRI	native	4	-5
leatherleaf	Chamaedaphne calyculata	CHACAL	native	8	-5
wood reedgrass	Cinna latifolia	CINLAT	native	5	-3
marsh thistle	**Cirsium palustre**	**CIRPAL**	**non-native**	**0**	**-3**
marsh cinquefoil	Comarum palustre	COMPAL	native	7	-5
silky dogwood	Cornus amomum	CORAMO	native	2	-3
bunchberry	Cornus canadensis	CORCAA	native	6	0
pink lady-slipper	Cypripedium acaule	CYPACA	native	5	-3
yellow lady-slipper	Cypripedium parviflorum	CYPPAR	native	5	0
crested shield fern	Dryopteris cristata	DRYCRI	native	6	-5
slender wheatgrass	Elymus trachycaulus	ELYTRA	native	8	3
water horsetail	Equisetum fluviatile	EQUFLU	native	7	-5
green-keeled cotton-grass	Eriophorum viridi-carinatum	ERIVID	native	8	-5
wintergreen	Gaultheria procumbens	GAUPRO	native	5	3
fowl manna grass	Glyceria striata	GLYSTR	native	4	-5
tamarack	Larix laricina	LARLAR	native	5	-3
canadian fly honeysuckle	Lonicera canadensis	LONCAN	native	5	3
mountain fly honeysuckle	Lonicera villosa	LONVIL	native	8	-3
tufted loosestrife	Lysimachia thyrsiflora	LYSTHY	native	6	-5
canada mayflower	Maianthemum canadense	MAICAN	native	4	3
false mayflower	Maianthemum trifolium	MAITRI	native	10	-5
buckbean	Menyanthes trifoliata	MENTRI	native	8	-5
bishops-cap	Mitella diphylla	MITDIP	native	8	3
sweet gale	Myrica gale	MYRGAL	native	6	-5
sensitive fern	Onoclea sensibilis	ONOSEN	native	2	-3
royal fern	Osmunda regalis	OSMREG	native	5	-5
reed	Phragmites australis var. americanus	PHRAUM	native	5	-3
black spruce	Picea mariana	PICMAR	native	6	-3
fowl meadow grass	Poa palustris	POAPAS	native	3	-3
rose pogonia	Pogonia ophioglossoides	POGOPH	native	10	-5
pink pyrola	Pyrola asarifolia	PYRASA	native	8	-3
alder-leaved buckthorn	Rhamnus alnifolia	RHAALN	native	8	-5
labrador-tea	Rhododendron groenlandicum	RHOGRO	native	8	-5
dwarf raspberry	Rubus pubescens	RUBPUB	native	4	-3
great water dock	Rumex orbiculatus	RUMORB	native	9	-5
slender willow	Salix petiolaris	SALPET	native	1	-3
pitcher-plant	Sarracenia purpurea	SARPUR	native	10	-5
bog goldenrod	Solidago uliginosa	SOLULI	native	4	-5

Appendix 7, continued. Species list for Carney Fen, Northern Opening.

Common Name	Scientific Name	Acronym	Native?	C	W
slender wedgegrass	Sphenopholis intermedia	SPHINT	native	4	0
marsh fern	Thelypteris palustris	THEPAL	native	2	-3
arbor vitae	Thuja occidentalis	THUOCC	native	4	-3
bulrush	Trichophorum alpinum	TRIALP	native	10	-5
star-flower	Trientalis borealis	TRIBOR	native	5	0
broad-leaved cat-tail	Typha latifolia	TYPLAT	native	1	-5
common bladderwort	Utricularia vulgaris	UTRVUL	native	6	-5
low sweet blueberry	Vaccinium angustifolium	VACANG	native	4	3
small cranberry	Vaccinium oxycoccos	VACOXY	native	8	-5
swamp valerian	Valeriana uliginosa	VALULI	native	10	-5
kidney-leaved violet	Viola renifolia	VIOREN	native	6	-3

Appendix 8. Conservation Metrics for Carney Fen, Central Opening.

