# Ecological Evaluation of Porter Legacy Dunes Preserve


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**Cover Photo:** Tyler Bassett surveying the open dune along Lake Michigan. Photo by Jesse M. Lincoln, 2021. Above: Common trillium in bloom during surveys in spring of 2021. Photo by Jesse M. Lincoln.

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# Introduction

Porter Legacy Dunes (alternately, the Preserve) is a 48-acre nature preserve recently acquired by the South Haven Area Recreation Authority in collaboration with the Southwest Michigan Land Conservancy (SWMLC), and managed by SWMLC. The Preserve is located three kilometers south of South Haven, MI in South Haven Township (NW ¼ of the SW ¼ of Section 28, T01S, R17W), Van Buren County, MI, and is a new addition to a three km conservation corridor stretching from Pilgrim Haven Natural Area (SWMLC) directly to the north, through Van Buren State Park to the south (Figure 1). This corridor protects critical dunes along Lake Michigan, is a regionally important for the conservation of both resident wildlife, and for supporting the migration of neotropical migrant birds (Brewer et al. 1991). Porter Legacy Dunes was acquired by SWMLC in 2020 to strengthen the conservation value of this corridor. However, the natural features supported by the preserve were not well documented at that time, limiting the capacity of SWMLC to set management and development priorities. Michigan Natural Features Inventory (MNFI) contracted with SWMLC in 2021 to conduct a baseline floristic inventory and delineate cover types intended form the backbone of that initial prioritization.

Porter Legacy Dunes occurs in the Southern Michigan Lakeplain Sub-subsection of the Allegan Subsection of Southern Lower Michigan, an area characterized by lacustrine sand and gravel overlain by aeolian dune sands (Farrand and Bell 1982, Albert et al. 1995). The vegetation circa 1800 was beech-sugar maple-hemlock forest in the western half and beech-sugar maple forest in the eastern half of the Preserve (Comer et al. 1995, Figure 2). The proximity to Lake Michigan strongly influences the climate here (Albert et al. 1995). Prevailing westerly winds accumulate moisture while crossing the lake, leading to high annual precipitation (up to 100 cm), and lake effect snowfall (up to 175 cm). The lake also moderates temperature fluctuations, allowing species with northern affinities to persist, where they commingle with species of southern affinities.

Porter Legacy Dunes occurs in a highly fragmented landscape. Imagery from 1938 (Figure 3) indicates that much of the surrounding landscape was cleared for agriculture. East from the preserve, the landscape is fragmented and developed with residences and agriculture (e.g., blueberries) with only small, isolated, degraded, fragmented patches of natural cover with a high degree of edge. Large, developed areas include the city of South Haven, the civil township of Covert, and the South Haven Regional Airport. Many areas that were historically cleared have recovered to a state of degraded forest. Many of these are surrounded by roads, have an understory dominated by non-native species, and occur in a fragmented matrix in which residential lots are common. Connectivity with natural habitats is highest in this region along the Lake Michigan shoreline. In addition to the approximately 3 km corridor containing the Preserve, additional mature natural cover in the immediate landscape includes Covert Township Park (semi-developed), SWMLC's Dunes Parkway Preserve, Thunder Mountain south of Palisades Power Plant, the Nature Conservancy's Ross Coastal Plain Marsh Preserve, Michigan Nature Association's Barvick's Dunes (Figure 1).

There is a steep bluff above the beach. Photo by Jesse M. Lincoln.

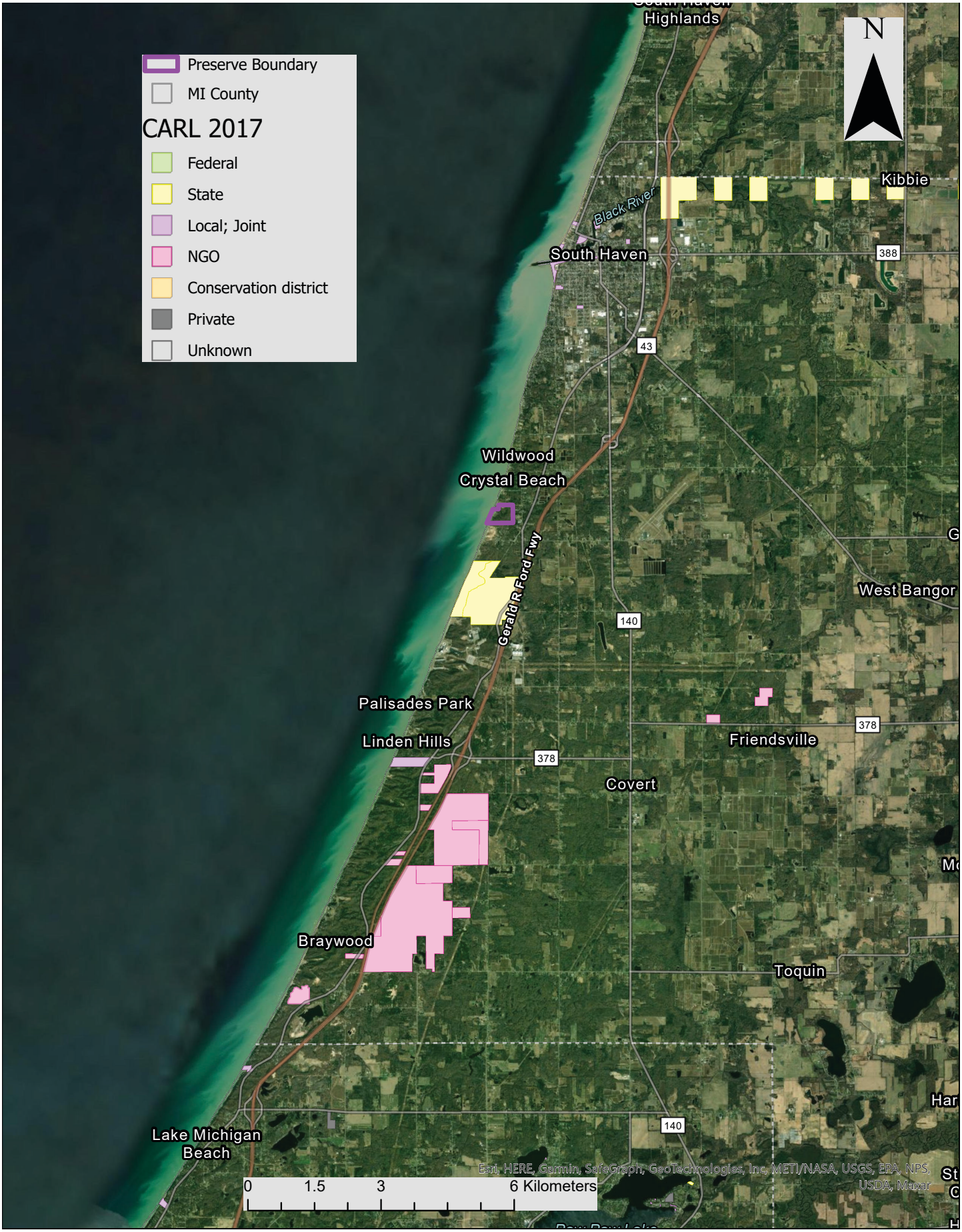


**Figure 1.** The location of Porter Legacy Dunes Preserve and other areas of conservation value in western Van Buren County (CARL = Conservation and Recreation Lands).