Carney Fen, Central Opening 06/30/2021
Practitioner: Jesse M. Lincoln

Conservatism-Based Metrics:

Total Mean C:	5.9
Native Mean C:	6.1
Total FQI:	40.4
Native FQI:	41.4
Adjusted FQI:	60.3
% C value 0:	2.1
% C value 1-3:	21.3
% C value 4-6:	34
% C value 7-10:	42.6
Native Tree Mean C:	3.7
Native Shrub Mean C:	6.8
Native Herbaceous Mean C:	6.2

Physiognomy Metrics:

Tree:	6	12.80%
Shrub:	14	29.80%
Vine:	0	0%
Forb:	12	25.50%
Grass:	3	6.40%
Sedge:	11	23.40%
Rush:	0	0%
Fern:	1	2.10%
Bryophyte:	0	0%

Species Richness:

Total Species:	47	
Native Species:	46	97.90%
Non-native Species:	1	2.10%

Duration Metrics:

Annual:	0	0%
Perennial:	46	97.90%
Biennial:	1	2.10%
Native Annual:	0	0%
Native Perennial:	46	97.90%
Native Biennial:	0	0%

Species Wetness:

Mean Wetness:	-3.5
Native Mean Wetness:	-3.5

Appendix 9. Species list for Carney Fen, Central Opening.

Common Name	Scientific Name	Acronym	Native?	C	W
balsam fir	*Abies balsamea*	ABIBAL	native	3	0
red maple	*Acer rubrum*	ACERUB	native	1	0
bog-rosemary	*Andromeda glaucophylla*	ANDGLA	native	10	-5
dragons mouth	*Arethusa bulbosa*	AREBUL	native	10	-5
swamp milkweed	*Asclepias incarnata*	ASCINC	native	6	-5
bog birch	*Betula pumila*	BETPUM	native	8	-5
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
grass-pink	*Calopogon tuberosus*	CALTUB	native	9	-5
sedge	*Carex flava*	CXFLAV	native	4	-5
sedge	*Carex interior*	CXINTE	native	3	-5
sedge	*Carex lasiocarpa*	CXLASI	native	8	-5
sedge	*Carex oligosperma*	CXOLIS	native	10	-5
sedge	*Carex sterilis*	CXSTER	native	10	-5
sedge	*Carex stricta*	CXSTRI	native	4	-5
marsh thistle	***Cirsium palustre***	**CIRPAL**	**non-native**	**0**	**-3**
silky dogwood	*Cornus amomum*	CORAMO	native	2	-3
bunchberry	*Cornus canadensis*	CORCAA	native	6	0
yellow lady-slipper	*Cypripedium parviflorum*	CYPPAR	native	5	0
shrubby cinquefoil	*Dasiphora fruticosa*	DASFRU	native	8	-3
golden-seeded spike rush	*Eleocharis elliptica*	ELEELL	native	6	-5
green-keeled cotton-grass	*Eriophorum viridi-carinatum*	ERIVID	native	8	-5
wintergreen	*Gaultheria procumbens*	GAUPRO	native	5	3
fowl manna grass	*Glyceria striata*	GLYSTR	native	4	-5
bog-laurel	*Kalmia polifolia*	KALPOL	native	10	-5
tamarack	*Larix laricina*	LARLAR	native	5	-3
mountain fly honeysuckle	*Lonicera villosa*	LONVIL	native	8	-3
leafy satin grass	*Muhlenbergia mexicana*	MUHMEX	native	3	-3
sweet gale	*Myrica gale*	MYRGAL	native	6	-5
grass-of-parnassus	*Parnassia glauca*	PARGLA	native	8	-5
black spruce	*Picea mariana*	PICMAR	native	6	-3
white pine	*Pinus strobus*	PINSTR	native	3	3
alder-leaved buckthorn	*Rhamnus alnifolia*	RHAALN	native	8	-5
labrador-tea	*Rhododendron groenlandicum*	RHOGRO	native	8	-5
beak-rush	*Rhynchospora capillacea*	RHYCAL	native	10	-5
dwarf raspberry	*Rubus pubescens*	RUBPUB	native	4	-3
pitcher-plant	*Sarracenia purpurea*	SARPUR	native	10	-5
hardstem bulrush	*Schoenoplectus acutus*	SCHACU	native	5	-5
canada goldenrod	*Solidago canadensis*	SOLCAN	native	1	3
bog goldenrod	*Solidago uliginosa*	SOLULI	native	4	-5
marsh fern	*Thelypteris palustris*	THEPAL	native	2	-3
arbor vitae	*Thuja occidentalis*	THUOCC	native	4	-3
bulrush	*Trichophorum alpinum*	TRIALP	native	10	-5
common bog arrow-grass	*Triglochin maritima*	TRIMAR	native	8	-5
broad-leaved cat-tail	*Typha latifolia*	TYPLAT	native	1	-5
low sweet blueberry	*Vaccinium angustifolium*	VACANG	native	4	3
small cranberry	*Vaccinium oxycoccos*	VACOXY	native	8	-5
swamp valerian	*Valeriana uliginosa*	VALULI	native	10	-5

Appendix 10. Conservation Metrics for Carney Fen, Wiregrass Lake.

Carney Fen, Wire Grass Lake 06/30/2021
Practitioner: Jesse M. Lincoln

Conservatism-Based Metrics:

Total Mean C:	6.4
Native Mean C:	6.4
Total FQI:	27.9
Native FQI:	27.9
Adjusted FQI:	64
% C value 0:	0
% C value 1-3:	15.8
% C value 4-6:	31.6
% C value 7-10:	52.6
Native Tree Mean C:	5
Native Shrub Mean C:	7.7
Native Herbaceous Mean C:	5.6

Physiognomy Metrics:

Tree:	1	5.30%
Shrub:	7	36.80%
Vine:	0	0%
Forb:	5	26.30%
Grass:	1	5.30%
Sedge:	5	26.30%
Rush:	0	0%
Fern:	0	0%
Bryophyte:	0	0%

Species Richness:

Total Species:	19	
Native Species:	19	100%
Non-native Species:	0	0%

Duration Metrics:

Annual:	1	5.30%
Perennial:	18	94.70%
Biennial:	0	0%
Native Annual:	1	5.30%
Native Perennial:	18	94.70%
Native Biennial:	0	0%

Species Wetness:

Mean Wetness:	-4.7
Native Mean Wetness:	-4.7

Appendix 11. Species list for Carney Fen, Wiregrass Lake.

Common Name	Scientific Name	Acronym	Native?	C	W
speckled alder	*Alnus incana*	ALNINC	native	5	-3
bog-rosemary	*Andromeda glaucophylla*	ANDGLA	native	10	-5
bog birch	*Betula pumila*	BETPUM	native	8	-5
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
sedge	*Carex lasiocarpa*	CXLASI	native	8	-5
sedge	*Carex oligosperma*	CXOLIS	native	10	-5
sedge	*Carex stricta*	CXSTRI	native	4	-5
leatherleaf	*Chamaedaphne calyculata*	CHACAL	native	8	-5
marsh cinquefoil	*Comarum palustre*	COMPAL	native	7	-5
shrubby cinquefoil	*Dasiphora fruticosa*	DASFRU	native	8	-3
spike-rush	*Eleocharis obtusa*	ELEOBT	native	3	-5
bog bedstraw	*Galium labradoricum*	GALLAB	native	8	-5
tamarack	*Larix laricina*	LARLAR	native	5	-3
sweet gale	*Myrica gale*	MYRGAL	native	6	-5
yellow pond-lily	*Nuphar variegata*	NUPVAR	native	7	-5
sweet-scented waterlily	*Nymphaea odorata*	NYMODO	native	6	-5
hoary willow	*Salix candida*	SALCAN	native	9	-5
hardstem bulrush	*Schoenoplectus acutus*	SCHACU	native	5	-5
marsh fern	*Thelypteris palustris*	THEPAL	native	2	-3
broad-leaved cat-tail	*Typha latifolia*	TYPLAT	native	1	-5

Appendix 12. 2007 Species list for Carney Fen. Compiled by Bradford Slaughter.