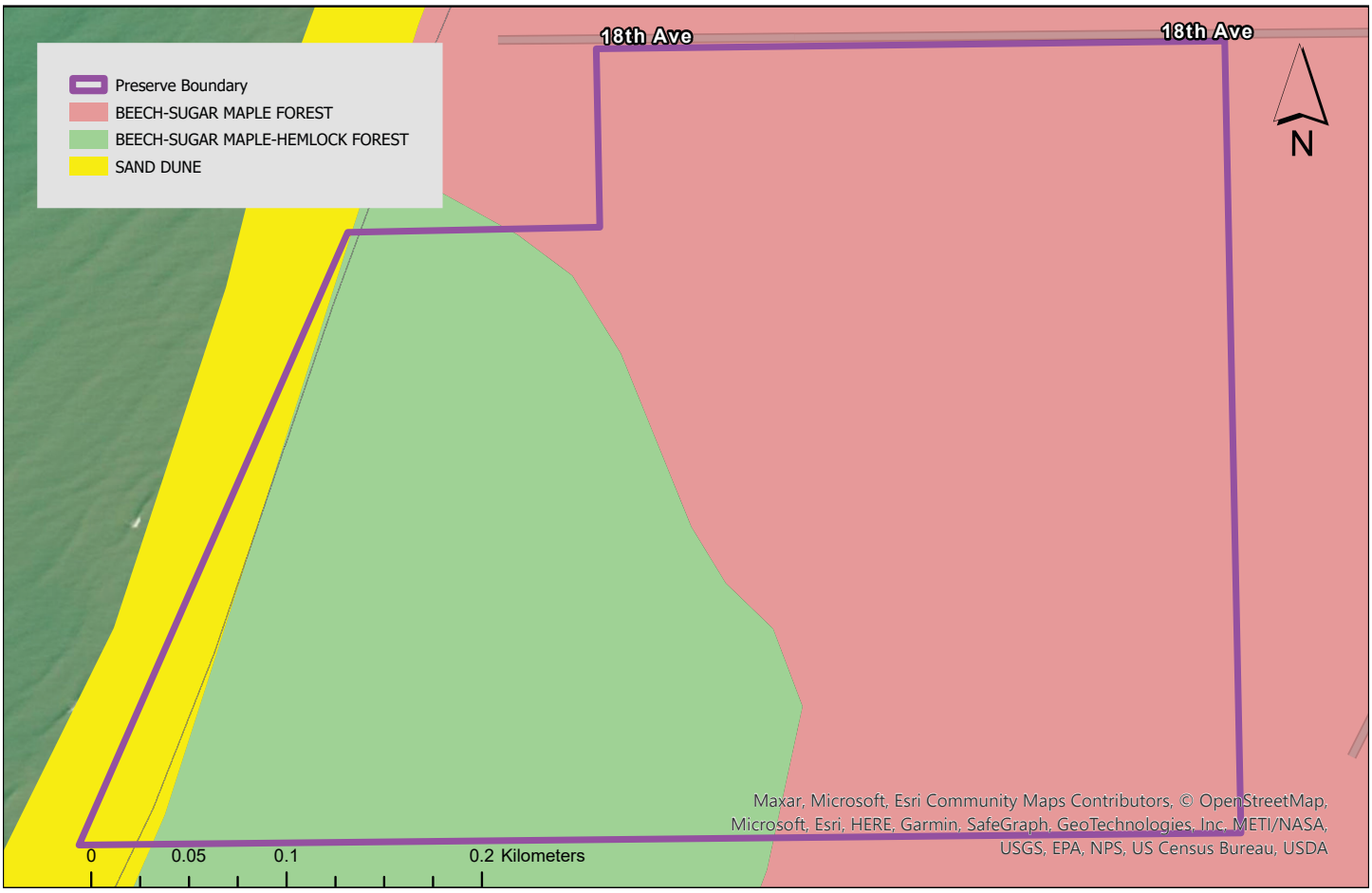


**Figure 2.** Circa-1800 vegetation cover of Porter Legacy Dunes Preserve.

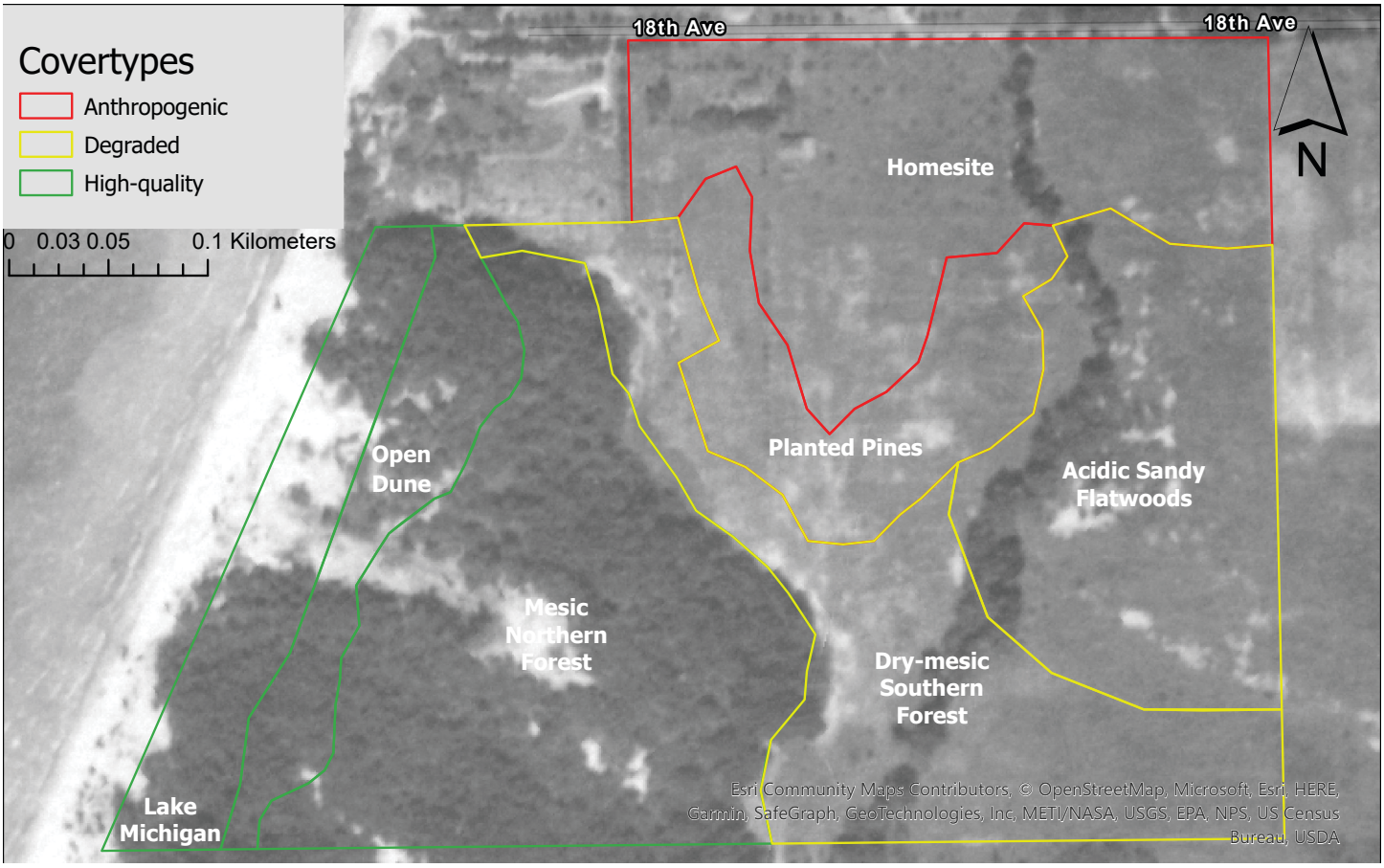


**Figure 3.** 1938 aerial photograph of Porter Legacy Dunes Preserve.

Areas that were forested in the 1938 imagery (top photo) tend to have the largest trees, the most native species, and most closely reflect conditions prior to European colonization. These areas also generally have the fewest invasive species and are top conservation priorities. Areas that were cleared and then reverted to forest tend to have much lower native plant diversity and higher components of invasive species (bottom photo). Photos by Jesse M. Lincoln.

# Methods

We conducted a floristic inventory and delineated cover types at the preserve over three site visits in 2021, on April 28, August 27, and September 29. We conducted meander surveys, recording the presence of each vascular plant species we observed and collecting data on key attributes of each natural community (see below). A meander survey maximizes the probability of observing every species that is present by zig-zagging through the survey area in such a way that the surveyor observes a large proportion of each natural community, and the microhabitats and unique landscape features within each natural community that may support unique species. This survey approach also increases the probability of observing species of conservation concern such as federally- and state-listed species, especially when they occur at low density. When we observed species of conservation concern we recorded the location with GPS, and recorded data on population size and condition, including associated species, soils, aspect, and apparent threats to population viability. We entered observations of federally- and state-listed species as element occurrences in the Michigan Natural Heritage Database (2022). Vascular plant species nomenclature follows Michigan Flora Online (2011).

We mapped cover types by recording data on vegetation structure, dominant plant species, canopy age, soil texture, slope, aspect, and hydrology. We delineated cover type boundaries in the field with GPS based on these and other factors and refined these boundaries using aerial photograph interpretation. Where cover types represent natural communities, with characteristics of Michigan's pre-European landscape, we recorded more detailed data, especially regarding the structure and composition of the natural community (Kost et al. 2007, Cohen et al. 2014). We focused this detailed data collection on the mesic northern forest, which we also mapped as an element occurrence in the Natural Heritage Database (MNFI 2022).

MNFI Botanist, Tyler J. Bassett, takes detailed notes during surveys in 2021. Photo by Jesse M. Lincoln.

We conducted a Floristic Quality Assessment (FQA) for the Preserve as a whole with the species list from the floristic inventory (Appendix 1), and a separate FQA (Appendix 2) for the high-quality mesic northern forest specifically with the subset of the species associated with that community (Reznicek et al. 2014). The FQA utilizes plant species composition to derive the Floristic Quality Index (FQI), a quantitative metric of habitat quality that can be used as a relatively objective comparison among natural community occurrences of a type. Drawing upon expert consensus among botanists familiar with the flora of Michigan, each vascular plant species in Michigan has been assigned an *a priori* coefficient of conservatism (C-value) that ranges from 0 to 10 on a scale of increasing fidelity to pre-European colonization habitats (Reznicek et al. 2014). All non-native species have a C-value of 0. We calculated FQI for each natural community occurrence as $C * \sqrt{n}$, where C = mean C-value and n = species richness. Natural community occurrences with an FQI of 35 or greater possess sufficient floristic conservatism to be considered of high quality. FQI scores greater than 50 indicate exceptional sites with extremely high conservation value (Herman et al. 2001).

The FQI is intended to characterize and compare the floristic quality of occurrences of natural community types, rather than a site as a whole containing multiple natural community types. The expected species richness varies by natural community type, so the inclusion of species richness in the calculation of FQI introduces a bias when comparing between two different community types with different expected species richness. However, the mean C-value alone is a useful quick metric for characterizing the overall floristic quality of a site. To the extent that the mean C-value increases with the ecological integrity of natural communities, a higher mean C-value generally indicates sites with higher-quality communities, and in the least a more conservative flora.

MNFI Ecologist, Jesse M. Lincoln, ages a white pine during surveys in 2021. Photo by Tyler J. Bassett.

# Results

We documented 202 vascular plant species at Porter Legacy Dunes, including 157 (78%) native and 45 (22%) non-native species (Appendix 1). The mean coefficient of conservatism was 3.4 (natives only = 4.4), suggesting a minimally to moderately conservative flora. A large proportion of the flora was moderately conservative (C =4-6, 41.6%), and most of the rest was minimally (C=1-3, 21.3%) or not (C=0, 25.2%) conservative. A small but significant proportion of the flora was highly conservative (C=7-10, 11.9%).