COMMON NAME	SCIENTIFIC NAME	ACRONYM	C	W
RED MAPLE	*Acer rubrum*	ACERUB	1	0
TAG ALDER	*Alnus rugosa*	ALNRUG	5	-5
BOG ROSEMARY	*Andromeda glaucophylla*	ANDGLA	10	-5
WILD SARSAPARILLA	*Aralia nudicaulis*	ARANUD	5	3
BLACK CHOKEBERRY	*Aronia prunifolia*	AROPRU	5	-3
EASTERN LINED ASTER	*Aster lanceolatus*	ASTLAN	2	-3
SWAMP ASTER	*Aster puniceus*	ASTPUN	5	-5
TALL FLAT TOP WHITE ASTER	*Aster umbellatus*	ASTUMB	5	-3
BOG BIRCH	*Betula pumila*	BETPUM	8	-5
FRINGED BROME	*Bromus ciliatus*	BROCIL	6	-3
BLUE JOINT GRASS	*Calamagrostis canadensis*	CALCAN	3	-5
BOG REEDGRASS	*Calamagrostis inexpansa*	CALINE	8	-4
GRASS PINK	*Calopogon tuberosus*	CALTUB	9	-5
MARSH MARIGOLD	*Caltha palustris*	CALTPA	6	-5
MARSH BELLFLOWER	*Campanula aparinoides*	CAMAPR	7	-5
SEDGE	*Carex disperma*	CXDISP	10	-5
SEDGE	*Carex flava*	CXFLAV	4	-5
SEDGE	*Carex hystericina*	CXHYST	2	-5
SEDGE	*Carex interior*	CXINTE	3	-5
SEDGE	*Carex lasiocarpa*	CXLASI	8	-5
SEDGE	*Carex leptalea*	CXLEPA	5	-5
BOG SEDGE	*Carex limosa*	CXLIMO	10	-5
SEDGE	*Carex sterilis*	CXSTER	10	-5
SEDGE	*Carex stricta*	CXSTRI	4	-5
LEATHERLEAF	*Chamaedaphne calyculata*	CHACAL	8	-5
TURTLEHEAD	*Chelone glabra*	CHEGLB	7	-5
WATER HEMLOCK	*Cicuta bulbifera*	CICBUL	5	-5
SWAMP THISTLE	*Cirsium muticum*	CIRMUT	6	-5
MARSH THISTLE	*CIRSIUM PALUSTRE*	CIRPAL	0	-4
TWIG RUSH	*Cladium mariscoides*	CLAMAR	10	-5
GOLDTHREAD	*Coptis trifolia*	COPTRI	5	-3
BUNCHBERRY	*Cornus canadensis*	CORCAA	6	0
RED OSIER DOGWOOD	*Cornus stolonifera*	CORSTO	2	-3
RAM'S HEAD LADY'S SLIPPER	*Cypripedium arietinum*	CYPARI	10	-4
SMALL YELLOW LADY'S SLIPPER	*Cypripedium calceolus var. parviflorum*	CYCAPA	7	-1
LARGE YELLOW LADY'S SLIPPER	*Cypripedium calceolus var. pubescens*	CYCAPU	5	-1
ROUND LEAVED SUNDEW	*Drosera rotundifolia*	DROROT	6	-5
THREE WAY SEDGE	*Dulichium arundinaceum*	DULARU	8	-5
GOLDEN SEEDED SPIKE RUSH	*Eleocharis elliptica*	ELEELL	6	-3
WATER HORSETAIL	*Equisetum fluviatile*	EQUFLU	7	-5
GREEN KEELED COTTON GRASS	*Eriophorum viridi-carinatum*	ERIVID	8	-5
COMMON BONESET	*Eupatorium perfoliatum*	EUPPER	4	-4
WILD STRAWBERRY	*Fragaria virginiana*	FRAVIR	2	1
SMALL BEDSTRAW	*Galium trifidum*	GALTRD	6	-4
CREEPING SNOWBERRY	*Gaultheria hispidula*	GAUHIS	8	-3
WINTERGREEN	*Gaultheria procumbens*	GAUPRO	5	3
YELLOW AVENS	*Geum aleppicum*	GEUALE	3	-1
FOWL MANNA GRASS	*Glyceria striata*	GLYSTR	4	-5
SPOTTED TOUCH ME NOT	*Impatiens capensis*	IMPCAP	2	-3
TAMARACK	*Larix laricina*	LARLAR	5	-3
LABRADOR TEA	*Ledum groenlandicum*	LEDGRO	8	-5
TWINFLOWER	*Linnaea borealis*	LINBOR	6	0
LOESEL'S TWAYBLADE	*Liparis loeselii*	LIPLOE	5	-4
BOG LOBELIA	*Lobelia kalmii*	LOBKAL	10	-5

Appendix 12, continued. 2007 Species list for Carney Fen. Compiled by Bradford Slaughter.

COMMON NAME	SCIENTIFIC NAME	ACRONYM	C	W
RED HONEYSUCKLE	*Lonicera dioica*	LONDIO	5	3
FLY HONEYSUCKLE	*Lonicera villosa*	LONVIL	8	-3
NORTHERN BUGLE WEED	*Lycopus uniflorus*	LYCUNI	2	-5
TUFTED LOOSESTRIFE	*Lysimachia thyrsiflora*	LYSTHY	6	-5
CANADA MAYFLOWER	*Maianthemum canadense*	MAICAC	4	0
BUCKBEAN	*Menyanthes trifoliata*	MENTRI	8	-5
MARSH WILD TIMOTHY	*Muhlenbergia glomerata*	MUHGLO	10	-4
SWEET GALE	*Myrica gale*	MYRGAL	6	-5
YELLOW POND LILY	*Nuphar variegata*	NUPVAR	7	-5
SENSITIVE FERN	*Onoclea sensibilis*	ONOSEN	2	-3
CINNAMON FERN	*Osmunda cinnamomea*	OSMCIN	5	-3
GRASS OF PARNASSUS	*Parnassia glauca*	PARGLA	8	-5
REED CANARY GRASS	*Phalaris arundinacea*	PHAARU	0	-4
REED	*Phragmites australis*	PHRAUS	0	-4
BLACK SPRUCE	*Picea mariana*	PICMAR	6	-3
WHITE PINE	*Pinus strobus*	PINSTR	3	3
TALL WHITE BOG ORCHID	*Platanthera dilatata*	PLADIL	10	-3
TALL NORTHERN BOG ORCHID	*Platanthera hyperborea*	PLAHYP	5	-4
FOWL MEADOW GRASS	*Poa palustris*	POAPAS	3	-4
SHRUBBY CINQUEFOIL	*Potentilla fruticosa*	POTFRU	10	-3
MARSH CINQUEFOIL	*Potentilla palustris*	POTPAL	7	-5
PINK PYROLA	*Pyrola asarifolia*	PYRASA	8	-3
ROUND LEAVED PYROLA	*Pyrola rotundifolia*	PYRROT	7	1
ALDER LEAVED BUCKTHORN	*Rhamnus alnifolia*	RHAALN	8	-5
BEAK RUSH	*Rhynchospora alba*	RHYALB	6	-5
BEAK RUSH	*Rhynchospora capillacea*	RHYCAL	10	-5
DWARF RASPBERRY	*Rubus pubescens*	RUBPUB	4	-4
WILD RED RASPBERRY	*Rubus strigosus*	RUBSTR	2	-2
COMMON ARROWHEAD	*Sagittaria latifolia*	SAGLAT	1	-5
HOARY WILLOW	*Salix candida*	SALCAN	9	-5
SLENDER WILLOW	*Salix petiolaris*	SALPET	1	-4
PITCHER PLANT	*Sarracenia purpurea*	SARPUP	10	-5
HARDSTEM BULRUSH	*Schoenoplectus acutus*	SCHACU	5	-5
WOOL GRASS	*Scirpus cyperinus*	SCICYP	5	-5
FALSE MAYFLOWER	*Smilacina trifolia*	SMITRI	10	-5
BOG GOLDENROD	*Solidago uliginosa*	SOLULI	4	-5
MEADOWSWEET	*Spiraea alba*	SPIALB	4	-4
NODDING LADIES' TRESSES	*Spiranthes cernua*	SPICER	4	-2
MARSH FERN	*Thelypteris palustris*	THEPAL	2	-4
ARBOR VITAE	*Thuja occidentalis*	THUOCC	4	-3
MARSH ST. JOHN'S WORT	*Triadenum fraseri*	TRIFRA	6	-5
BULRUSH	*Trichophorum alpinum*	TRIALP	10	-5
BULRUSH	*Trichophorum cespitosum*	TRICES	10	-5
STARFLOWER	*Trientalis borealis*	TRIBOR	5	-1
COMMON BOG ARROW GRASS	*Triglochin maritimum*	TRIMAR	8	-5
BROAD LEAVED CATTAIL	*Typha latifolia*	TYPLAT	1	-5
LARGE CRANBERRY	*Vaccinium macrocarpon*	VACMAC	8	-5
CANADA BLUEBERRY	*Vaccinium myrtilloides*	VACMYR	4	-2
SMALL CRANBERRY	*Vaccinium oxycoccos*	VACOXY	8	-5
BOG VALERIAN	*Valeriana uliginosa*	VALULI	10	-4
KIDNEY LEAVED VIOLET	*Viola renifolia*	VIOREN	6	-3