We documented two state-listed species during our surveys, Pallas' bugseed (*Corispermum pallasii*; state special concern) and ginseng (*Panax quinquefolius*; state threatened), among other species of high conservation value. We also documented several populations of invasive plant species, including in areas where they threaten high conservation value targets. Finally, we delineated six cover types (Figure 4.), including two anthropogenic types (homesite, planted pines), two degraded forest types (acidic sandy flatwoods, dry-mesic southern forest), and two high-quality natural communities (open dunes, mesic northern forest).

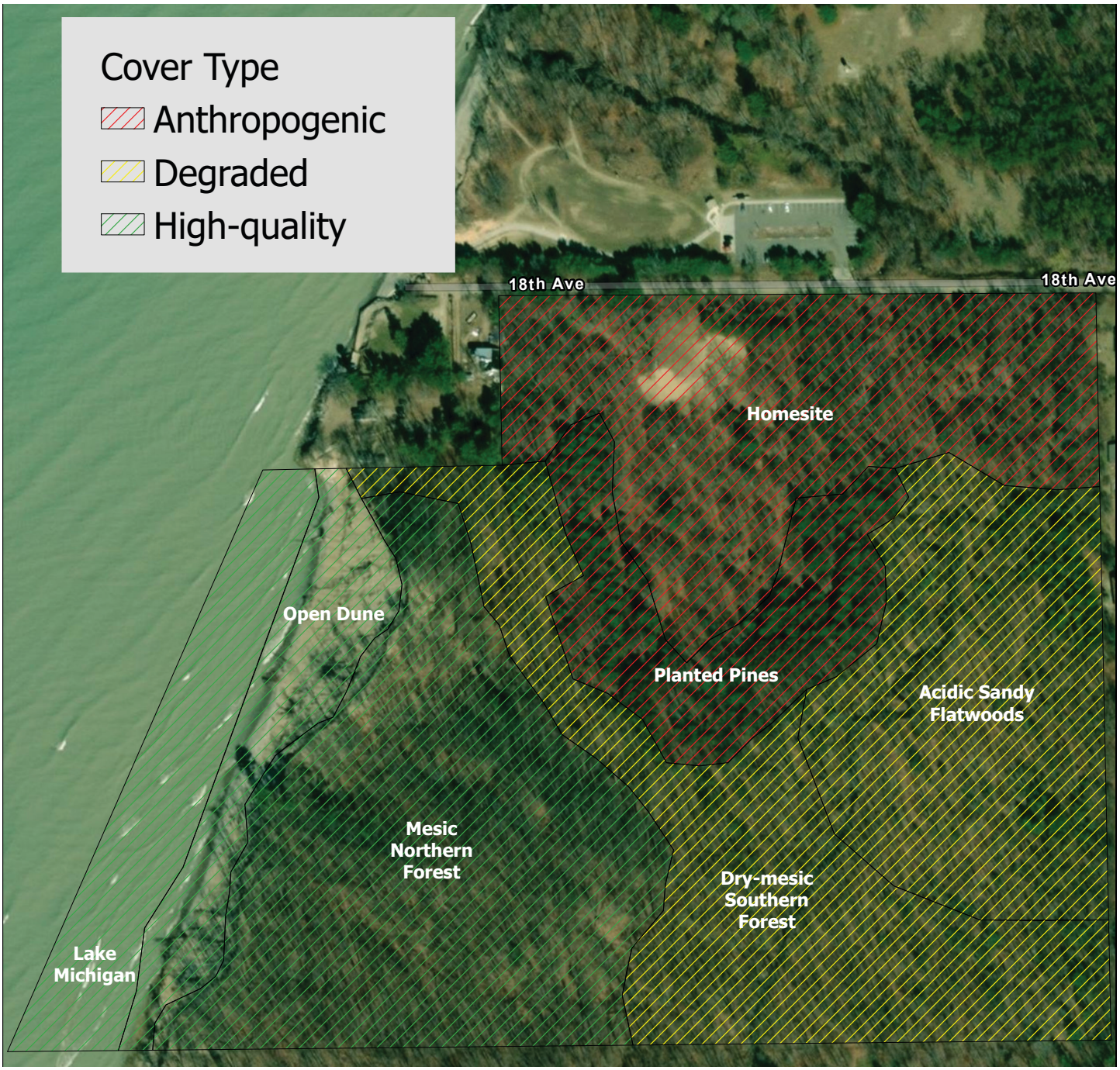


**Figure 4.** Vegetation cover types of Porter Dunes Preserve.

The open dune features extensive zones of barren, exposed soil. Much of the erosion seems to be caused from recent historic high water levels. Photo by Jesse M. Lincoln.

Portions of the mesic northern forest have profusions of spring wildflowers. Photo by Jesse M. Lincoln.

# Discussion

**Species of Conservation Concern**

We observed two state-listed plant species during our surveys. Pallas' bugseed (*Corispermum pallasii*, state special concern) an annual forb found in Michigan mostly in dunes and sandy beaches of all the Great Lakes. This species was very common along the sparsely vegetated open dune within the preserve, where it was associated with winged pigweed (*Cycloloma atriplicifolium*), tall goldenrod (*Solidago altissima*), sassafras (*Sassfras albidium*), and marram grass (*Ammophila breviligulata*). The disturbance associated with the erosion of open dune during recent (2016-2020) high lake levels appears to benefit germination and spread of this species. Pallas' bugseed is considered apparently insecure globally (inexact, G4?) (NatureServe 2022). Since our surveys were limited to the boundaries of the preserve, it is not known whether this population extends further to the north or south in dunes in adjacent properties.

Ginseng (*Panax quinquefolius*, state threatened) is a perennial forb found in Michigan in moist, shaded forests concentrated in the southern Lower Peninsula, also occurring sporadically in the northern lower peninsula and western upper peninsula (MNFI 2022, Penskar and Higman 1996). According to recent modelling based on Michigan populations, ginseng is most commonly found on steep, shaded aspects with deep (3.5-5.0 cm) leaf litter, in large tracts of forest with a mature canopy (Hackett et al. 2020). Most viable populations of this species in Michigan are found in mature mesic forests, with an intact canopy of large diameter trees such as sugar maple (*Acer saccharum*), basswood (*Tilia americana*), American beech (*Fagus grandifolia*), red oak (*Quercus rubra*), eastern hemlock (*Tsuga canadensis*), and yellow birch (*Betula allegheniensis*). At Porter Legacy Dunes, we observed a total of ten individuals of ginseng in four different locations in mesic northern forest and adjacent dry-mesic southern forest. Here, ginseng was associated with hairy sweet cicely (*Osmorhiza claytonii*), enchanter's-nightshade (*Circaea canadensis*), annual bedstraw (*Galium aparine*), and big-leaved aster (*Eurybia macrophylla*).

We also observed plant species that, while not federally- or state-listed, are of conservation concern. Chief among these is Canada yew (*Taxus canadensis*), which we observed in the southwest of the Preserve at the boundary between mesic northern forest and open dune (Figures 4,5). Canada yew was once prevalent in mesic and boreal forests across the northeastern United States and adjacent Canada but is a preferred browse of native ungulates and has seen sharp declines in recent decades due to white-tailed deer (*Odocoileus virginianus*) overabundance and climate change (Windels and Faspohler 2011). Canada yew now persists as low-statured seedlings that evade winter deer browse below snowpack. We observed several low-statured seedlings at the Preserve in a roughly 20 X 20 m area, where it was associated with wood betony (*Pedicularis canadensis*), bellwort (*Uvularia grandiflora*), and starry false Solomon's-seal (*Maianthemum stellatum*).

Pallas' bugseed (foreground) is a rare species that grows on the open dunes at Porter Dunes. Photo by Tyler J. Bassett.

Ginseng is a state threatened species found at Porter Legacy Dunes. Photo by Jesse M. Lincoln.

Canada yew is a shrub that was historically characteristic of mesic forests in Michigan, but has become very rare due to deer herbivory. A small population persists at Porter Legacy Dunes. Photo by Jesse M. Lincoln.

**Anthropogenic Cover Types**

*Homesite*

The homesite along the northern boundary of the property is comprised of a disturbed opening with a few scattered walnut (*Juglans nigra*) and other trees, surrounded by a zone with a thin canopy of sugar maple and black cherry (*Prunus serotina*), and an understory dominated by non-native invasive shrubs. Autumn olive (*Elaeagnus umbellata*) and common privet (*Ligustrum vulgare*) are particularly dominant in this zone. There is a small sandy opening with a few conservative species typical of dry prairies and dunes, including prickly pear (*Opuntia humifusa*), little bluestem (*Schizachyrium scoparium*), poverty grass (*Danthonia spicata*), and hairy hawkweed (*Hieracium gronovii*).

*Planted Pines*

The planted pines serve as a transition between the anthropogenically disturbed northern one-third of the Preserve, and the degraded to high-quality natural communities that comprise the southern two-thirds. We measured one red pine (*Pinus resinosa*), aged 30-35 years, at 10.2 inches diameter at breast height (DBH). A white pine (*P. strobus*) was also aged 30-35 years. We aged a 16.6-inch DBH red oak (*Quercus rubra*) at 55 years old, at the boundary with dry-mesic southern forest. The ground layer plant community here is depauperate and composed largely of weedy, non-conservative species.