Appendix 13. Conservation Metrics from 2007 Species list for Carney Fen. Compiled by Bradford Slaughter.

FLORISTIC QUALITY DATA

NATIVE SPECIES	104
Total Species	105
NATIVE MEAN C	5.9
W/Adventives	5.8
NATIVE FQI	59.8
W/Adventives	59.5
NATIVE MEAN W	-3.6
W/Adventives	-3.6
Fac. Wetland (+)	AVG:

Native	104	99.0%
Tree	5	4.8%
Shrub	21	20.0%
W-Vine	1	1.0%
H-Vine	0	0.0%
P-Forb	44	41.9%
B-Forb	1	1.0%
A-Forb	1	1.0%
P-Grass	8	7.6%
A-Grass	0	0.0%
P-Sedge	19	18.1%
A-Sedge	0	0.0%
Fern	4	3.8%

Adventive	1	1%
Tree	0	0%
Shrub	0	0%
W-Vine	0	0%
H-Vine	0	0%
P-Forb	0	0%
B-Forb	1	1%
A-Forb	0	0%
P-Grass	0	0%
A-Grass	0	0%
P-Sedge	0	0%
A-Sedge	0	0%

Appendix 14. Conservation Metrics for Carney Swamp.

Rich Conifer Swamp at Carney Fen
Practitioner: Jesse M. Lincoln 07/02/2021

Conservatism-Based Metrics:

Total Mean C:	5.3
Native Mean C:	5.6
Total FQI:	52.5
Native FQI:	54.3
Adjusted FQI:	54.8
% C value 0:	5.1
% C value 1-3:	16.3
% C value 4-6:	51
% C value 7-10:	27.6
Native Tree Mean C:	3.8
Native Shrub Mean C:	5.8
Native Herbaceous Mean C:	5.7

Physiognomy Metrics:

Tree:	8	8.20%
Shrub:	15	15.30%
Vine:	0	0%
Forb:	40	40.80%
Grass:	8	8.20%
Sedge:	13	13.30%
Rush:	1	1%
Fern:	13	13.30%
Bryophyte:	0	0%

Species Richness:

Total Species:	98	
Native Species:	94	95.90%
Non-native Species:	4	4.10%

Duration Metrics:

Annual:	1	1%
Perennial:	96	98%
Biennial:	1	1%
Native Annual:	1	1%
Native Perennial:	93	94.90%
Native Biennial:	0	0%

Species Wetness:

Mean Wetness:	-1.7
Native Mean Wetness:	-1.9

Appendix 15. Species for Carney Swamp.