**Degraded Forest**

*Acidic sandy flatwoods*

Acidic sandy flatwoods occur on deep acidic lakeplain sands (>70% sand, > 100 cm deep) along the southern shore of lake Michigan in Michigan and Indiana and are typically dominated by red oak and red maple (*Acer rubrum*) in the canopy and greenbrier (*Smilax rotundifolia*) and bracken fern (*Pteridium aquilinum*) in the understory (USDA-NRCS 2022). Red oak and red maple dominate the canopy at Porter Legacy Dunes, while common understory species include wintergreen (*Gaultheria procumbens*), poverty grass, and greenbrier. We aged a 17-inch DBH red oak at 59 years old. Blackgum (*Nyssa sylvatica*) is locally common, with scattered white oak (*Q. alba*) and white pine (*Pinus strobus*), which is typically of this natural community (USDA-NRCS 2022). Acidic sandy flatwoods is not classified as a natural community by MNFI (Cohen et al. 2014). The wetter extremes, which are dominated by red maple and black gum, would be classified as southern hardwood swamp. The drier extremes typified by the occurrence at the Preserve would be classified as dry southern forest or dry-mesic southern forest, and dominated by red oak, or occasionally black and white oak.

The area around the old homesite is especially degraded and dominated by non-native species. Photo by Jesse M. Lincoln.

*Dry-mesic southern forest*

Dry-mesic southern forest occurs on level ground from the base of the dune, east to the stream and acidic sandy flatwoods, and is bordered on the north by planted pines. Historically, the areas now comprised of anthropogenic cover types likely supported dry-mesic or mesic southern forest. Typical dry-mesic southern forest is dominated by red, white, or black oak, and co-dominated by hickory (*Carya* sp.) (Lee 2007). At the Preserve, this cover type is dominated by red oak and sub-dominated by young sassafras (*Sassfras albidum*). The prevalence of sassafras, which colonizes canopy gaps and cleared forests, indicates the young age of this forest patch. We measured one sassafras tree at 11.5 inches DBH, and aged an eight-inch DBH sassafras at approximately 50 years old. The subcanopy is dominated by seedlings and saplings of white ash (*Fraxinus americana*) and red maple (*Acer rubrum*), often under dense patches of spicebush (*Lindera benzoin*) and the invasive Japanese barberry (*Berberis thunbergii*). Several minimally conservative native species dominate the ground layer, including downy Solomon's-seal (*Polygonatum pubescens*), jumpseed (*Persicaria virginiana*), Canada mayflower (*Maianthemum canadense*), and bluestem goldenrod (*Solidago caesia*). A large patch of non-native sweet woodruff (*Galium odoratum*), established in the south of this zone, may threaten native biodiversity and is a concern as a potentially invasive species.

Large portions of the understory of dry-mesic southern forest is dominated by spicebush. Photo by Jesse M. Lincoln.

**High-quality Natural Communities**

*Open dunes*

Open dunes occur in a thin band along the Lake Michigan shore. Sands appear to be destabilized from recent high-water years where ice cut against the base of the dune, causing slides and exposing more sand (note position of lakeshore in imagery from 1938 in Figure 3). Some ledges are six meters vertical and access to the water is impossible, absent serious investment in infrastructure. Erosion at the top of the dune is cutting away at adjacent mesic northern forest. Blowing sands are also deposited on the back side of the dune in mesic northern forest. Sand is accumulating at substantial depths in places, covering portions of the ground layer plant community and potentially leading to canopy tree mortality. The state special concern plant species Pallas' bugseed was observed in open dune. Tires, bricks, and concrete have been deposited on the beach.

The open dune has sparse vegetation (bottom). Winged pigweed is locally abundant (top). Photos by Tyler J. Bassett.

The top of the open dune. Photo by Jesse M. Lincoln.

The top of the open dune. Photo by Tyler J. Bassett.

*Mesic northern forest*

The high-quality mesic northern forest occupies the steep back dune between open dunes on the west and the flat dry-mesic southern forest to the east. We documented 105 vascular plant species here, including 99 native species, with a mean C of 4.3, and FQI of 44.1. A comprehensive species list is provided in Appendix 2 and conservation metrics are provided in Appendix 3. The state threatened plant species ginseng was observed in mesic northern forest.

The Porter Dunes mesic northern forest is a mature, second-growth forest dominated by large-diameter red oak, with sugar maple, black cherry, and basswood as important canopy co-dominants. The prevalence and the minimal component of sugar maple in the canopy may be a result of historic clearing. The dominance of sugar maple in the subcanopy suggests that red oak will gradually phase out of the canopy as succession advances. White pine and sassafras are infrequent in the canopy. A single individual of the typically northern-ranging eastern hemlock occur here. Eastern hemlock, which contributes to distinguishing mesic northern forest from mesic southern forest, extends its Michigan range south in a narrow band along Lake Michigan dunes to near the Berrien-Van Buren county line just south of the Preserve.

Canopy coverage in this mesic northern forest is generally between 80 and 90% and trees ranged from 14 to 33 inches DBH. We observed several downed white ash, which we estimate may have occupied as much as 10% (locally as high as 30%) of the canopy before this species was eliminated from most forest canopies in Michigan over the past two decades by the invasive insect, emerald ash borer (*Agrilus planipennis*). Most canopy trees appear to be part of a single cohort that established after clearing in the late 1800s or early 1900s. We estimated an 18-inch DBH red oak at around 140 years. Additional red oaks were 13.7, 19.9, 29.3, and 32.5 inches DBH. A 25.9-inch DBH white pine at the edge of the dune had 100 rings observed but some early growth was contorted and difficult to count, suggested an age closer to 120 years. A basswood, black cherry, and sassafras were 16.7, 18.7, and 19.1 inches DBH, respectively.

The subcanopy (woody species over 5 m in height) is typically 50 to 60% coverage and dominated by sugar maple and ironwood (*Ostrya virginiana*). The density of sugar maple in the subcanopy, a height class that is largely not susceptible to deer herbivory, suggests that sugar maple will become dominant in the canopy over the next few decades to century. Other common subcanopy species include basswood, white ash, American elm (*Ulmus americana*), American beech (*Fagus grandifolia*), serviceberry (*Amelanchier* spp.), and occasionally white pine. The understory and low shrub layer (woody species 1-5 m in height) is locally dominated by paw-paw (*Asimina triloba*) in the north portion of the forest. Spicebush is abundant throughout, while prickly gooseberry (*Ribes cynosbatia*) and raspberry (*Rubus* spp.) are also common. Red-berried elderberry (*Sambucus racemosa*), maple-leaf viburnum (*Viburnum acerifolium*), chokecherry (*Prunus virginiana*), witch-hazel (*Hamamelis virginiana*), leatherwood (*Dirca palustris*), and the invasive shrub Japanese barberry are infrequent to occasional. Canada yew is locally common in a small saddle between two dune ridges along the boundary with open dunes.

The herbaceous layer of the mesic northern forest often forms a carpet of native species. Photo by Jesse M. Lincoln.

The mesic northern forest is characterizied by large, maturing red oak in the canopy (top). Paw-paw is locally dominant in the understory (bottom). Photo by Jesse M. Lincoln.

The herbaceous layer of the mesic northern forest is continuous (e.g., 90-100% cover) and diverse, and dominated by spring ephemerals. Common species, in approximate decreasing order of frequency, include squirrel corn and dutchmen's breeches (*Dicentra canadensis* and *D. cucullaria*), common trillium (*Trillium grandiflorum*), running strawberry bush (*Euonymus obovatus*), bellwort (*Uvularia grandiflora*), marginal woodfern (*Dryopteris marginalis*), spring-beauty (*Claytonia virginica*), Yellow trout lily (*Erythronium americanum*), blue cohosh (*Caulophylum thalictroides*), false spikenard (*Maianthemum racemosum*), and Canada mayflower (*M. canadense*). Other species include rough-leaved rice-grass (*Oryzopsis asperifolia*), Sedges (*Carex pedunculata, C. albursina, C. gracillima, C. rosea, C. pensylvanica*), bottlebrush grass (*Elymus hystrix*), big-leaved aster (*Eurybia macrophylla*), herb Robert (*Geranium robertianum*), ghost pipe (*Monotropa uniflora*), annual bedstraw and white wild licorice (*Galium aparine* and *G. circaezans*), yellow and long-spurred violet (*Viola pubescens* and *V. rostrata*), jumpseed (*Persicaria virginiana*), wood betony (*Pedicularis canadensis*), upright carrion-flower and bristly greenbrier (*Smilax ecirrata* and *S. hispida*), bluestem goldenrod (*Solidago caesia*), lopseed (*Phryma leptostachya*), and rice-grass (*Piptatherum racemosum*).

Numerous species were blooming at the time of surveys in April of 2021. These include long-spurred violet (top), common trillium (bottom right), and wood-betony (bottom left). Photos by Jesse M. Lincoln.

Mature patches of mesic northern forest are valuable reservoirs of biodiversity (Cohen 2000). Neotropical migrant birds depend on diverse, intact forest canopies, particularly in nearshore flyways (Brewer et al. 1991). We recommend that SWMLC prioritize management of this mesic northern forest, by controlling invasive species and maintaining a mature canopy of large-diameter trees. We observed deer and earthworm herbivory, and invasive plant species, as likely or potential threats to the integrity of this natural community. Preferential herbivory by white-tailed deer (*Odocoileus virginianus*), which we discuss in more detail below, has disproportionately negative effects on ephemeral wildflowers, especially common trillium, and evergreen woody species, especially hemlock and Canada yew. Deer herbivory may be all but excluding the latter two species from this community. Downed ash and other trees may serve to protect some tree saplings from deer herbivory, facilitating a locally diverse recruitment class. Leaf litter maintains a moist microclimate at the ground level, which many mesophytic species and tree seedlings depend upon. Leaf decomposition is also important for building up soil organic matter and nutrient cycling. The presence of non-native earthworms can consume leaf litter at rates faster than they are deposited, leading to stressed conditions for native herbaceous ground layer species and tree seedlings, and facilitating the spread of invasive species such as garlic mustard (*Alliaria petiolata*) (Bohlen et al. 2004, Nuzzo et al. 2009). There is no known effective management for non-native earthworms. While occasional canopy gaps are important for allowing tree saplings to recruit into the canopy, large canopy gaps can also lead to conditions that are too warm and dry for many mesophytic species, as well as providing a large burst of light for invasive species to become firmly established in the understory. The invasive shrub Japanese barberry is a primary threat here, although autumn olive and multiflora rose (*Rosa multiflora*) are also established and should be managed. Garlic mustard is also present, at densities low enough to be manageable.