Common Name	Scientific Name	Acronym	Native?	C	W
balsam fir	*Abies balsamea*	ABIBAL	native	3	0
red maple	*Acer rubrum*	ACERUB	native	1	0
maidenhair fern	*Adiantum pedatum*	ADIPED	native	6	3
speckled alder	*Alnus incana; a. rugosa*	ALNINC	native	5	-3
bog-rosemary	*Andromeda glaucophylla*	ANDGLA	native	10	-5
wild sarsaparilla	*Aralia nudicaulis*	ARANUD	native	5	3
dragons mouth	*Arethusa bulbosa*	AREBUL	native	10	-5
swamp milkweed	*Asclepias incarnata*	ASCINC	native	6	-5
bog birch	*Betula pumila*	BETPUM	native	8	-5
rattlesnake fern	*Botrypus virginianus*	BOTVIR	native	5	3
northern shorthusk	*Brachyelytrum aristosum*	BRAARI	native	7	5
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
grass-pink	*Calopogon tuberosus*	CALTUB	native	9	-5
marsh-marigold	*Caltha palustris*	CALPAR	native	6	-5
sedge	*Carex arctata*	CXARTT	native	3	5
sedge	*Carex aurea*	CXAURE	native	3	-3
sedge	*Carex disperma*	CXDISP	native	10	-5
sedge	*Carex eburnea*	CXEBUR	native	7	3
sedge	*Carex interior*	CXINTE	native	3	-5
sedge	*Carex leptalea*	CXLEPA	native	5	-5
sedge	*Carex magellanica*	CXMAGE	native	8	-5
sedge	*Carex pseudo-cyperus*	CXPSEU	native	5	-5
sedge	*Carex stricta*	CXSTRI	native	4	-5
sedge	*Carex trisperma*	CXTRIS	native	9	-5
turtlehead	*Chelone glabra*	CHEGLB	native	7	-5
water hemlock	*Cicuta bulbifera*	CICBUL	native	5	-5
wood reedgrass	*Cinna latifolia*	CINLAT	native	5	-3
small enchanters-nightshade	*Circaea alpina*	CIRALP	native	4	-3
marsh thistle	***Cirsium palustre***	**CIRPAL**	**non-native**	**0**	**-3**
bluebead-lily; corn-lily	*Clintonia borealis*	CLIBOR	native	5	0
goldthread	*Coptis trifolia*	COPTRI	native	5	-3
early coral-root	*Corallorhiza trifida*	CORTRF	native	6	-3
silky dogwood	*Cornus amomum*	CORAMO	native	2	-3
bunchberry	*Cornus canadensis*	CORCAA	native	6	0
beaked hazelnut	*Corylus cornuta*	CORCOR	native	5	3
pink lady-slipper	*Cypripedium acaule*	CYPACA	native	5	-3
yellow lady-slipper	*Cypripedium parviflorum*	CYPPAR	native	5	0
showy lady-slipper	*Cypripedium reginae*	CYPREG	native	9	-3
ground-cedar	*Diphasiastrum digitatum*	DIPDIG	native	3	5
round-leaved sundew	*Drosera rotundifolia*	DROROT	native	6	-5
crested shield fern	*Dryopteris cristata*	DRYCRI	native	6	-5
slender wheatgrass	*Elymus trachycaulus*	ELYTRA	native	8	3
water horsetail	*Equisetum fluviatile*	EQUFLU	native	7	-5
dwarf scouring rush	*Equisetum scirpoides*	EQUSCI	native	7	0
green-keeled cotton-grass	*Eriophorum viridi-carinatum*	ERIVID	native	8	-5
wild strawberry	*Fragaria virginiana*	FRAVIR	native	2	3
black ash	*Fraxinus nigra*	FRANIG	native	6	-3
red ash	*Fraxinus pennsylvanica*	FRAPEN	native	2	-3
small bedstraw	*Galium trifidum*	GALTRD	native	6	-3
fragrant bedstraw	*Galium triflorum*	GALTRR	native	4	3
creeping-snowberry	*Gaultheria hispidula*	GAUHIS	native	8	-3
wintergreen	*Gaultheria procumbens*	GAUPRO	native	5	3
fowl manna grass	*Glyceria striata*	GLYSTR	native	4	-5
oak fern	*Gymnocarpium dryopteris*	GYMDRY	native	5	3

Appendix 15, continued. Species for Carney Swamp.