Deer herbivory on several species was obvious and extensive during every survey. Herbivory can be difficult to convey in photos so the hand was included to clearly show stems that had been browsed. Photos by Jesse M. Lincoln.

# Conservation and Management Concerns

**Sensitive Areas**

As SWMLC develops Porter Legacy Dunes for public access, we recommend that ecologically sensitive areas be protected by routing trails away from these areas. Trail development can also provide viewscapes centered around less sensitive areas (Figure 5). Specifically, we recommend avoiding the steepest of slopes in mesic northern forest, the top of the open dune where mesic northern forest is eroding toward Lake Michigan (seen in Figure 3 as the boundary between open dune and mesic northern forest), the areas containing Canada yew and ginseng, and the slopes of the stream that bisects the Preserve. We note a location for a possible bench overlooking the stream, that may facilitate a viewscape of the stream without the need for visitors to walk along the edge and cause undue erosion.

**Deer Overabundance**

We frequently encountered the impacts of white-tailed deer overabundance during surveys, in particular selective browsing of rare and common herbaceous plant species and seedlings of canopy trees. High white-tailed deer densities generally degrade ecosystems and can be a barrier to management success (Rooney and Waller 2003, Cote et al. 2004). Through preferential browsing of tree seedlings and palatable understory herbs, high deer herbivory reduces understory plant diversity, altering herbaceous composition and limiting the recruitment of particular tree species to the canopy. Deer herbivory can also facilitate establishment and population growth of invasive species by reducing competition from native species and creating bare ground for seed establishment (Knight et al. 2009). The regeneration of northern hardwood ecosystems in particular appears to be impacted by deer herbivory on oak seedlings (Rooney and Waller 2003). These impacts of deer overabundance may not be easily reversible if population growth in native plants is depressed for a long period, so efforts to reduce deer densities are urgent (Cote et al. 2004). Depending on the density and longevity of deer overabundance, removing deer alone may result in noticeable benefits to the restoration of native herbaceous species (Kalisz et al. 2014). Managers can mediate the impacts of deer overabundance by increasing the resiliency of ecosystems as well as by directly reducing the density or abundance of deer. For example, managing large blocks of mature contiguous forest reduces the tendency for deer to congregate in that landscape, by reducing the abundance of available low browse associated with clearcuts and edge habitat. Large habitat patches also increase the resiliency and viability of plant populations, including understory herbs (MacArthur and Wilson 1967). The ideal deer density for canopy regeneration and thriving understory plant populations requires focused research to determine but may be as low as 5-10 deer/km2 (15-25/mi2) (Ristau et al. 2012, McWilliams et al. 2018). Antlerless hunts (i.e., hunting does rather than bucks) may be necessary to reduce population growth (Cote et al. 2004).

**Invasive Species**

We observed invasive plant species that occur at high abundance and currently threaten native biodiversity, and those that occur at low abundance that can be easily managed in the short term before they reach densities that threaten biodiversity. Species that are widespread throughout the Preserve, in declining order of abundance, include the shrubs Japanese barberry, autumn olive, multiflora rose, and winged euonymus (*Euonymus alata*), and the biennial herb garlic mustard. There are also locally abundant populations of common privet (Homesite), Japanese honeysuckle (*Lonicera japonica*; Homesite), and sweet woodruff. The tree Norway maple (*Acer platanoides*), the shrub (*Rhodotypus scandens*), and the herbs spotted knapweed (*Centaurea stoebe*) and Japanese knotweed (*Fallopia japonica*) occur locally at low density. The low density of this latter suite of species, combined with their high potential to impact biodiversity, suggest that they should be a high priority for management.

Invasive species Japanese knotweed along the stream (above) and Japanese barberry in mesic northern forest (below). Photos by Tyler J. Bassett (above), Jesse M. Lincoln (below).

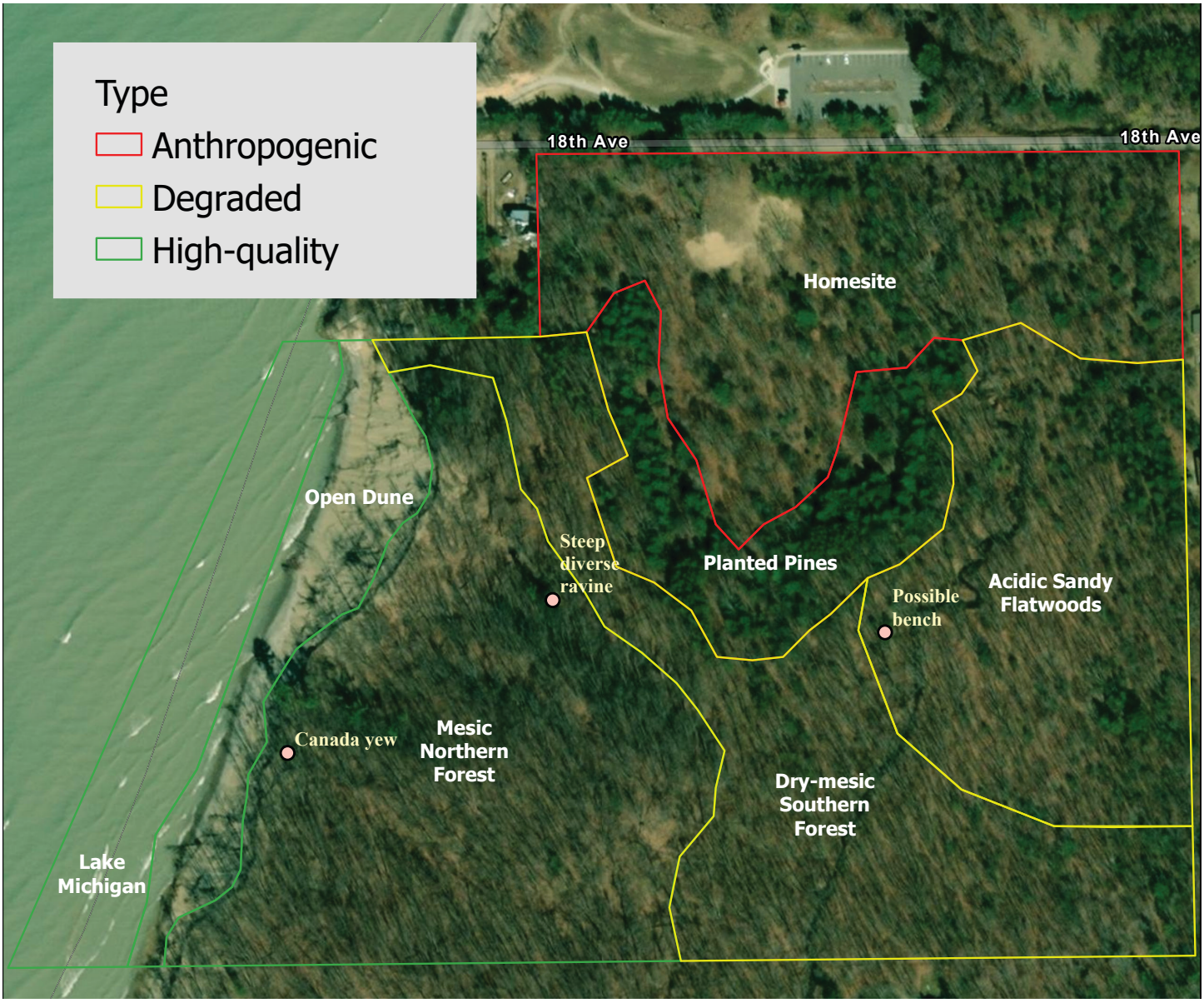


**Figure 5.** Vegetation cover types of Porter Dunes Preserve highlighting sensitive areas.

A small stream forms a narrow and deep crevasse through the property. The extent to which this is naturally occuring or an artifact of historic land use is not obvious. Special care should be taken to avoid disturbing the sandy soils around the stream that appear to be especially vulnerable to erosion. Photos by Tyler J. Bassett (above), Jesse M. Lincoln (below).

# Conclusions

At Porter Legacy Dunes Preserve, MNFI documented populations of rare plants, two high-quality natural communities, and established a description of vegetative composition that can be used as a baseline to understand how the systems change over time. We recommend that conservation actions be taken to minimize threats to biodiversity. In particular, we recommend prioritizing the treatment of invasive species in the mesic northern forest, avoiding trails in the most diverse areas, and immediately reducing deer densities to mitigate negative impacts on preferred browse. Additionally, canopy regeneration in mesic forests are influenced by gap phase dynamics, where by individual trees die, creating canopy gaps in which saplings recruit into the canopy. Downed trees also contribute to the accrual of coarse woody debris.

Within the mesic northern forest, we strongly recommend that management approaches focus on allowing gap-phase dynamics to proceed unhindered, leaving fallen trees on site and minimizing silvicultural interventions that would alter the canopy composition and openness. Forestry actions may be warranted to achieve more desirable future conditions in other portions of the preserve. However, increased canopy openness may lead to increased growth of invasive species. Silviculture should be paired with treatment of invasive species that are locally dominant in younger forests with longer histories of anthropogenic disturbance. Additionally, special care should be taken to avoid negative impacts on the stream bisecting the Preserve. The sandy banks are especially sensitive to erosion and disturbance near the stream could reduce water quality.

Porter Legacy Dunes Preserve is part of a corridor of natural areas along the coast of Lake Michigan. Its location is especially valuable for migratory birds, rare plants, and the public that wish to experience high-quality nature near the lakeshore. The coast is characterized by private homes and reduction of important natural cover has been accelerating over the past several decades. Land trusts such as the Southwest Michigan Land Conservancy, state and local parks, and private landowners committed to protecting natural cover are key to slowing rates of biodiversity loss in this region.

The duneward edge of mesic northern forest is increasingly eroding. Photo by Jesse M. Lincoln.

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# Appendices

**Appendix 1**. All plant species observed at Porter Dunes Preserve during surveys in 2021.

| Scientific Name | Common Name | C | W | Physiognomy | Duration |
|---|---|---|---|---|---|
| ***Acer platanoides*** | **norway maple** | **0** | **5** | **tree** | **perennial** |
| *Acer rubrum* | red maple | 1 | 0 | tree | perennial |
| *Acer saccharum* | sugar maple | 5 | 3 | tree | perennial |
| *Actaea pachypoda* | dolls-eyes | 7 | 5 | forb | perennial |
| *Agrostis scabra* | ticklegrass | 4 | 0 | grass | perennial |
| ***Agrostis stolonifera*** | **creeping bent** | **0** | **-3** | **grass** | **perennial** |
| ***Allium vineale*** | **field garlic** | **0** | **3** | **forb** | **perennial** |
| *Ambrosia artemisiifolia* | common ragweed | 0 | 3 | forb | annual |
| *Amelanchier arborea* | juneberry | 4 | 3 | tree | perennial |
| *Amelanchier interior* | serviceberry | 4 | 5 | shrub | perennial |
| *Amelanchier sanguinea* | round-leaved serviceberry | 5 | 5 | shrub | perennial |
| *Ammophila breviligulata* | marram grass | 10 | 5 | grass | perennial |
| ***Anthoxanthum odoratum*** | **sweet vernal grass** | **0** | **3** | **grass** | **perennial** |
| *Apocynum androsaemifolium* | spreading dogbane | 3 | 5 | forb | perennial |
| *Aquilegia canadensis* | wild columbine | 5 | 3 | forb | perennial |
| *Arabidopsis lyrata* | sand cress | 7 | 3 | forb | biennial |
| *Aralia nudicaulis* | wild sarsaparilla | 5 | 3 | forb | perennial |
| *Arnoglossum atriplicifolium* | pale indian plantain | 8 | 5 | forb | perennial |
| *Artemisia campestris* | wormwood | 5 | 5 | forb | biennial |
| *Asimina triloba* | pawpaw | 9 | 0 | tree | perennial |
| *Asplenium platyneuron* | ebony spleenwort | 2 | 3 | fern | perennial |
| ***Barbarea vulgaris*** | **yellow rocket** | **0** | **0** | **forb** | **biennial** |
| ***Berberis thunbergii*** | **japanese barberry** | **0** | **3** | **shrub** | **perennial** |
| ***Berteroa incana*** | **hoary alyssum** | **0** | **5** | **forb** | **annual** |
| *Boechera canadensis* | sickle-pod | 7 | 5 | forb | biennial |
| *Boehmeria cylindrica* | false nettle | 5 | -5 | forb | perennial |
| *Botrypus virginianus* | rattlesnake fern | 5 | 3 | fern | perennial |
| *Brachyelytrum erectum* | long-awned wood grass | 7 | 5 | grass | perennial |
| *Calamagrostis canadensis* | blue-joint | 3 | -5 | grass | perennial |
| ***Cardamine hirsuta*** | **hoary bitter cress** | **0** | **3** | **forb** | **annual** |
| *Carex albursina* | sedge | 5 | 5 | sedge | perennial |
| *Carex blanda* | sedge | 1 | 0 | sedge | perennial |
| *Carex gracillima* | sedge | 4 | 3 | sedge | perennial |
| *Carex pedunculata* | sedge | 5 | 3 | sedge | perennial |
| *Carex pensylvanica* | sedge | 4 | 5 | sedge | perennial |
| *Carex rosea* | curly-styled wood sedge | 2 | 5 | sedge | perennial |
| *Carex swanii* | sedge | 4 | 3 | sedge | perennial |
| *Carex tribuloides* | sedge | 3 | -3 | sedge | perennial |
| *Carya cordiformis* | bitternut hickory | 5 | 0 | tree | perennial |
| *Caulophyllum thalictroides* | blue cohosh | 5 | 5 | forb | perennial |
| *Celastrus scandens* | american bittersweet | 3 | 3 | vine | perennial |
| ***Centaurea stoebe*** | **spotted knapweed** | **0** | **5** | **forb** | **biennial** |
| *Chelone glabra* | turtlehead | 7 | -5 | forb | perennial |
| ***Chenopodium album*** | **lambs-quarters** | **0** | **3** | **forb** | **annual** |
| *Chimaphila maculata* | spotted wintergreen | 8 | 5 | shrub | perennial |
| *Cinna arundinacea* | wood reedgrass | 7 | -3 | grass | perennial |

**Appendix 1, continued**. All plant species observed at Porter Dunes Preserve during surveys in 2021.

| Scientific Name | Common Name | C | W | Physiognomy | Duration |
|---|---|---|---|---|---|
| *Circaea canadensis* | enchanters-nightshade | 2 | 3 | forb | perennial |
| *Claytonia virginica* | spring-beauty | 4 | 3 | forb | perennial |
| *Conopholis americana* | squaw-root | 10 | 5 | forb | perennial |
| ***Convallaria majalis*** | **lily-of-the-valley** | **0** | **5** | **forb** | **perennial** |
| *Corispermum pallasii** | bugseed | 3 | 5 | forb | annual |
| *Cornus alternifolia* | alternate-leaved dogwood | 5 | 3 | tree | perennial |
| ***Cycloloma atriplicifolium*** | **winged pigweed** | **0** | **3** | **forb** | **annual** |
| *Cyperus schweinitzii* | rough sand sedge | 5 | 3 | sedge | perennial |
| ***Dactylis glomerata*** | **orchard grass** | **0** | **3** | **grass** | **perennial** |
| *Danthonia spicata* | poverty grass; oatgrass | 4 | 5 | grass | perennial |
| *Dicentra canadensis* | squirrel-corn | 7 | 5 | forb | perennial |
| *Dicentra cucullaria* | dutchmans-breeches | 7 | 5 | forb | perennial |
| *Dichanthelium clandestinum* | panic grass | 3 | -3 | grass | perennial |
| *Dichanthelium latifolium* | broad-leaved panic grass | 5 | 3 | grass | perennial |
| *Dichanthelium meridionale* | mat panic grass | 7 | 5 | grass | perennial |
| *Diphasiastrum digitatum* | ground-cedar | 3 | 5 | fern | perennial |
| *Dirca palustris* | leatherwood | 8 | 0 | shrub | perennial |
| *Dryopteris marginalis* | marginal woodfern | 5 | 3 | fern | perennial |
| ***Elaeagnus umbellata*** | **autumn-olive** | **0** | **3** | **shrub** | **perennial** |
| *Elymus canadensis* | canada wild rye | 5 | 3 | grass | perennial |
| *Elymus hystrix* | bottlebrush grass | 5 | 3 | grass | perennial |
| *Equisetum arvense* | common horsetail | 0 | 0 | fern | perennial |
| *Eragrostis spectabilis* | purple love grass | 3 | 5 | grass | perennial |
| *Erythronium americanum* | yellow trout lily | 5 | 5 | forb | perennial |
| ***Euonymus alatus*** | **winged euonymus** | **0** | **5** | **shrub** | **perennial** |
| *Euonymus obovatus* | running strawberry-bush | 5 | 3 | shrub | perennial |
| *Eurybia macrophylla* | big-leaved aster | 4 | 5 | forb | perennial |
| *Fagus grandifolia* | american beech | 6 | 3 | tree | perennial |
| ***Fallopia convolvulus*** | **false buckwheat** | **0** | **3** | **vine** | **annual** |
| ***Fallopia japonica*** | **japanese knotweed** | **0** | **3** | **forb** | **perennial** |
| *Festuca subverticillata* | nodding fescue | 5 | 3 | grass | perennial |
| ***Festuca trachyphylla*** | **sheep fescue** | **0** | **5** | **grass** | **perennial** |
| ***Forsythia intermedia*** | **forsythia** | **0** | **5** | **shrub** | **perennial** |
| *Fragaria virginiana* | wild strawberry | 2 | 3 | forb | perennial |
| *Fraxinus americana* | white ash | 5 | 3 | tree | perennial |
| *Galium aparine* | annual bedstraw | 0 | 3 | forb | annual |
| *Galium circaezans* | white wild licorice | 4 | 3 | forb | perennial |
| ***Galium odoratum*** | **sweet woodruff** | **0** | **5** | **forb** | **perennial** |
| *Galium pilosum* | hairy bedstraw | 6 | 5 | forb | perennial |
| *Gaultheria procumbens* | wintergreen | 5 | 3 | shrub | perennial |
| *Geranium robertianum* | herb robert | 3 | 3 | forb | annual |
| *Geum canadense* | white avens | 1 | 0 | forb | perennial |
| *Hamamelis virginiana* | witch-hazel | 5 | 3 | shrub | perennial |
| ***Hedera helix*** | **english ivy** | **0** | **3** | **vine** | **perennial** |
| ***Hemerocallis fulva*** | **orange day-lily** | **0** | **5** | **forb** | **perennial** |