Common Name	Scientific Name	Acronym	Native?	C	W
orange hawkweed	***Hieracium aurantiacum***	**HIEAUR**	**non-native**	**0**	**5**
european hawkweed	***Hieracium lachenalii***	**HIELAC**	**non-native**	**0**	**5**
spotted touch-me-not	*Impatiens capensis*	IMPCAP	native	2	-3
tamarack	*Larix laricina*	LARLAR	native	5	-3
twinflower	*Linnaea borealis*	LINBOR	native	6	0
loesels twayblade	*Liparis loeselii*	LIPLOE	native	5	-3
canadian fly honeysuckle	*Lonicera canadensis*	LONCAN	native	5	3
common wood rush	*Luzula multiflora*	LUZMUL	native	5	3
running ground-pine	*Lycopodium clavatum*	LYCCLA	native	4	0
fringed loosestrife	*Lysimachia ciliata*	LYSCIL	native	4	-3
canada mayflower	*Maianthemum canadense*	MAICAN	native	4	3
false mayflower	*Maianthemum trifolium*	MAITRI	native	10	-5
naked miterwort	*Mitella nuda*	MITNUD	native	8	-3
sweet gale	*Myrica gale*	MYRGAL	native	6	-5
sensitive fern	*Onoclea sensibilis*	ONOSEN	native	2	-3
cinnamon fern	*Osmunda cinnamomea*	OSMCIN	native	5	-3
royal fern	*Osmunda regalis*	OSMREG	native	5	-5
water smartweed	*Persicaria amphibia*	PERAMP	native	6	-5
reed canary grass	***Phalaris arundinacea***	**PHAARU**	**non-native**	**0**	**-3**
black spruce	*Picea mariana*	PICMAR	native	6	-3
white pine	*Pinus strobus*	PINSTR	native	3	3
fowl meadow grass	*Poa palustris*	POAPAS	native	3	-3
rose pogonia	*Pogonia ophioglossoides*	POGOPH	native	10	-5
gay-wings	*Polygala paucifolia*	POLPAU	native	7	3
white lettuce	*Prenanthes alba*	PREALB	native	5	3
pink pyrola	*Pyrola asarifolia*	PYRASA	native	8	-3
tall or common buttercup	***Ranunculus acris***	**RANACR**	**non-native**	**0**	**0**
labrador-tea	*Rhododendron groenlandicum*	RHOGRO	native	8	-5
swamp dewberry	*Rubus hispidus*	RUBHIS	native	4	-3
great water dock	*Rumex orbiculatus*	RUMORB	native	9	-5
pitcher-plant	*Sarracenia purpurea*	SARPUR	native	10	-5
false melic	*Schizachne purpurascens*	SCHPUP	native	5	3
bulrush	*Scirpus atrovirens*	SCIATV	native	3	-5
soapberry	*Shepherdia canadensis*	SHECAN	native	7	5
stiff clubmoss	*Spinulum annotinum*	SPIANN	native	5	0
swamp aster	*Symphyotrichum puniceum*	SYMPUN	native	5	-5
marsh fern	*Thelypteris palustris*	THEPAL	native	2	-3
arbor vitae	*Thuja occidentalis*	THUOCC	native	4	-3
bulrush	*Trichophorum alpinum*	TRIALP	native	10	-5
star-flower	*Trientalis borealis*	TRIBOR	native	5	0
low sweet blueberry	*Vaccinium angustifolium*	VACANG	native	4	3
canada blueberry	*Vaccinium myrtilloides*	VACMYR	native	4	-3
swamp valerian	*Valeriana uliginosa*	VALULI	native	10	-5
kidney-leaved violet	*Viola renifolia*	VIOREN	native	6	-3

Appendix 16. An example of a possible data sheet for orchid population monitoring. Ideally this would be a digital form, entered into a program such as Survey123. Historic surveys could be entered in this form to take advantage of old data. Surveys should be organized by survey site, therefore developing agreed upon names for specific locations is critical.

Observer:	Date:
Species:	
Location Description:	GPS Coordinates:
Habitat Description:	Canopy coverage
Number of Clumps	
Number of Stems	
Number of Flowering Stems	
Non-Flowering Individuals	
Number of Successfully Pollinated Flowers	
Signs of Deer Herbivory?	
Species showing herbivory?	
Invasive Species Present:	
Notes:	

Appendix 17. Nearby locations to investigate for populations of orchids.

Site	Coordinates	Description	Ownership
1	45.542639, -87.774417	Sunset Lake, Goodman Brook	Private
2	45.627494, -87.710321	Small unnamed creek, north of De Haas Creek	Private
3	45.636217, -87.678349	Open wetland along De Haas Creek	State and Private
4	45.575493, -87.656707	Small opening ~1500 ft east of northern part of Wiregrass Lake	State
5	45.586454, -87.642910	Opening along eastern edge of Carney Swamp	State

A mural in the town of Carney.