**Appendix 1, continued**. All plant species observed at Porter Dunes Preserve during surveys in 2021.

| Scientific Name | Common Name | C | W | Physiognomy | Duration |
|---|---|---|---|---|---|
| *Hepatica acutiloba* | sharp-lobed hepatica | 8 | 5 | forb | perennial |
| ***Hieracium caespitosum*** | **king devil** | **0** | **5** | **forb** | **perennial** |
| *Hieracium gronovii* | hairy hawkweed | 5 | 5 | forb | perennial |
| *Huperzia lucidula* | shining clubmoss | 5 | 0 | fern | perennial |
| *Impatiens capensis* | spotted touch-me-not | 2 | -3 | forb | annual |
| *Iris virginica* | southern blue flag | 5 | -5 | forb | perennial |
| *Juglans nigra* | black walnut | 5 | 3 | tree | perennial |
| ***Lamium purpureum*** | **purple dead-nettle** | **0** | **5** | **forb** | **annual** |
| ***Lathyrus latifolius*** | **everlasting pea** | **0** | **5** | **vine** | **perennial** |
| ***Ligustrum vulgare*** | **common privet** | **0** | **3** | **shrub** | **perennial** |
| ***Linaria vulgaris*** | **butter-and-eggs** | **0** | **5** | **forb** | **perennial** |
| *Lindera benzoin* | spicebush | 7 | -3 | shrub | perennial |
| *Lonicera dioica* | red honeysuckle | 5 | 3 | vine | perennial |
| ***Lonicera japonica*** | **japanese honeysuckle** | **0** | **3** | **vine** | **perennial** |
| *Lycopus uniflorus* | northern bugle weed | 2 | -5 | forb | perennial |
| *Lysimachia ciliata* | fringed loosestrife | 4 | -3 | forb | perennial |
| *Maianthemum canadense* | canada mayflower | 4 | 3 | forb | perennial |
| *Maianthemum racemosum* | false spikenard | 5 | 3 | forb | perennial |
| *Maianthemum stellatum* | starry false solomon-seal | 5 | 0 | forb | perennial |
| *Mitchella repens* | partridge-berry | 5 | 3 | forb | perennial |
| *Mitella diphylla* | bishops-cap | 8 | 3 | forb | perennial |
| *Monarda fistulosa* | wild-bergamot | 2 | 3 | forb | perennial |
| *Monarda punctata* | horse mint | 4 | 5 | forb | perennial |
| *Monotropa uniflora* | indian-pipe | 5 | 3 | forb | perennial |
| ***Morus alba*** | **white mulberry** | **0** | **3** | **tree** | **perennial** |
| *Muhlenbergia tenuiflora* | slender satin grass | 8 | 5 | grass | perennial |
| ***Muscari botryoides*** | **grape-hyacinth** | **0** | **5** | **forb** | **perennial** |
| ***Narcissus pseudonarcissus*** | **daffodil** | **0** | **5** | **forb** | **perennial** |
| *Nyssa sylvatica* | black-gum | 9 | -3 | tree | perennial |
| *Oenothera biennis* | common evening-primrose | 2 | 3 | forb | biennial |
| *Onoclea sensibilis* | sensitive fern | 2 | -3 | fern | perennial |
| *Opuntia humifusa* | prickly-pear | 7 | 5 | shrub | perennial |
| *Oryzopsis asperifolia* | rough-leaved rice-grass | 6 | 5 | grass | perennial |
| *Osmunda cinnamomea* | cinnamon fern | 5 | -3 | fern | perennial |
| *Osmorhiza claytonii* | hairy sweet-cicely | 4 | 3 | forb | perennial |
| *Ostrya virginiana* | ironwood; hop-hornbeam | 5 | 3 | tree | perennial |
| *Panax quinquefolius** | ginseng | 10 | 5 | forb | perennial |
| *Panicum capillare* | witch grass | 0 | 0 | grass | annual |
| *Parthenocissus quinquefolia* | virginia creeper | 5 | 3 | vine | perennial |
| *Pedicularis canadensis* | wood-betony | 10 | 3 | forb | perennial |
| *Persicaria virginiana* | jumpseed | 4 | 0 | forb | perennial |
| *Phryma leptostachya* | lopseed | 4 | 3 | forb | perennial |
| *Phytolacca americana* | pokeweed | 2 | 3 | forb | perennial |
| ***Picea abies*** | **norway spruce** | **0** | **5** | **tree** | **perennial** |
| *Pinus resinosa* | red pine | 6 | 3 | tree | perennial |

**Appendix 1, continued**. All plant species observed at Porter Dunes Preserve during surveys in 2021.

| Scientific Name | Common Name | C | W | Physiognomy | Duration |
|---|---|---|---|---|---|
| *Solidago rugosa* | rough-leaved goldenrod | 3 | 0 | forb | perennial |
| *Symphyotrichum cordifolium* | heart-leaved aster | 4 | 5 | forb | perennial |
| *Symphyotrichum urophyllum* | arrow-leaved aster | 2 | 5 | forb | perennial |
| ***Syringa vulgaris*** | **common lilac** | **0** | **5** | **shrub** | **perennial** |
| *Taxus canadensis* | yew | 5 | 3 | shrub | perennial |
| *Thalictrum dioicum* | early meadow-rue | 6 | 3 | forb | perennial |
| *Tilia americana* | basswood | 5 | 3 | tree | perennial |
| *Trillium grandiflorum* | common trillium | 5 | 3 | forb | perennial |
| *Tsuga canadensis* | hemlock | 5 | 3 | tree | perennial |
| *Ulmus americana* | american elm | 1 | -3 | tree | perennial |
| *Uvularia grandiflora* | bellwort | 5 | 5 | forb | perennial |
| *Vaccinium angustifolium* | low sweet blueberry | 4 | 3 | shrub | perennial |
| *Vaccinium corymbosum* | highbush blueberry | 6 | -3 | shrub | perennial |
| ***Verbascum thapsus*** | **common mullein** | **0** | **5** | **forb** | **biennial** |
| *Viburnum acerifolium* | maple-leaved viburnum | 6 | 5 | shrub | perennial |
| ***Vinca minor*** | **periwinkle** | **0** | **5** | **shrub** | **perennial** |
| *Viola pubescens* | yellow violet | 4 | 3 | forb | perennial |
| *Viola rostrata* | long-spurred violet | 6 | 3 | forb | perennial |
| *Viola sororia* | common blue violet | 1 | 0 | forb | perennial |
| *Vitis aestivalis* | summer grape | 6 | 3 | vine | perennial |
| *Vitis riparia* | river-bank grape | 3 | 0 | vine | perennial |

**Appendix 2**. Plant species observed in Porter Dunes mesic northern forest during surveys in 2021.

| Scientific Name | Common Name | Acronym | Native? | C | W |
|---|---|---|---|---|---|
| *Acer saccharum* | sugar maple | ACESAU | native | 5 | 3 |
| *Actaea pachypoda* | dolls-eyes | ACTPAC | native | 7 | 5 |
| *Amelanchier arborea* | juneberry | AMEARB | native | 4 | 3 |
| *Amelanchier sanguinea* | round-leaved serviceberry | AMESAN | native | 5 | 5 |
| *Aquilegia canadensis* | wild columbine | AQUCAN | native | 5 | 3 |
| *Aralia nudicaulis* | wild sarsaparilla | ARANUD | native | 5 | 3 |
| *Asimina triloba* | pawpaw | ASITRI | native | 9 | 0 |
| *Asplenium platyneuron* | ebony spleenwort | ASPPLA | native | 2 | 3 |
| *Berberis thunbergii* | japanese barberry | BERTHU | non-native | 0 | 3 |
| *Boechera canadensis; arabis c.* | sickle-pod | BOECAN | native | 7 | 5 |
| *Boehmeria cylindrica* | false nettle | BOECYL | native | 5 | -5 |
| *Botrypus virginianus* | rattlesnake fern | BOTVIR | native | 5 | 3 |
| *Brachyelytrum erectum* | long-awned wood grass | BRAERE | native | 7 | 5 |
| *Carex albursina* | sedge | CXALBU | native | 5 | 5 |
| *Carex blanda* | sedge | CXBLAN | native | 1 | 0 |
| *Carex gracillima* | sedge | CXGRAA | native | 4 | 3 |
| *Carex pedunculata* | sedge | CXPEDU | native | 5 | 3 |
| *Carex pensylvanica* | sedge | CXPENS | native | 4 | 5 |
| *Carex rosea; c. convoluta* | curly-styled wood sedge | CXROSE | native | 2 | 5 |
| *Carex swanii* | sedge | CXSWAN | native | 4 | 3 |
| *Carya cordiformis* | bitternut hickory | CARCOR | native | 5 | 0 |
| *Caulophyllum thalictroides* | blue cohosh | CAUTHA | native | 5 | 5 |
| *Celastrus scandens* | american bittersweet | CELSCA | native | 3 | 3 |
| *Cinna arundinacea* | wood reedgrass | CINARU | native | 7 | -3 |
| *Circaea canadensis; c. lutetiana* | enchanters-nightshade | CIRCAN | native | 2 | 3 |
| *Claytonia virginica* | spring-beauty | CLAVIR | native | 4 | 3 |
| *Conopholis americana* | squaw-root | CONAME | native | 10 | 5 |
| *Cornus alternifolia* | alternate-leaved dogwood | CORALT | native | 5 | 3 |
| *Dicentra canadensis* | squirrel-corn | DICCAN | native | 7 | 5 |
| *Dicentra cucullaria* | dutchmans-breeches | DICCUC | native | 7 | 5 |
| *Dichanthelium latifolium; panicum l.* | broad-leaved panic grass | DICLAT | native | 5 | 3 |
| *Dirca palustris* | leatherwood | DIRPAL | native | 8 | 0 |
| *Dryopteris marginalis* | marginal woodfern | DRYMAR | native | 5 | 3 |
| *Elaeagnus umbellata* | autumn-olive | ELAUMB | non-native | 0 | 3 |
| *Elymus hystrix; hystrix patula* | bottlebrush grass | ELYHYS | native | 5 | 3 |
| *Equisetum arvense* | common horsetail | EQUARV | native | 0 | 0 |
| *Erythronium americanum* | yellow trout lily | ERYAME | native | 5 | 5 |
| *Euonymus alatus* | winged euonymus | EUOALA | non-native | 0 | 5 |
| *Euonymus obovatus* | running strawberry-bush | EUOOBO | native | 5 | 3 |
| *Eurybia macrophylla; aster m.* | big-leaved aster | EURMAC | native | 4 | 5 |
| *Fagus grandifolia* | american beech | FAGGRA | native | 6 | 3 |
| *Festuca subverticillata; f. obtusa* | nodding fescue | FESSUB | native | 5 | 3 |
| *Fraxinus americana* | white ash | FRAAME | native | 5 | 3 |
| *Galium aparine* | annual bedstraw | GALAPA | native | 0 | 3 |
| *Galium circaezans* | white wild licorice | GALCIR | native | 4 | 3 |
| *Geranium robertianum* | herb robert | GERROB | native | 3 | 3 |
| *Geum canadense* | white avens | GEUCAN | native | 1 | 0 |
| *Hamamelis virginiana* | witch-hazel | HAMVIR | native | 5 | 3 |
| *Hepatica acutiloba* | sharp-lobed hepatica | HEPACU | native | 8 | 5 |
| *Huperzia lucidula* | shining clubmoss | HUPLUC | native | 5 | 0 |
| *Impatiens capensis* | spotted touch-me-not | IMPCAP | native | 2 | -3 |
| *Lindera benzoin* | spicebush | LINBEN | native | 7 | -3 |
| *Lonicera dioica* | red honeysuckle | LONDIO | native | 5 | 3 |
| *Maianthemum canadense* | canada mayflower | MAICAN | native | 4 | 3 |

**Appendix 2, continued**. Plant species observed in Porter Dunes mesic northern forest during surveys in 2021.

| Scientific Name | Common Name | Acronym | Native? | C | W |
|---|---|---|---|---|---|
| *Maianthemum racemosum; smilacina r.* | false spikenard | MAIRAC | native | 5 | 3 |
| *Maianthemum stellatum; smilacina s.* | starry false solomon-seal | MAISTE | native | 5 | 0 |
| *Monotropa uniflora* | indian-pipe | MONOUN | native | 5 | 3 |
| *Muhlenbergia tenuiflora* | slender satin grass | MUHTEN | native | 8 | 5 |
| *Oryzopsis asperifolia* | rough-leaved rice-grass | ORYASP | native | 6 | 5 |
| *Ostrya virginiana* | ironwood; hop-hornbeam | OSTVIR | native | 5 | 3 |
| *Panax quinquefolius* | ginseng | PANQUI | native | 10 | 5 |
| *Parthenocissus quinquefolia* | virginia creeper | PARQUI | native | 5 | 3 |
| *Pedicularis canadensis* | wood-betony | PEDCAN | native | 10 | 3 |
| *Persicaria virginiana; polygonum v.* | jumpseed | PERVIR | native | 4 | 0 |
| *Phryma leptostachya* | lopseed | PHRLEP | native | 4 | 3 |
| *Pinus strobus* | white pine | PINSTR | native | 3 | 3 |
| *Piptatherum racemosum; oryzopsis r.* | rice-grass | PIPRAC | native | 8 | 5 |
| *Poa compressa* | canada bluegrass | POACOM | non-native | 0 | 3 |
| *Polygonatum pubescens* | downy solomon seal | POLPUB | native | 5 | 5 |
| *Prenanthes alba* | white lettuce | PREALB | native | 5 | 3 |
| *Prunus serotina* | wild black cherry | PRUSER | native | 2 | 3 |
| *Prunus virginiana* | choke cherry | PRUVIR | native | 2 | 3 |
| *Pteridium aquilinum* | bracken fern | PTEAQU | native | 0 | 3 |
| *Quercus rubra* | red oak | QUERUB | native | 5 | 3 |
| *Ranunculus abortivus* | small-flowered buttercup | RANABO | native | 0 | 0 |
| *Rhodotypos scandens* | jetbead | RHOSCA | non-native | 0 | 5 |
| *Ribes cynosbati* | prickly or wild gooseberry | RIBCYN | native | 4 | 3 |
| *Rosa multiflora* | multiflora rose | ROSMUL | non-native | 0 | 3 |
| *Rubus allegheniensis* | common blackberry | RUBALL | native | 1 | 3 |
| *Rubus occidentalis* | black raspberry | RUBOCC | native | 1 | 5 |
| *Rubus pensilvanicus* | dewberry | RUBPEN | native | 2 | 3 |
| *Rubus setosus* | bristly blackberry | RUBSET | native | 3 | -3 |
| *Rubus strigosus* | wild red raspberry | RUBSTR | native | 2 | 0 |
| *Sambucus racemosa* | red-berried elder | SAMRAC | native | 3 | 3 |
| *Sanicula odorata; s. gregaria* | black snakeroot | SANODO | native | 2 | 0 |
| *Sassafras albidum* | sassafras | SASALB | native | 5 | 3 |
| *Sceptridium dissectum* | cut-leaved grape-fern | SCEDIS | native | 5 | 0 |
| *Smilax ecirrata* | upright carrion-flower | SMIECI | native | 6 | 5 |
| *Smilax lasioneura* | carrion-flower | SMILAS | native | 5 | 5 |
| *Smilax rotundifolia* | common greenbrier | SMIROT | native | 6 | 0 |
| *Solidago caesia* | bluestem goldenrod | SOLCAE | native | 6 | 3 |
| *Symphyotrichum cordifolium; aster c.* | heart-leaved aster | SYMCOR | native | 4 | 5 |
| *Taxus canadensis* | yew | TAXCAN | native | 5 | 3 |
| *Thalictrum dioicum* | early meadow-rue | THADIO | native | 6 | 3 |
| *Tilia americana* | basswood | TILAME | native | 5 | 3 |
| *Trillium grandiflorum* | common trillium | TRIGRA | native | 5 | 3 |
| *Tsuga canadensis* | hemlock | TSUCAN | native | 5 | 3 |
| *Ulmus americana* | american elm | ULMAME | native | 1 | -3 |
| *Uvularia grandiflora* | bellwort | UVUGRA | native | 5 | 5 |
| *Viburnum acerifolium* | maple-leaved viburnum | VIBACE | native | 6 | 5 |
| *Viola pubescens* | yellow violet | VIOPUB | native | 4 | 3 |
| *Viola rostrata* | long-spurred violet | VIOROS | native | 6 | 3 |
| *Viola sororia* | common blue violet | VIOSOR | native | 1 | 0 |
| *Vitis aestivalis* | summer grape | VITAES | native | 6 | 3 |
| *Vitis riparia* | river-bank grape | VITRIP | native | 3 | 0 |

**Appendix 3**. Conservation metrics for Porter Dunes mesic northern forest during surveys in 2021.

Porter Dunes Mesic Northern Forest
Practitioners: Tyler J. Bassett and Jesse M. Lincoln

Conservatism-Based Metrics:

| | |
|---|---|
| Total Mean C: | 4.3 |
| Native Mean C: | 4.6 |
| Total FQI: | 44.1 |
| Native FQI: | 45.8 |
| Adjusted FQI: | 44.7 |
| % C value 0: | 9.5 |
| % C value 1-3: | 20 |
| % C value 4-6: | 56.2 |
| % C value 7-10: | 14.3 |
| Native Tree Mean C: | 4.7 |
| Native Shrub Mean C: | 3.9 |
| Native Herbaceous Mean C: | 4.7 |

Species Richness:

| | | |
|---|---|---|
| Total Species: | 105 | |
| Native Species: | 99 | 94.30% |
| Non-native Species: | 6 | 5.70% |

Species Wetness:

| | |
|---|---|
| Mean Wetness: | 2.7 |
| Native Mean Wetness: | 2.6 |

Physiognomy Metrics:

| | | |
|---|---|---|
| Tree: | 15 | 14.30% |
| Shrub: | 20 | 19% |
| Vine: | 7 | 6.70% |
| Forb: | 40 | 38.10% |
| Grass: | 9 | 8.60% |
| Sedge: | 7 | 6.70% |
| Rush: | 0 | 0% |
| Fern: | 7 | 6.70% |
| Bryophyte: | 0 | 0% |

Duration Metrics:

| | | |
|---|---|---|
| Annual: | 3 | 2.90% |
| Perennial: | 101 | 96.20% |
| Biennial: | 1 | 1% |
| Native Annual: | 3 | 2.90% |
| Native Perennial: | 95 | 90.50% |
| Native Biennial: | 1 | 1% |